THE ECOSYSTEM OF THE YAHUDIA NATURE RESERVE

WITH EMPHASIS ON

DYNAMICS OF GERMINATION AND DEVELOPMENT

OF

QUERCUS ITHABURENSIS DECNE

Promotoren : dr. M.F. Mörzer Bruyns, oud hoogleraar in het Natuurbehoud en Natuurbeheer

: prof. G. Orshan, Botany Department of the Hebrew University of Jerusalem

YEDIDYA KAPLAN

THE ECOSYSTEM OF THE YAHUDIA NATURE RESERVE WITH EMPHASIS ON DYNAMICS OF GERMINATION AND DEVELOPMENT OF QUERCUS ITHABURENSIS DECNE

Proefschrift

ter verkrijging van de graad van
doctor in de landbouwwetenschappen,
op gezag van de rector magnificus,
dr. C.C. Oosterlee,
hoogleraar in de veeteeltwetenschap,
in het openbaar te verdedigen
op woensdag 29 februari 1984
des namiddags te vier uur in de aula
van de Landbouwhogeschool te Wageningen.

Stellingen

1. The noda analysis system should be used to analyse complex vegetation in order to recognize vegetation units on an exact objective basis. These units are not necessarily comparable with the classical phytosociological units, such as associations.
2. By using aerial photography for vegetation mapping, less random sampling is required over the relevant area. Consequently much less field records need to be taken.
3. Regulation of large predators should generally be avoided even close to populated areas, as long as the food chain is complete and well balanced.
4. Although domestic herbivores should not generally be used in nature reserve management, their use need not be completely excluded.
5. The Mediterranean maquis is not a climax association, but an inhibited stage in succession towards Mediterranean forest due to manmade fires, overgrazing and felling.
6. The uncertainly about the feeding of the Loch Ness Monster (L.N.M.) accompanied with data of lake productivity leads to the conclusion that population density of the L.N.M. in the lake is 10-20 specimens, if a carnivorous diet is assumed, and 2-5 specimens, if a facultative canibalistic diet is assumed.
7. The kibbutz is a living example of the possibility to maintain an equal socialist community.
8. It is important to set up a domestic breeding stock of falcon species, used for sport hunting, and sell them as an alternative to intensive uncontrolled poaching, which causes a severe decrease of the populations.

Proefschrift van Yedidya Kaplan
The ecosystem of Yahudia Nature Reserve with emphasis on dynamics of Germination and development of Quercus ithaburensis Decne
Wageningen, 29 februari 1984

CONTENTS

VOLUME II

This volume is to be available in the following libraries:

1. Nature Conservation Department, Agricultural University of Wageningen, The Netherlands
2. Botany Department, Hebrew University of Jerusalem, Israel
3. Nature Reserves Authority, Jerusalem, Israel
4. Nature Reserves Authority, Northern regional office, Zefad, Isreal.

Appendix	5.1.II	:	List of plant species in systematic order, and their codes
Appendix	5.4.II	:	TABLEF - tables of vegetation records
Appendix	5.6.II	:	ORDIN 1 and 8 : Vegetation analysis for the determination of vegetation units
Appendix	5.7.II	:	ORDIN 3, 4, and 6 : Vegetation analysis of herbaceous vegetation in a typical *Quercus ithaburensis* Park Forest
Appendix	8.1.II	:	Data matrix of germination and survival of *Quercus ithaburensis* seedlings (CULT I)
Appendix	8.2.II	:	Chi square crosstabs of survival (PLIVE I) by difference in mean number of leaves (DML I) of *Quercus ithaburensis* seedlings (CULT I) in each habitat
Appendix	8.3.II	:	Chi square crosstabs of survival (PLIVE I) by difference in mean number of leaves (DML I) of *Quercus ithaburensis* seedlings (CULT I) in each grazing treatment

LIST OF MAPS

ACKNOWLEDGEMENTS

I wish to express my deep gratitude to Prof. M.F. Mörzer Bruyns of the Agricultural University of Wageningen who introduced me to the subject of Nature Conservation and followed with interest the development of my research work.

I am indebted to Prof. G. Orshan, of the Hebrew University of Jerusalem, who helped me in the various stages of my work as well as in the processing and presentation of data.

I wish to give special thanks to Prof. I. Noy-Meir for his valuable help in the analysis and interpretation of results and his constructive comments concerning the manuscript.

I am very grateful to Nature Reserves Authority, especially to the General Director Mr. A. Shapira and the Chief Scientist Dr. A. Rabinovitch who allowed me to carry out this research in the framework of my position at the Nature Reserves Authority and put at my disposal all the necessary means.

I would like to thank my colleagues of the Nature Reserves Authority who helped me during my research work, especially Mrs. M. Paltin who devoted much time and patience in her precise and faithful translation of the hebrew text into english as well as Mrs. M. Mossek who helped in this difficult task.

I benefitted much from the experience of Miss S. Greenberg in computer work and thank her for her help.

My deep thanks to Dr. M. Gutman for his helpful advice in the early stages of my work and beneficial discussions of the results.

Dr. Y. Wachs, Dr. I. Ayanot, Miss A. Keisar, Mrs. A. Halevy, Katcha and other cattlemen of Kibbutz Neve-Eytan, Miss N. Iceland, Mrs. N. Margalit, Mr. Y. Taylor, Mr. J. Maman, Mrs. E. Hadjaj, Mrs. A. Weil have all contributed in many ways in the success of my work and I express my sincere gratitude to all of them.

My very deep thanks to my wife, Bina, who gave me her full support during all this busy period and contributed much to its final stages.

The last but not least, thanks to my horse, Liby, who carried me with patience on her back during long work days in the Reserve.

1 PREFACE

The aim of this paper is to present an inventory of, and principal processes occurring in, the Yahudia Nature Reserve, with a view to creating suitable tools for its management.

The fires endangering the *Quercus ithaburensis* forest led to the introduction in 1969 of cattle grazing. The existing age gap between seedlings and adult trees which springs to the eye in the forest, induced second thoughts about regrowth and establishment of trees. The need of studying effects of fire and grazing on, and problems of regrowth of, *Quercus ithaburensis* in an endeavour to preserve the ecosystem which is centred on the *Quercus ithaburensis* forest, has led to this research.

The paper deals with six main subjects: a description of the physical and historical background of the Reserve; inventory of vertebrates; inventory of vegetation; several aspects of *Quercus ithaburensis* with emphasis on germination and establishment of the species, and fires and grazing and their impact on the ecosystem.

Structure of paper: each subject has been presented and dealt with separately, and each constitutes a more or less self-contained unit for perusal by anyone interested in the specific subject. The comprehensive discussion and recommendation for management of the reserve are based on the synthesis of all the subjects presented.

2 NATURE CONSERVATION AND NATURE MANAGEMENT

2.1 General concept of conservation and management of nature

2.1.1 *Nature conservation and its motives*

The increased impact on the environment by the growth of population and the urban industrial development, the increased use of nature resources and the need for outdoor recreation, have raised, most severely in this century, the issue of nature conservation.

Nature conservation, according to Van Leeuwen (1966), is the maintenance of variety in space, and of stability. Van Leeuwen's theory, dealing with interrelations of vegetation pattern and process, bases the study of these interrelations on the connection between variety in space (pattern) and variety in time (process). Richness in species (variety in space) is usually linked to stability (no variety in time), while poorness in species - in many cases due to disturbed habitats - is connected with non-stability in time.

A close concept is that of Shimwell (1971), who states that maintenance of maximum biological diversity in all remaining ecosystems is synonumous with conservation.

Mörzer Bruyns and Westhoff (1963) emphasize the biological variety created by geographical variation, as well as by man-made environment, as an important criterium for defining reserved areas.

Based on Mörzer Bruyns (1967), six main motives for conservation can be enumerated. Since then, many more papers have been published on the motives for conservation and the categories which may be discerned. For this study the six motives mentioned are chosen, because they fit the purpose well:

1 Ethics: As the most successful species on earth, man, with his conscience and sense of responsibility, needs to stimulate action to prevent the extinction of species, and cruelty;
2 Aesthetics: The desire to preserve the beauties of nature, be the landscape, animals or plants, may be one of the major reasons for public interest in nature and nature conservation;

Since, unfortunately, the aesthetic as well as the ethical motive cannot be measured objectively, these motives have been neglected in planning, while economic motives have been given dominance.

3 Economics: Nature, directly or indirectly, is the only source of men's sustenance, clothes, minerals, and most of his energy. It is only reasonable to utilise nature for production, but in such a way that its assets will be preserved. A balance should be maintained between all resources which are usually interdependent (Bell, 1971). Nature as a source of gene diversity should be preserved for improvement of production by hybridization with wild species, thus building up tolerance to diseases (Mason, 1962; Cain, 1970);

4 Science: The best field laboratory, both for fundamental and for applied research, is a natural ecosystem. Using dynamic ecosystems is the only way to investigate the guiding principles of all types of relations between organisms and habitats, including human influences on the ecosystem;

5 Sociology and public health: In modern society there is a growing need for turning to nature to create a balance between work and rest (Bourliere, 1967). Dubos (1970) sees the cultural and social homogenization in the modern life style as a hindrance to the full exploitation of the biological richness of the human species. It is therefore essential to keep the environment as diverse as possible to provide the means for diverse mental and physical development.

Urbanization and industrialization also create severe problems of illness, most of which due to soil, water and air pollution. By keeping the environment, or at least large protected areas, clean of pollutants, many illnesses can be avoided;

6 Education: None of the abovementioned motives for nature conservation will have significance for the coming generations if nature is not used for developing ethical and aesthetical attitudes towards it, and consciousness of its economic, scientific and social importance. Much of the destruction of habitats and of mismanagement of natural resources is due to ignorance.

2.1.2 *Nature reserves and their functions*

Nature reserves are only one means, though probably the most important one, of nature conservation. It is extremely important to have at least all representative habitats preserved and well managed in nature reserves.

Preservation of flora and fauna elements

Reserves are safe shelters for species, and thus all species should be represented in them. Special attention should be paid to species under threat of extinction. Causes of rareness may be natural or may arise from hunting, for from introduction of predators or exotic species, or from habitat disturbance through human activities to which the greater part of species extinction is due. These problems have been described and discussed very clearly for plants as well as for animal species in the period when the IUCN-Red Data books were pbulished for the first time (cf. Fisher et al., 1969; Melville, 1970).

Preservation of ecosystems

Preservation of ecosystems is at a higher level than that of species, because it is concerned with diversity of biotopes and not only of species. Undisturbed relations in the ecosystem can be studied where man's impact is minimal (Fosberg, 1968).

Preservation of geological, geomorphological and historical monuments

These monuments have biological significance by creating a diversity of habitats, a great aesthetic and scientific value, and play an important rôle in education.

Some types of preserved areas are defined in accordance with their functions. For this study types are chosen as defined by IUCN (IUCN, 1971) and also accepted by United Nations in its "List of National Parks and equivalent reserves" (U.N., 1971; 1972), although more recently some other types and different categories have been suggested.

National parks

Relatively large areas where steps have been taken to prevent exploitation or occupation of the area; where natural elements are preserved and visitors are allowed to enter.

Natural parks

Nature areas aim at recreation where measures are taken to adopt recreation while protecting the natural basis.

Landscape parks

Large natural areas aiming at preservation of landscape where the objective is its aesthetic value which can be used for recreation and tourism as well.

Nature reserves

Areas given reserve status to conserve the nature of the area such as plant and wildlife, and geological and geomorphological forms.

Nature monuments

Nature objects, often of small size, of "monumental" beauty and outstanding value on which preservation is based.

2.1.3 *Criteria for determination and evaluation of nature reserves*

Evaluation is necessary to make it possible to indicate with certainty which areas should have priority over others in conservation (Helliwell, 1969). The most objective criterium for evaluation is the monetary value of a reserve measured by direct returns (hunting, fishing, wood, licences, admission fees, tourism, etc.) as well as by indirect returns such as genetic resources, education, science, etc. (Helliwell, 1969). All attempts to evaluate a nature reserve in monetary terms neglect the ethic, aesthetic and social aspects. Several studies made in the seventies to find ways to include these values in monetary values have not been successful. In this study they are not discussed.

Comparative evaluation only can at present express the relative importance of conserving a reserve also with regard to its unmeasurable aspects.

In planning and evaluating areas for reserves, several practical criteria should be taken into consideration. On the basis of personal experience 6 criteria are chosen from the literature. These criteria fit well in the situation in Israel. In the last decade several publications have been published concerning criteria and their application in conservation. These are more sophisticated and will certainly be valuable when worked out and checked. In this study the following basic papers are used: Helliwell (1969 b); Mörzer Bruyns & Westhoff (1963); Westhoff (1970); Helliwell (1971); Crowe (1972).

Criteria: Size : The reserve should be large enough to support the population and represent its richness.

Shape : The more circular the area, the better can it be protected from outside influences.

Bufferzones : Buffer zones around the reserve contribute to its value as a protective area. Along the borders there is interaction of external and internal influences, and the centre is largely preserved.

Diversity : The more diverse the area, the greater its value.

Human influences : The less an area is under human influence the greater is its value for conservation.

Management potential : The technical possibility to control external influences as well as internal processes makes the reserve more valuable.

2.1.4 *Establishment and management of nature reserves*

Establishment of nature reserves is possible after planning and coordination at national and international levels in order to have a suitable choice of areas for conservation. Regulations, taking into account ownership of, and laws protecting the area and its elements, form the legal basis for conservation.

Basic requirements essential for most reserves are:

Boundaries - these should be well defined and marked. Sometimes fencing is obligatory.

Access - roads and paths are meant to enable people to come to the area, but also to regulate their numbers: Access to areas of high natural value should be by less and less comfortable paths or none at all.

Facilities - parking areas, picnic areas, camping grounds, lodging and catering, if essential, should be located as far away as possible from the highly-protected natural-value areas, and should be built in harmony with the environment (Senge, 1972).

Strict reserves and buffer zones - where there is likelihood of human activities causing damage to the protected areas, strict reserves should be established to which access without special permission is forbidden. External impact on the reserve should be reduced by means of buffer zones (Hart, 1966). The reserve itself is preserved as the inner core of a protected area. Around the reserve a middle belt should be part of the buffer zone with possibilities for recreation, parking places, camping and grazing. Outside this middle belt an outer belt should be part of the buffer zone. This can be an agricultural area (Hart, 1966).

When a reserve has been established, a management policy needs to be maintained in many cases with a view to external impacts and internal processes that may demand intervention. Conservation aims at leaving nature to itself on the one hand, and maintaining maximum diversity on the other. The latter may at times justify intervention. Intervention is essential mainly when species are in danger of extinction, and more intensively so when there is greater human impact.

Non-intervention will be possible only in very large reserves where human impact is minimal, and this is regarded as the ideal policy. But the smaller a reserve the more intervention is required. The dilemma of non-intervention or intervention in the management of nature reserves has been an item discussed since the first nature reserves came into existence. This discussion goes on until the present time and will be continued into the future. Two IUCN Technical Meetings have given special attention to this: the Technical Meeting in The Hague, 1950, and the Technical Meeting in Edinburgh in 1956. The papers of Pluygers (1952) and of Nicholson (1957) are quoted especially in this respect.

The basis for nature management is the scientific knowledge of a reserve's inventory and processes (Shimwell, 1971). The carrying capacity of a reserve as regards wildlife and vegetation as well as grazing and visitors density in time and space should be studied with a view to establishing a maximum density level at which no damage to the reserve will ensue (Dasman, 1964).

Management regimes which may be or should be applied in nature reserves management master-plans are: grazing, burning, felling, replanting, hunting, supplying food and building refuges for animals, etc. These regimes were already recognized in the early phases of managing reserves on the basis of scientific knowledge (Bourliere, 1962; Van Leeuwen, 1966; Gabriels, 1957; Nicholson, 1957; Wildfowl Trust, 1957).

In many cases management means continuation of processes having taken place before declaration of the reserve, because cessation of these may cause undesirable processes, even if this involves hunting, burning or certain agricultural activities.

We shall try in this study tc get acquainted with the internal processes in the Yahudia Nature Reserve and with the external impacts on it, on which a management policy should be based.

Prior to this, we shall present a brief review of nature conservation and nature management in the Middle East and in Israel.

2.2 Nature conservation and nature management in Israel in the context of the surrounding countries

2.2.1 *Nature conservation in the Middle East*

Boyd (1965) states that lack of understanding of the true nature problems, of conservation and of the links between tourism and development to nature, have brought about an untolerable nature management in Jordan. This is the situation in most countries of the Middle East (Ghabbour, 1971; Kaul, Thalen, 1971). In Iran, during the 60's of this century, 3 wildlife parks and 18 protected areas were established (Firouz et al., 1970). However, in the U.N. list of national parks and equivalent reserves (United Nations, 1971) no national parks of equivalent reserves are mentioned in Cyprus, Egypt, Iraq, Jordan, Lebanon and Syria.

In these circumstances, the nature conservation situation in Israel is an exception.

2.2.2 *Nature conservation and management in Israel*

Israel's location at the meeting point of extreme climatic regions, ranging from cool, continental to mediterranean and arid desert climates, and at the junction of variegated geographical regions, has resulted in a meeting of zoographical and phytogeographical regions that produce an immense wealth of species (Ross and Macdonald, 1971).

The lines which follow are based on the book by Dr. Uzi Paz "Nature Reserves in Israel", which constitutes a comprehensive survey of the history of nature conservation and nature reserves in Israel (Paz, 1981). Paz points out that there are some 2600 flowering species growing in Israel, some 130 of which are endemic, and about 650 species of vertebrates are living there, excluding Mediterranean and Red Sea fish. This wealth used to be even richer but has suffered a decline in the course of Israel's checkered history. The main wave of annihilation of plant- and wildlife extended from the second half of the

19th century to the beginning of the twentieth century - a period in which the country became more densely settled and firearms were introduced into the region. During this period the following animal species were exterminated inter alia: the ostrich, the brown bear, roe deer and the crocodile, together with tens of thousands of hectares of oak forest.

Under the British Mandate, a hunting law (1924) and a forest order (1926) were enacted, and 40 forest reserves were declared. While the rate of tree felling in forests decreased as a result of this, the hunting law was not being enforced, and diminution of wildlife continued.

Jewish settlement in Israel, and the establishment of the State of Israel in 1948, brought about a huge momentum in development, construction, preparation of agricultural areas, and use of poisons, and heightened the pressure on Israel's inorganic plant and wildlife. More species were exterminated or faced with danger of extinction during this period.

In the early fifties, circles in Israel were becoming concerned and started to agitate for a setting-aside of conservation areas. This concern arose in the wake of the draining of Lake Huleh which put in jeopardy a whole world of wildlife and plantlife. As a result, it was decided to leave 400 ha of the Huleh swamps undrained, and to set them aside for conservation purposes. Furthermore, the agitation resulted in the enactment of the Wildlife Protection Law (1955), the setting up of the Nature Protection Society (1953), and of the Nature Conservation Branch at the Ministry of Agriculture (1958) which gave birth to the establishment of the Nature Reserves Authority (1963) - a State Authority excercising legal powers.

The activities of the Nature Reserves Authority extend over a number of spheres, such as proclamation, development and management of nature reserves, enforcement of nature preservation laws, liaison with public institutions over policies by which preservation of natural assets and landscapes within and outside nature reserves can be carried through, and also education towards nature preservation, and information work.

Up to 1980, 97 nature reserves were proclaimed in Israel, and an additional 50 are in various stages of preparation, the inclusive size of area covered being about 37,000 ha.

Israel's nature reserves can be divided into three main categories:

1. Nature and landscape reserves, preserving undamaged landscapes with the aim of conserving habitat, fauna and flora variety. Such are the Yahudia and Mt Meron Reserves, the latter covering an area of about 10,000 ha of

variegated mediterranean forest.

2. Scientific reserves, whose central aim is the preservation and presentation of natural phenomena of scientific value, such as temporary ponds, which are habitats that are on the wane, and also the dunes of the western Negev.
3. Representational reserves for certain phenomena such as a plant or animal species - for instance the Doum Palm (*Hyphaene thebaica*) Reserve, the northernmost point of this species' global distribution, or the Shoreq Reserve, a stalactite and stalagmite reserve which is of particular scientific and aesthetic value.

Reserve planning and management is carried out at three levels:

1. Fully developed reserves which the public are invited to visit, and in which various facilities have been laid on for the visiting public. Such are: the Tel-Dan Reserve containing some of the sources of the River Jordan, and the Coral-Reef Reserve in the northern part of the Gulf of Eilat.
2. Open reserves with wild scenery and little development, where hiking is mainly on foot, such as the Yahudia Reserve or the Canyons Reserve in the Judean Desert.
3. Strict reserves containing sensitive natural assets and to parts of which the public are given no access, such as stretches of the Huleh Swamps Reserve, or parts of the Ein-Gedi Reserve in the Judean Desert.

The existing system of legislation in Israel gives legal status not only to the Nature Reserves but also to protected inanimate wildlife and plantlife assets also out of nature reserves. These, of course, also include endangered species for whose rescue active steps are being taken. An example is the establishment of a breeding nucleus of the Lappet-faced vulture in cooperation with Tel Aviv University; incubation of sea turtle eggs and setting the turtles free at a more advanced age; fertilisation of Iris species, and transplantation of Narcissus bulbs from places earmarked for construction. Israel's "Red Data Book" of rare species facing extinction or already extinct (Agami, 1975) includes 81 plant species, 12 of which appear to have become extinct during the last few decades, and most of which are connected with water sceneries that have disappeared with the draining of swamps and catching of springs at the end of last century and during the first half of the present century. The book also lists 96 species of vertebrates, 20 of which appear to have become extinct in this century.

Steps have been taken to prevent indirect harm being caused to protected animals through poisoning, but as far as this subject is concerned we have been only partly successful owing to intensive agriculture on the one hand, and the delay in development of biological or technical means of pest control on the other.

Nonetheless, several of the measures taken have proved successful; for instance

(1) shooting of stray dogs, which are potential rabies carriers, instead of poisoning them, which latter method causes non-selective poisoning of predators;

(2) putting up electric fencing to prevent gazelles invading agricultural areas;

(3) controlled hunting of non-protected animal species, particularly in regions where damage to agriculture is envisaged, thus limiting poisoning.

The picture drawn of the state of nature conservation in Israel, showing impressive achievements on the one hand, but a worrying situation of species and landscape destruction in the wake of development on the other, necessitates not only passive conservation and active management but also intensified research and deepening of knowledge.

This paper aims to be a contribution towards this objective.

3 INTRODUCTION TO THE YAHUDIA FOREST NATURE RESERVE

3.1 Location and geographical data

The Yahudia Forest Nature Reserve is a proclaimed reserve (under Regulation No. 286 of 28.12.72 (Nature Reserves Authority 1980), and covers an area of 6620 ha. The reserve extends over the eastern basin of the River Jordan in the Golan region, north-east of Lake Tiberias between latitude 32°53'-32°59' north (641-654 U T M) and longitude 35°38'-35°47' (748-760 U T M) (see Map 3.1). The lowest regions of the reserve lie at an altitude of -192 m below Mediterranean Sea level, and the highest at an altitude of +720 m, though the greater part lies at altitudes 0-300 m above Mediterranean Sea level (Land Survey Department, 1979; see Map 3.2).

The greater part of the area is on a more or less level plane and moderately inclined towards the south-west. This area is cleft by a number of streams, mostly perennial, which form a varying landscape of streams which, flowing in shallow beds in their upper courses, turn into canyons in mid-course, and into broad, though steep-banked streams in the lower courses.

The streams divide the reserve area into three drainage basins:

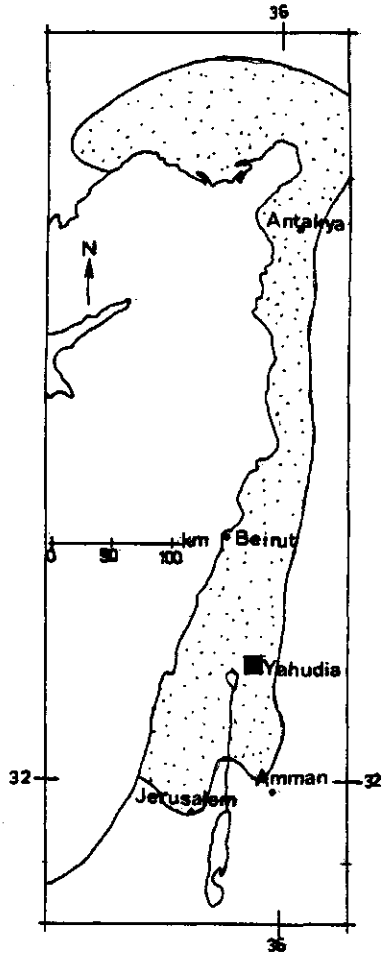
Northern basin	:	the Meshoshim stream drains 33 sq km of reserve land, and a total of 161 sq km.
Central basin	:	the Yahudia stream drains 12 sq km of reserve land, and a total of 78 sq km.
Southern basin	:	the Daliot stream drains 21 sq km of reserve land, and a total of 114 sq km.

Contributaries of the Meshoshim stream within the reserve area are the Aslyiah and Zavitan streams. The contributary of the Yahudia stream is the Tayba stream, and the contributaries of the Daliot stream are the Batra, Gamla, Northern Daliot and Southern Daliot streams.

Flow of springs and streams

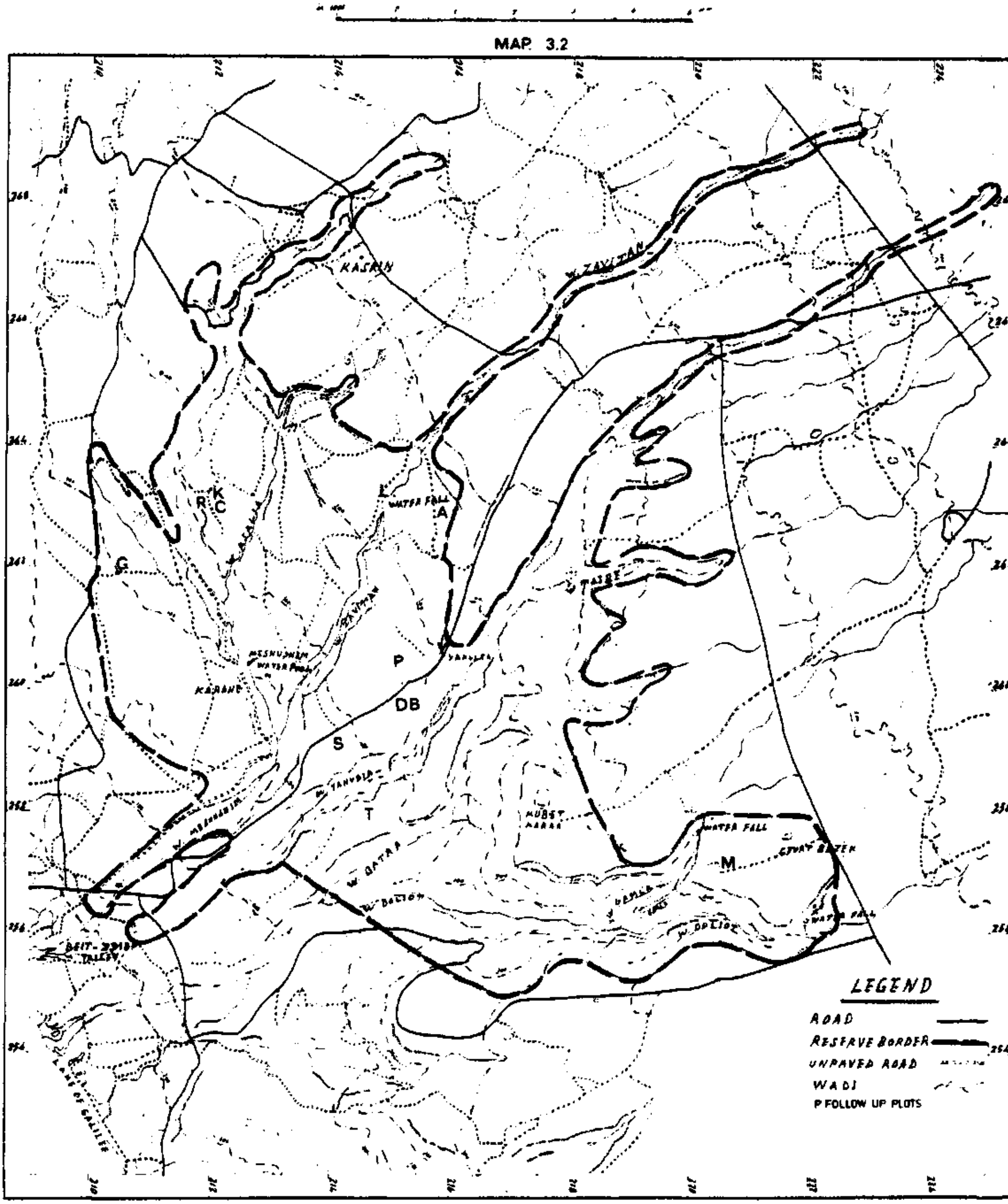
According to Inbar (1970), Laor et al. (1977) and the Hydrological Service (1973), the basins of the streams and springs can be divided physiographically as follows (we have adapted the original division of Inbar (1970) to fit the areas represented within the confines of the reserve):

Map 3.1: Location of Yahudia Nature Reserve in the region. Black square is enlarged in Map 3.2. Dotted area represents *Quercus ithaburensis* distribution area according to Awishai (1967), (see 5.1.2).



YAHUDIA NATURE RESERVE

MAP 3.2



a. Masil area. Here we have stream beds which are shallow in their upper courses. This region has a low drainage potential but a high infiltration-into-depth potential, and does not generally drain water during the whole of the year. The springs have a relatively low drainage potential and usually form swamps. For instance: the Sheikh H'ssein Spring (Coord. 21582632) has an average drainage potential of 22 m^3 per hour, and its waters flow into the Zavitan stream.
b. The dense drainage region. Here, the stream beds are deeper and morecrowded, and the region contains few springs with seasonal flow only.
c. The canyon region. In this area the streams excavate the rocks, forming cliffs, waterfalls and ponds. Here are to be found most of the springs whose flow potential exceeds 36 m^3 per hour. In this region we have many springs welling forth from among the basalt layers bisected by the stream and whose base is baked fossil soil (see below). Most of these springs cannot be indentified, but they contribute to the flow increase of streams here. For example: Ein Nadhut (Coord. 21502684), possessing a constant average flow of 90 m^3 per hour and Ein Snaber (Coord. 21302678) with an average flow of 134 m^3 per hour; both supplying most of the waters of the Meshoshim stream.
d. The broad bed region. Here the stream widens, its bed is alluvial, its slopes are steep, and it contains a few springs, in particular between the basalt flows. For example: Ein Dardera (Coord. 21152578) which has a constant average flow potential of 3 m^3 per hour.

In the drainage basin of the Meshoshim stream, Inbar (1970) discovered 39 springs, of which 9 are in the Yahudia Reserve, and 7 of these have constant flow. We found 2 additional springs, of which one has constant flow.

In the drainage basin of the Yahudia stream we discovered 4 springs within the reserve, 3 of which with constant flow. The principal water sources of this stream are outside the reserve.

In the drainage basin of the Daliot stream we found 14 springs in the reserve area - 9 with constant flow - and these in addition to the many springs in the stream bed and along the rocky stream banks that cannot be easily spotted.

Total minimum flow of springs in the principal streams:

In the Meshoshim stream: 310 m^3/hour, of which 60 m^3/hour are being utilized, leaving 250 m^3/hour.

In the Yahudia stream : 206 m^3/hour, of which 90 m^3/hour are being utilized, leaving 116 m^3/hour.

In the Daliot stream : 260 m^3/hour, of which 150 m^3/hour are being utilized, leaving 110 m^3/hour.

Utilization is for agriculture as well as for drinking water.

3.2 Rock and Soil

3.2.1 *Geological History (according to Michaelson 1972, 1974)*

Tectonic activity in the neogene period caused the sea covering this region to retreat eastwards, and brought about continental conditions. Tectonic uplift of the region resulted in heavy erosion of the land, and in erosion matter being deposited in broad streams and sweet-water lakes in the form of conglomerates, pebbles, dunes, chalk and marl, which make up the Herod Formation (H), which subsided in the Middle and Upper Miocene epoch (see Figure 3.1).

The episodic penetration of the sea in the Pliocene epoch was the last of its kind in the region. In its wake, a Gesher formation (Ge), composed of oolitic limestone and marl, subsided in sweet-water basis.

In the Upper Pliocene epoch there were also volcanic eruptions which continued until the beginning of the Pleistocene. This basalt, called cover basalt, lies on the underlying sedimental layers in an unconformity plane. The depth of the basalt layer in the region under review is 140-175 m, and the basalt originates from the volcanos to the north-east, and from local volcanos such as Kubat Kar'a (see Fig. 3.1), as also from local fissures that were formed and that left basalt dykes which are dispersed in the area.

The basalt which erupted is of the olivine basalt type, which is hard, massive or vesicular. This basalt erupted in a number of lava flows (10 such flows can be discerned in the Daliot stream). Between these flows, clay soil formed to a depth of up to 2 m and was baked into fossil soil by the lava flow. The ground layer of each flow is usually dense and massive, and in it a 4-7 facets column structure developed. The upper layer is more vesicular and brittle.

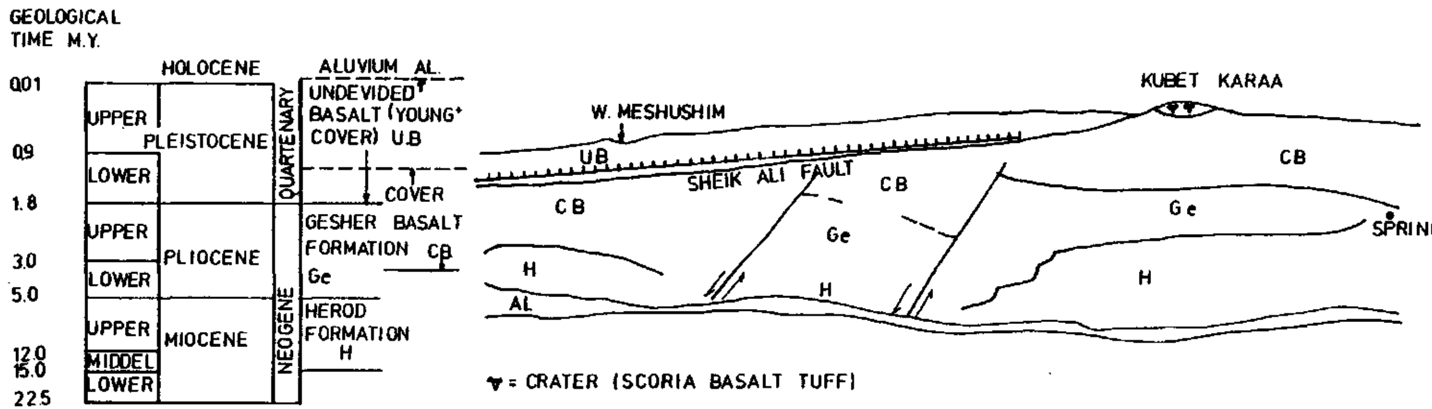


Figure 3.1: Panorama of geological formations of the northern slopes of the Daliot stream and of the Yahudia Forest (view from Coord. 21702557 to the north), and schema of geological bedding in accordance with its periods (according to Michaelson, 1972).

The columns phenomenon, which is of singular beauty, stands out in a number of sites in the reserve area, where it is most conspicuous in the Meshoshim Pool (Coord. 21252605) and in the Zavitan stream (Coord. 21532635). During the slow cooling process the lave was riven into facted column formations. This structure was formed in the lower layers of the flow, which are slower to cool by heat conduction only and not by radiation. When the lava reached a temperature of 800-600 ^{o}C, jointing occurred in the direction of the temperature gradient which was chiefly perpendicular.

The paleomagnetism phenomenon occurs frequently in the cover basalt. The presence of ferrous minerals, such as Magnetite and Ilmenite, which formed when the magnetic pole of the globe was alternating between north and south, and which retained their magnetic properties, yet causes the compass to deviate from the north near some of the rocky cover-basalt layers. In the same epoch, the Lower Pleistocene, strong fissure activities took place, creating the deep valley of the River Jordan. The low erosive basis formed caused excavation of the cover basalt in its direction, and led to the formation of the deep river canyons dissecting the Yahudia Reserve.

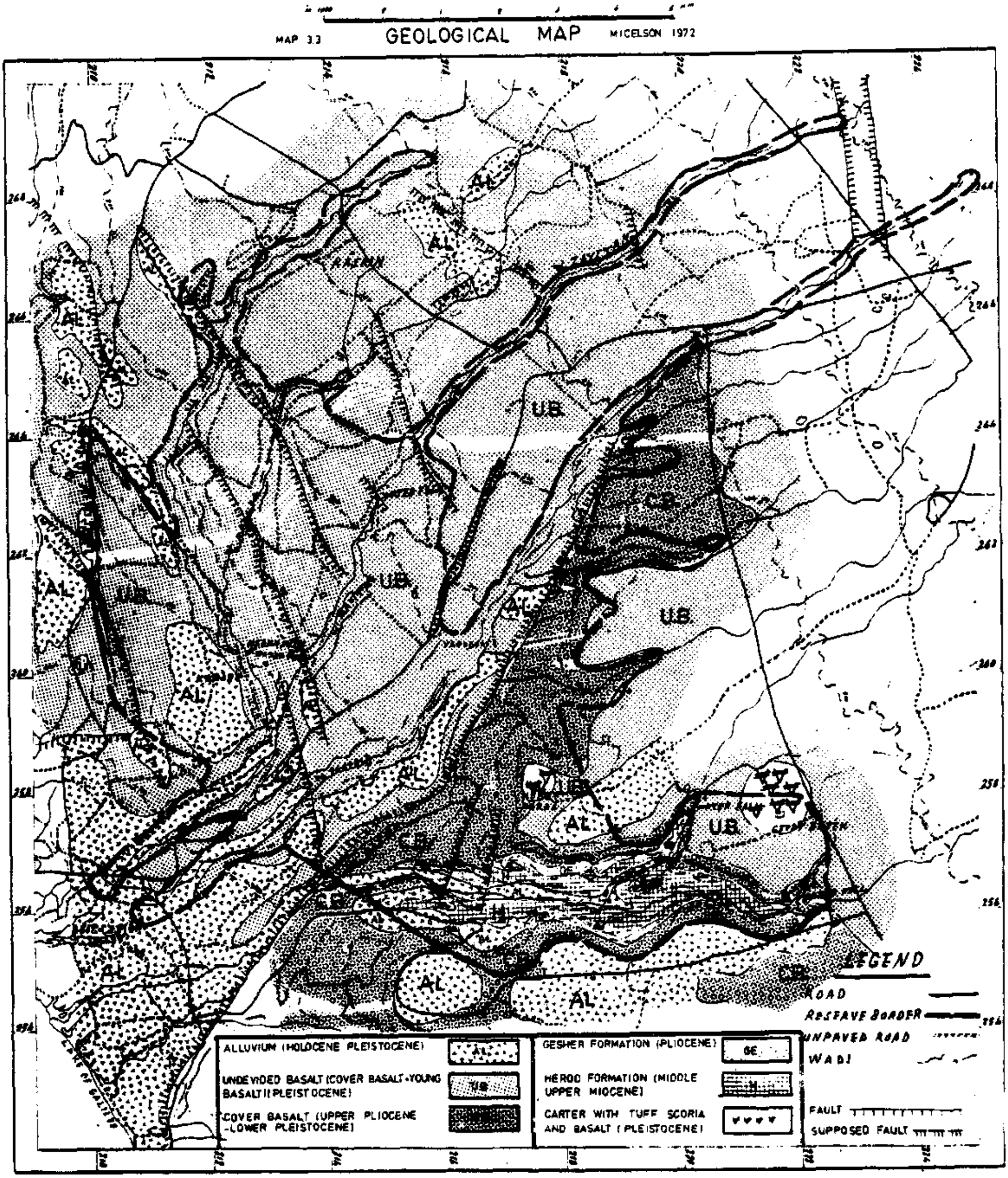
Additional volcanic eruptions in the Middle and Upper Pleistocene, and perhaps also at the beginning of the Holocene epoch, brought about an effluence of young lavas not possessing paleomagnetic properties. The northern part of the Yahudia Reserve (see Map 3.3) is covered in its greater part by cover basalt, although it perhaps also contains a residue of young lava basalt, which Michaelson calls 'undivided basalt' (U.B.). Between the cover basalt (C.B.) and the undivided basalt (U.B.) is the Sheikh Ali Fault - the only fault whose dislocation exceeds 100 m.

Mor (1973) divides the basalts of the Golan into two main formations:

1. Cover basalt, which includes Low basalt (B.A.), and overlying it Dallawe basalt (B.D.).
2. Golan formation, which is younger and composed of Ein Zivan basalt (BE) and Muessa basalt (BM). In accordance with this division it seems that in the Yahudia Reserve, inclusive of its northern part, the cover basalt formation is dominant.

YAHUDIA NATURE RESERVE

MAP 3.3 GEOLOGICAL MAP MICELSON 1972



Perusale of Map 3.3 shows that the greater part of the reserve is covered by basalt, and only in a few areas on the banks of the Daliot streams there are exposures of layers of Herod (H) and Gesher (Ge) formations.

3.2.2 *Soil*

In the soil association map of Israel (Dan et al., 1975), the soil of the Yahudia Nature Reserve is described as belonging to the "basaltic protogrumusols, basaltic brown grumusols and pale rendzinas association". Steep slopes and eroded plateaus are dominated by protogrumusols which are shallow, fine-textured basaltic soils, non-calcareous, stony, with many outcropping rocks. More gentle slopes and non-eroded plateaus are dominated by brown grumusols, which are heavy-texture soils. The clay fractions consist of expanding clay minerals, mainly montmorillonite, which causes the soil to fissure badly during the alternating wet and dry seasons, and to show considerable churning action.

Three structural horizons may be observed: an upper granular horizon, a prismatic horizon, and a deeper and pyramidic horizon. These soils are rich in phosphorus and poor in calcium (Dan, 1972; Dan & Singer, 1973). Basaltic protogrumusols in the Yahudia Forest occupy the slopy stream banks and the streams themselves, geological fault lines, and basaltic flow fronts, while in the remainder of the mostly level are, basaltic brown grumusols are dominant (Dan, 1972).

3.3 Climate

3.3.1 *Precipitation (Gat & Paster, 1974)*

The rainy season in the Golan region extends from September to May, with about 2/3 of the rains occurring in December-February. In December, we have 16-25% of the precipitation; in January, which is the rainiest month, 22-31%, and in February 16-25% of annual precipitation. At the beginning and end of season precipitation is lower: in October 1-3%, in November 8-18%, in March 12-16%, in April 4-6% and in May 1-2% of annual precipitation.

Distribution of rainy days during the months of the year matches the distribution of rains. The number of days on which more than 1 mm rain occurs in the Yahudia area amount to 33-40 days, 25% of which occur in January.

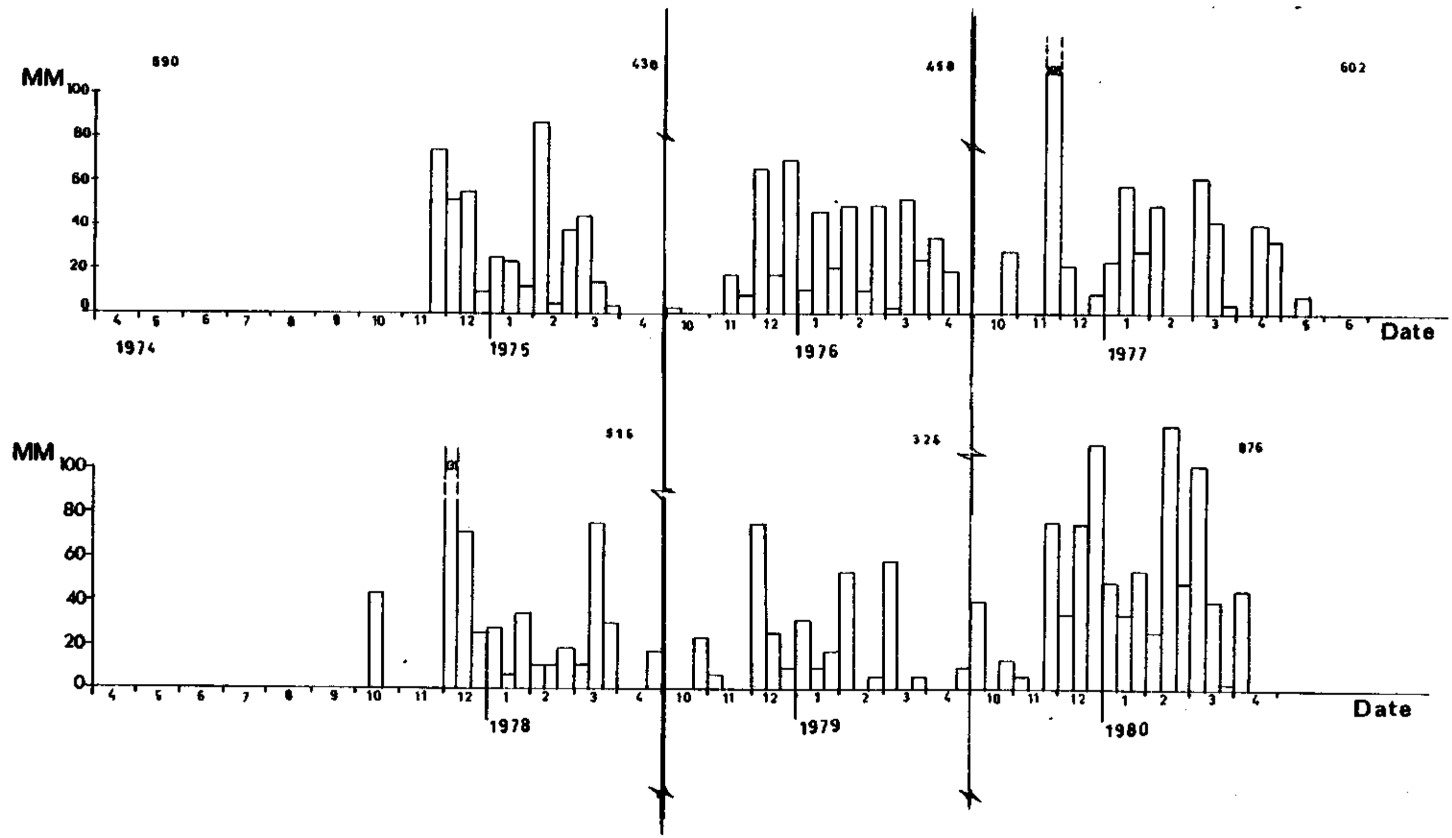


Figure 3.2: Distribution of precipitation in Yahudia in 10-days units, and annual precipitation in mm, in het years 1973/74 - 1979/80.

On the Golan we have a good correlation between quantity of precipitation and altitude. The multi-annual quantity of precipitation in Yahudia is 500 mm, varying from 550 mm to 450 mm between higher and lower regions respectively.

Measurements carried out by us in Yahudia in 1973/74 - 1979/80 (see Figure 3.2) showed that there was an annual mean of 544 mm rain, and that December and February were generally the peak months of precipitation quantity.

3.3.2 *Temperature (Gat & Paster, 1975)*

Lowering of temperature on the Golan Heights is commensurate with rise in altitude and moving to the east. In a survey carried out by Gat and Paster in 1975, a control point was fixed in the Yahudia Reserve at +140 m altitude. If we take this point as being representative, we learn that:

the mean daily maximum temperature of the year was 26.7 °C
" " " minimum " " " " " 16.7 °C
" " " " " " " " 21.7 °C
" " " temperature in January (the coldest month) was 12.4 °C
" " " " " August (the hottest month) was 28.2 °C and
" " " fluctuation per year was 14.4 °C.

From the Isotherms map of the aforementioned survey it can be learned that in Yahudia:

Daily mean temperature in the hottest month, August, is about 27 °C
" maximum " " " " " " " " 36 °C
" minimum " " " " " " " " 21 °C
" mean " " " coldest " January " " 10 °C
" maximum " " " " " " " " 17 °C
" minimum " " " " " " " " 9 °C and
the annual mean temperature is about 19 °C.

The process of temperature change is such that there is a gradual rise from January to August, and a gradual fall from August to January with no intermediate peaks.

Frosts are not envisaged in the Yahudia region.

3.3.3 *Relative humidity (Gat & Paster, 1975)*

The continental character of the Golan Heights, due to their distance from the sea, gives them a relatively low humidity compared with Western Israel. However, the large quantity of precipitation causes a relatively higher humidity than would be expected in this continental region. The anuual move of relative humidity points to a principal maximum in winter (January) and to a principal minimum at the beginning of summer (June), to a secondary maximum in summer (August-September) and to a secondary minimum in autumn (October).

From an extrapolation of Gat & Paster's survey data of 1975, it can be learned that the relative humidity values in Yahudia at 14.00 hrs, in terms of monthly means, are:

principal maximum 64% ; principal minimum 34%
secondary maximum 42% ; secondary minimum 39%

Khamsin conditions prevail mostly in the transitional seasons (spring and autumn). Light Khamsins occur some 42 times a year. A light Khamsin is described as being an occurrence during which relative humidity in a single observation falls to 15%, or during which the mean of 3 observations is not higher than 45%.

Heavy Khamsin conditions develop some 10 times a year. A heavy Khamsin is described as being an occurrence during which the mean daily temperature is higher than the multi-annual mean, and the mean relative humidity lower than 25%.

3.3.4 *Winds (Gat & Lomas, 1969)*

In the central region of the Golan Heights westerly winds are prevailing in summer, and easterly winds in winter. The easterly, or north-easterly "sharkiya" winds in winter are stronger than the westerly summer winds.

In winter, the characteristic is an ununiform wind pattern which is contingent on barometrical high and low pressures, and winds are blowing mostly during the morning hours. In summer, the wind pattern is stable. Westerly winds are registered daily from the late morning hours until the late afternoon hours. Wind strength in stormy conditions may reach up to 62 kmh, and in "sharkiya" wind conditions (easterly winds) up to 50 kmh. In summer, the most prevailing wind strength is between 12 kmh and 28 kmh, and in winter between 20 kmh and 28 kmh.

3.3.5 *Clowdiness (Gat and Lomas, 1969)*

Clowdiness is generally low in the central part of the Golan. The clowdiest months are January and February, and after these, December, March and April. June and July are less clowdy. The extent of mean daily clowdiness in January and February is a usually more than half-clowded sky; in December, March and April a 1/2 - 1/3 clowded sky; during June-September a less than 1/8 clowded sky, and in May-October a 1/8 - 1/4 clowded sky.

In spring and summer, the heaviest clowdiness was recorded in the morning, but in winter, at noon. In the evening and during the first hours of night clowdiness is minimal throughout the year.

3.4 Human history

On the basis mainly of the archaeological survey made of the Golan (Epstein & Gutman, 1972) and of the historical review by Gal (1978), the following picture emerges with regard to the human history of the Golan in general and of the Yahudia region in particular.

Only a few and non-continuous remains have been discovered from the prehistoric era, and even those mainly on the western fringes of the Golan. In the Calcolithic age (4000-3150 BC) there was widespread settlement by shepherds who also engaged in tilling of the soil. Sites discovered near springs and streamlets are characterised by elongated structures of basalt stone, storage vessels, flint tools and idols. Near them were found remains of irrigation agriculture based on the springs (Epstein, C. - personal information). Two such sites were found, and excavated, at the eastern border of the Yahudia Reserve. From this period there were also discovered in the Yahudia Forest cairns (tumuli) which most probably served as burial sites. In the Bronze age (from 3150 BC) and mainly in the Middle Bronze age I (2200-2000 BC), megalithic construction was developed on the Golan, comprising many Dolmen fields and fortified enclosures of areas situated at the confluence of two streams.

The Dolmens on the Golan have been surveyed and described already by Schumacher (1888). The survey was widened, and research increased, by Epstein (Epstein, 1974; Epstein & Gutman, 1972), who found that the Dolmens appear in large concentrations, each being characterised by a certain type of construction. Three main construction types have been discovered, and all of them are represented in the Yahudia Reserve: Trilitones - which are small Dolmens of two vertical stones and one horizontal stone laid across them. Such Dolmens are to be found in the higher regions of the Yahudia Forest (for example M, see Map 3.2). A second type are bigger Dolmens built of a greater number of vertical stones and large horizontal stone slabs. These structures are often sunk, and they are frequently surrounded by large tumuli. A number of these Dolmens have a narrow side entrance leading to an underground chamber. They are very widespread throughout the Yahudia Forest (for instance site Y, D, K, R and others - see Map 3.2). A third type of Dolmens, which are very rare and the like of which has so far not been found anywhere else, except in the area between the Yahudia and Daliot streams (T - see Map 3.2), are the "Tank Dolmens". These are giant Dolmens built of many courses of large stone slabs and rising to a height of about 3 m.

The Dolmens served as secondary burial sites for wandering tribes which had penetrated from the east. These massive sites served as evidence of their having taken possession of the area. Bones, cult objects, pottery and metal tools were found in the Dolmens. The fortified enclosures of that period served as holy places, or else as cattle corrals. Such a site is the "Yitzhaki enclosure" (Coord. 21982654) in the Yahudia Nature Reserve.

The Middle Bronze I civilisation suddenly disappeared from the Golan, and settlement there was disrupted for a period of about 2000 years, from the end of the third millenium BC until the Hellenistic period.

In the First Century BC, settlement on the Golan began on a large scale, and with it many Jewish agricultural settlements sprang up.

During the Roman-Byzantine periods (1st to 7th century C.E.) there were many Jewish settlements on the Golan. Among these, Gamla - situated within the Yahudia Nature Reserve - has become particularly famous for its courageous stand in the uprising against the Romans, which ended with its fall in the year 67 C.E. Today, Gamla is undergoing scientific archeaological excavation and is being visited by many hikers. Among other relics, there can be seen the city walls, the synagogue, the ritual bath, and dwellings (Gutman, 1977). The remains of the many synagogues are witness of the dense Jewish settlement in the Roman-Byzantine period. Remains of settlements and synagogues in the Yahudia Reserve were found at the following places and coordinates:
Yahudia (2161 2603), Asalyia (2135 2636), Zamamira (21392613), Batra (21382567), Ein Nashut (2149 2686), Taybeh (21782614), Hurvat Zavitan (21832645), and

Daliot (22012560) (Maoz, 1979; Safrai, 1978) (see Map 3.2).

In the Byzantine period (324-640 CE), Jewish settlement is declining and Christian settlement appears on the scene, with Churches such as at Dir-Karukh (M, see Map 3.2) in the Yahudia Reserve.

With the Arab conquest in 636, the number of permanent settlers diminished on the Golan, which turned into a region of Nomadic tribes, remaining sparsely settled until the 19th century. In the thirties of the 19th century, the Egyption Government started settling the Bedouin in permanent settlements. The Ottoman Government, in the second half of the 19th century, settled immigrants from North Africa, Kurds and Circassions. The Circassians settled in the central Golan, and their destructive impact on the forest will be touched upon later (6.3.2).

At the end of the 19th century, experiments were also made to effect Jewish settlement on the Golan, and these continued until the French regime took over in 1918. During the French regime the momentum of Bedouin settlement continued, and many villages were added until the year 1946, when Syria achieved independence. No significant changes concerning population and land use occurred during the Syrian regime. In 1967, in the wake of the Six Day War, the rule over the Golan passed from Syria to Israel. Most of the former inhabitants left the area, and new settlements were established, some of which on the border of the Yahudia Reserve, such as the town of Katzrin to the north-east, the village of Ani'am in the east, and the settlement of Ma'aleh Gamla in the south.

4 INVENTORY OF FAUNA IN THE YAHUDIA NATURE RESERVE

Introduction

In each ecosystem the fauna plays an important rôle. From the management point of view especially the herbivores should be studied, being the consumers of primary production.

The Yahudia Forest Reserve cattle are by far the most important herbivores, but all other herbivores and also other animals have to be taken into account because of the foodweb relations existing in the ecosystem.

In the following chapters full attention is given to the cattle, especially concerning their functions for *Quercus ithaburensis*.

In this chapter all available data are given concerning the wild fauna in the reserve. Many of these data are of great interest for effective and wise management of the reserve to be informed about the fauna existing in the area, especially about the vertebrate fauna.

This chapter deals with the vertebrates in general, with special paragraph on rodents and birds.

4.1 Methods and results

4.1.1 *General inventory list*

The general inventory list is concerned only with subphylum *Vertebrata*. In the absence of adequate information it has not been possible to consider other animals.

4.1.1.1 Collection of data was effected by noting down observations made during 1973-1980. Most of these were chance sightings, with the exception of systematic observations of the birds classis *Aves* (see 4.1.3) and the rodents of the sub-order *Myomorpha* (see 4.1.2). Several observations were collected from other sources, of which mention has been made in the inventory table appended. A number of widely distributed species found in the vicinity of, but not in the nature reserve, were assumed also to occur in the reserve itself. These appear in the table with the annotation "Golan". The inventory is drawn up in systematic order, and the remarks as to behaviour, nutriment, and distribution within the reserve are based entirely on our observations. For purposes of systematization and comprehension of observations, we have taken to aid other sources (Ilani, 1979; Dor, 1965; Makin, 1977; Baharav, 1975). The inventory of the fish classis Osteichthyes was prepared on the basis of observations of Dr. Menahem Goren (Tel Aviv University - personal information) for which due gratitude was expressed to to him.

4.1.1.2 Population estimate is only approximate, or in order to magnitude. Estimates are based on accumulation of observations in a given area unit of habitat, multiplied by the number of area units of the reserve habitat concerned. This method has been applied only to animals regarding which we were able to collect sufficient data. There is no numerical estimate on the others.

4.1.1.3 Inventory Table. See Table No. 4.1. List of classis *Aves* appears in Table No. 4.4 under 4.1.3.5.

4.1.2 *Survey of rodents of sub-order Myomorpha* *)

4.1.2.1 Object: Inventory of rodents of sub-order *Myomorpha* and their inter-relations with *Quercus ithaburensis*.

4.1.2.2 Work Methods

1. Trapping: this was done with 22x10x10 cm perforated rodent box-traps, baited with bread smeared with peanut butter. Traps were set immediately after sunset, and collected before sunrise on the following morning.
2. Sampling methods:

   a. Qualitative survey: The purpose of the study was to learn about the rodent species present in the Yahudia Forest. To this end, varying numbers of traps were set at the fringes and centre of the forest. Rodents trapped were identified and subsequently released. Various observations of rodents, and of traces of their activities, were also noted down.

---

*) This survey was carried out in cooperation with Yaron Taylor for a graduation exercise at Kfar Blum Secondary School.

Table 4.1: Inventory list of subphylum Vertebrata in Yahudia Nature Reserve.

Species	Population Estimate	Social Organization	Occupied Biotopes	Additional Sightings - Remarks
classis: Osteichthyes				
order : Cypriniformes				M. Goren, 1980 - personal information
Caposeta damascina			Perennial streams	
Garra rufa			Perennial streams	
Pseudophoxinus zeregi			Runnels, Ponds	
Nosmacheilus angorae			Perennial streams	
Nosmacheilus panthera			Runnels, Ponds	
classis: Amphibia				
order: Anura				
Bufo viridis			Winter Puddles in forest and batha,* streams	
Hyla arborea			Winter Puddles in forest and batha, streams	
Rana ridibunda			Streams	
classis: Reptilia				
order: Testudinata				
Clemmis caspica			Streams	
Testudo graeca			Forest, batha	
order: Lacertilia				
Agama stellio			Forest, batha, streams	
Chamaeleo chamaeleon			Forest, streams	
Ptyodactylus hasselquistii			Rocks, cliffs	
Eumeces schneideri				Golan, Tel Aviv Univ. Coll.
Mabuya vittata			Forest, batha, streams	
Chalcides ocellatus				Golan
Chalcides guentheri				Golan, Tel Aviv Univ. Coll.
Lacerta laevis				Golan, Tel Aviv Univ. Coll.
Lacerta trilineata			Streams	
Ophisops elegans				Golan, Tel Aviv Univ. Coll
order: Ophidia				
Typhlops vermicularis				Golan, Tel Aviv Univ. Coll.
Natrix tessellata			Stagnant waterpools	
Coluber jugularis			Forest, batha	
Coluber najadum				Golan, Tel Aviv Univ. Coll.
Coluber ravergieri			Forest, batha	
Eirenis decemlineata			Batha	

Table 4.1: continued.

Eirenis rothi				Golan, Tel Aviv Univ. Coll.
Malpolon monspessulanus			Forest, batha	
Telescopus fallax			Batha	
Psammophis schokari			Forest, batha	
Micrelaps muelleri			Batha	
Vipera palaestinae			Forest, batha, streams	
<u>classis: Aves</u>				See § 4.1.3.5
<u>classis: Mammalia</u>				
<u>order: Insectivora</u>				
Crocidura russula				Golan, Tel Aviv Univ. Coll.
<u>order: Chiroptera</u>				
Michrochiroptera	10^2	Colonies numbering dozens of specimens	Caves in wadis and canyons	Hundreds of specimens were sighted during the months of March-September in places that are empty in the winter period, no doubt because of winter migration to other regions (Makin, 1977a, b). One single specimen was identified as Pipistrellus kuhli.
<u>order: Lagomorphia</u>				
Lepus europaeus	10^2		Batha plains	
<u>order: Rodentia</u>				
Microtus guentheri	10^5		Forest, batha	3 dead specimens were found. Remainder of data have been concluded from observation of burrow holes. Animals do not enter traps
Gerbillus dasyurus	10^2		Forest	
Meriones tristrami	10^2		Batha	
Apodemus mystacinus	10^4		Forest	Food: Acorns
Apodemus sylvaticus	10^3		Forest, batha	Food: Acorns
Rattus rattus			Forest	Only one specimen was trapped.
Acomys cahirinus	10^5		Forest, batha	Food: Acorns
Spalax ehrenbergi	10^4		Forest, batha	Few direct observations; mainly assumptions based on small ventilation mounds. The birth mounds, which are bigger, are sometimes violated by Wild Board.
Hystrix indica	10^2		Forest, batha, wadis	Food: Acorns, roots, tubers and bulbs. Nocturnal activities
<u>order: Carnivora</u>				
Canis aureus	60-120	Groups of 1-10 specimens	Forest, batha, meadows, wadis	Food: various animal carcasses; devouring of calves during birth. Two specimens were observed devouring a Procavia capensis. Excrement was found to contain remnants of vegetable matter, grasses and fruit of Zizyphus sp. Nocturnal, or diurnal activity at dawn and dusk. Diurnal activity more pronounced at cattle calving season. Puppies observed in June.

Table 4.1: continued.

Canis lupus	2-5	Solitary		Sparse data. Single direct observation (Boldo, A., 1979 - personal information). Two doubtful sightings. Sheep, bearing characteristic signs of having been killed by wolves, were found on fringe of reserve.
Vulpes vulpes	30-60	In general solitary sometimes groups of 2-3	Forest, batha, meadows, wadis	Food: carcasses of fowl and mammals. Activities chiefly nocturnal
Martes foina			Forest	Single observation (Boldo, A., 1980 - personal information)
Vormela peregusna				(Ilany, 1979).
Mellivora capensis	2-10			(Ilany, 1979) (Aderet, J., 1973 - personal information.
Meles meles	10-25			Main observations were specimens run over by vehicles on roads within and around the reserve.
Lutra lutra	2-10		Perennial streams	Food: Crabs, fish. Excretion on stones protruding from the water.
Herpestes ichneumon	80-120	Family groups of 2-5 specimens	Forest, wadis	
Hyaena hyaena	2-4			Few observations. Three direct observations; two indirect observations (faeces and tracks).
Felis lybica	50-100	Solitary	Forest, batha	
Felis chaus	5-20	Solitary	Wetland habitats and springs excepting deep streams	
Panthera pardus	1-2			Indirect observation 7 km south of reserve (faeces - Ilany, G., 1971 - personal information)(tracks - Boldo, A., 1976 - personal information). It can reasonably be assumed that the home range of this leopard includes also the Yahudia Reserve.
<u>order: Protungulata</u>				
Procavia capensis	$5x10^2-10^3$	Family groups numbering several dozens of specimens	Stonefalls and cairns. Stony slopes and cliffs	Food: Quercus ithaburensis - leaves; Zizyphus spina Christi - fruits and leaves. Puppies sighted in June. Dawn and dusk activity. Lying out on rock on sunny winter days.
<u>order: Artiodactyla</u>				
Sus scrofa	200-400	Singles and families 1-28 specimens	Forest, batha, open streams and canyons	Food: Roots, tubers and bulbs, acorns, Zizyphus sp. fruit. Green grasses (chewing, sucking and spitting out); puppies of Spalax ehrenbergi and carcasses of various animals. Young were sighted in March-June. Observations of newborn litter of 6 being suckled.
Gazella gazella gazella	200-350	Solitary males. Young males in herds of up to 13 specim. Females w.young in herds of up to 18 specimens.	Forest, batha; wide, non-canyon wadi beds.	Food: Mainly annual grasses: Gramineae, Papilonaceae;Urginea maritima leaves; Lupus various seeds; Zizyphus sp. fruit. Fawns sighted during February-July. Frequent visiting of defecation places (territory marks) during October-November may be an indication of rutting season being at its height.
Capra ibex nubiana	6-10		Batha, wadi slopes	2 males and 2 females were transferred to the reserve in 1970, since when the following observations have been made: April 1973 - one male; July 1974 - 2 males, 3 females, 1 young; December 1978 - 2 specimens.

*batha - herbaceous grassland sometimes with dwarf bushes
forest—Quercus ithaburensis park forest

b. Qualitative dynamic survey: We selected a plot in a typical forest of *Quercus ithaburensis* with a uniform distribution of 4-5 trees per ha - a plot fenced off already in 1973 to keep out the cattle - the fence enclosing an area measuring 100x100 m, with an inner enclosure of 33x33 m fenced off against wild boar. The plot was divided in gridform (10x10 m), giving us 100 points for setting traps. Setting of traps was carried out on three consecutive days each, in September, October, and November 1976. Rodents caught were identified; sex and trapping sites noted; the animals were marked and then set free. Trapping sites were grouped according to habitat. Marking was effected by lopping off first toe joints, following numbering method of Basis 4, whereby each foot stands for single, tens, hundreds, or thousands respectively (Ritte, 1964; Burt, 1940). The joints were cut off with a nail clipper - no bleeding resulted, nor was the functioning of the rodents impaired.

3. Statistical methods:

a. Calculation of population size: Calculation is based on the capture-marking-recapture system recommended by Lincoln (Lincoln, 1930) which presupposes that:

- population size remains stable during test period;
- each specimen within the population has equal chance of being captured;
- likelihood of capture applies also to specimens already trapped in the past;
- homogenous intermingling of specimens released after sampling takes place.

Size of population (P) is calculated on the basis of magnitude of first sample (N_1), second sample (N_2), and number of marked specimens in second sample (M), the ratio being

$$\frac{N_1}{P} = \frac{M}{N_2}$$

It thus follows that the calculated size of population is $P = \frac{N_1 N_2}{M}$, also known as the Lincoln Index (see Table 4.3).

b. Calculation of home range: A hypothetical centre of activities was established on the basis of capture points at which multiple capture of a specimen had taken place. The location of the centre was arrived at by taking the average of trapping points on axis X and axis Y, the grid of trapping points being regarded as a system of axes.

The home-range radius was calculated by taking the distance of the trapping point farthest away from the centre of activities (modified from Ritte, 1964) (see Table 4.3).

4.1.2.3 Results

1. Results of Qualitative Survey of Small Rodent Species.

Table 4.2: Qualitative Survey of small rodent species in the main vegetation types.

Vegetation type / Rodent	Quercus ithaburensis	Zizyphus lotus	Zizyphus spina-Christi	Remarks
Microtus guentheri	+	+	+	Not captured in traps. Data based on burrow holes.
Gerbillus dasyurus	+			Trapped twice only. First found on Golan in this survey. Specimens are of darker colour than those common in Israel (Zuk Rimon, 1976, personal information).
Meriones tristrami		+	+	No trapping. Observation only.
Apodemus mystacinus	+			
Apodemus sylvaticus	+	+		
Rattus rattus	+			One trapping only. Sparse data. Possibly occurring also in places with other vegetation types.
Acomys cahirinus	+	+	+	
Spalax ehrenbergi	+	+	+	Did not enter traps. Data are based on burrow ventilation holes.

For description of vegetation types see 5.3.2 and Table 5.6.

2. Results of Qualitative Dynamics Survey of Small Rodent Species Populations: In the course of this survey we listed 70 trappings, representing 7.8% of all traps set. Division of biotopes and captured species is as under.

Rodent	Acomys cahirinus	Apodemus mystacinus	Gerbillus dasyurus
No. of trappings	51	17	2
% of total trappings (70)	72.9	24.2	2.9
No. of different specimens	23	16	2
Sex age class:			
o (%)	41	82	
♀ (%)	59	18	
Young (%)	22		
Mature (%)	78	100	
% in biotope			
Tree cairn	47	47	
Cairn	43	29	
Tree	6	12	
Open Ground	4	12	

Tree cairn = on cairn girdling a *Quercus ithaburensis* tree
Cairn = on cairn
Tree = under *Quercus ithaburensis* tree
Open Ground = on non-stony, open ground.

It follows from the above data that trapping as a method to a quantitative study of the rodent population in Yahudia Forest is in fact concerned with mainly the *Acomys cahirinus* and *Apodemus mystacinus* species.

-Estimated population size and home range of *Acomys cahirinus*

Table 4.3:

Month	September			October			November		
Day of capture	A	B	C	A	B	C	A	B	C
Number od animals captured	4	13	6	8	4	1	7	4	4
Number of recaptures during month		4	4		4	1		1	1
Number of two recaptures during month			1			1			
Number of recaptures in different months					6			8	
Number of two recaptures in different months								5	
Calculated mean size of population during days connected by arrow	<---12			<---10.7			<---28		
	<--------24			<---------8			<--------28		
		18---->			4---->				
Calculated mean population size in month		18±6			7.6±3.4			28±0	
Mean size of population					17.9±10.2				
Mean amplitude range in metres		12.9			12.5			(7.1)	
Maximal mean amplitude range in metres		27.5			20.0			(15.0)	
Calculated area for month in m^2		2376.0			1257.0				
Mean size of area in m^2					1816 ± 560				

-Estimated population size and home range of *Apodemus mystacinus*:
Because of the small number of recaptures it was not possible to estimate the population size and home range of this animal.

-Distribution pattern of *Acomys cahirinus* and *Apodemus mystacinus* in trial areas:
For the purpose of this examination the trial area was divided into 9 equal squares of 33.3x33.3 m, one of which was the plot that had been fenced off against wild boar. The greatest number of trappings was recorded in the plot fenced off against wild boar: 15 trappings as against 9, which was the maximum number of trappings in other squares. Also with regard to trapping sites, 8 out of 9 in the area fenced against wild boar were found to have rodents trapped, as against 5 out of 9 (or 12) which was the maximum in the other squares. Furthermore, in the plot fenced against wild boar we caught the greatest number of marked rodents whose centre of activities was situated in that plot.

The distribution pattern of *Acomys cahirinus* was more or less uniform in all the squares, while that of *Apodemus mystacinus* showed considerable preference for the fenced-off plot. All the specimens of *Apodemus mystacinus* were caught in that particular square or in its close vicinity, and at any rate at a distance of no more than 30 m.

3. Observations of effect of rodent activities on *Quercus ithaburensis*.

a. Feeding: Remnants of gnawed acorns found in the area are proof of the important rôle of *Quercus ithaburensis* in the diet of these rodent species. Quantities of acorns are gathered together by them on rock surfaces ("dining platforms") and eaten there. We also found gnawed acorns still hanging on trees where they only could have been reached by climbing.

b. Hoarding: We found several acorn hoarding places hidden among stones. Part of the acorns had been gnawed, others had germinated, and some had germinated although gnawed on from the apical side of the cotyledons.

c. Gnawing of root neck: Teeth marks led us to the conclusion that the incidence of gnawed root-necks in 1-2 year old *Quercus ithaburensis* trees was due to gnawing by small rodents. Gnawing of root-necks severs all young shoots above ground, and generally causes the seedling to die off.

4.1.3 *Inventory of Birds (CLASSIS AVES) at the Yahudia Nature Reserve* *)

4.1.3.1 Object: Inventory of birds at the Yahudia Nature Reserve in general, and in two representative habitats in particular: the Tabor Oak (*Quercus ithaburensis*) Park Forest, and the perennial stream and its banks.

4.1.3.2 Survey of habitats: From among the reserve habitats two were chosen as being the most characteristic and representative of the greater part of the reserve area:

a. The Tabor Oak Park Forest, situated between Yahudia and Nahal Zavitan (the Zavitan Stream);
b. Nahal Zavitan, including the bank on its northern bend, a declivity on the southern bend, and a stretch of the flowing stream.

The survey was carried out between February 1977 and March 1978, sampling taking place once a month, excepting August-September. Starting at first light, habitat (a) was surveyed for some two hours, and habitat (b) consecutively. On each sampling day both habitats were surveyed for about five hours.

Sampling and recording methods: a roughly 1300 m long route was chosen in habitat (a), from Coord. 21562605 to Coord. 21462613 (see Map 3.2), and a route of about 1900 m in habitat (b), from Coord. 21462613 to Coord. 21472618, crossing the banks of the stream and the stream itself. All birds that were seen or heard along this route, and within 50 m on both sides of it, were recorded. Each sample specimen was listed and its activities registered in accordance with a standard specification key (see below).

4.1.3.3 General Survey: Concerning the species listed in the aforementioned habitats, additional data on these were collected throughout the entire reserve, and additional species observed in the reserve during the years 1972-1980 were also recorded and listed.

---

*) Collection and processing of data by Per Schluter and the author.

4.1.3.4 Processing of data: A list of species was drawn up in systematic order (Heinzel et al., 1972), and their presence and activities registered in the enclosed table.

Conclusions as to a bird's status in the reserve and degree of certitude as to its breeding therein, are listed in two separate columns. The conclusions are based on the survey data as well as on additional data and information collected by the survey people in 1972-80.

As regards the species included in the general survey, their status and degree of breeding certitude alone were listed, but not the dates of their appearance, the follow-up not having been continuous. The key for the breeding-certitude degree is based on the following international criteria (according to Dybbro, 1976):

B_3 Breeding certain if one of the following requisites is met:

1 Diversion tactics of adult bird
2 Fresh nest of current year
3 Adult bird carrying excreta in beak
4 Adult bird with food for young or seen feeding its young
5 Adult bird flying to and from nest in circumstances showing that nest is active
6 Nest containing eggs, or fresh egg shells in vicinity
7 Nest with young, or fledglings in the area.

B_2 Breeding reasonably certain if one of the following requisites is met:

1 Male singing during breeding season
2 Birds defending their territory during breeding season
3 Courtship and copulation
4 Adult bird addressing alarm calls to young in nest or in vicinity
5 Nest-building

B_1 Breeding doubtful: Birds seen during breeding season in habitat suitable for breeding.

4.1.3.5 Survey table 4.4. Chart - showing results of survey, and conclusions as to status of bird in reserve and degree of breeding certitude.

Key to symbols in chart:

S - singing
U - nest being built
Ū - breeding
Y - nestlings

Table 4.4.

Classis Aves at the Yehudia Nature Reserve

Habitat: Quercus ithaburensis forest (months I II III IV V VI VII VIII IX X XI XII) — Stream and Stream banks (months I II III IV V VI VII VIII IX X XI XII)

Species	Status in Reserve	Breeding in Reserve
Egretta garzetta	V	
Bubulcus ibis	V	
Nycticorax nycticorax	V	
Ciconia ciconia	PM	
Ciconia nigra	PM	
Milvus migrans	WV,PM	
Circaetus gallicus	SB	B_3
Accipiter nisus	WV	
Accipiter brevipes	PM	
Buteo buteo	PM	
Buteo rufinus	R	B_3
Pernis apivorus	PM	
Hieraaetus fasciatus	R	B_3
Hieraaetus pennatus	PM	
Aquila pomarina	PM	
Neophron percnopterus	SB	B_3
Gyps fulvus	R	B_3
Falco tinnunculus	R	B_3
Alectoris chukar	R	B_3
Coturnix coturnix	WV,PM	
Tringa ochropus	WV	
Scolopax rusticola	WV	
Gallinago gallinago	WV	
Columba livia	R	B_3
Columba oenas	PM	
Streptopelia decaocto	R	B_1
Streptopelia turtur	SB	B_2
Streptopelia senegalensis	O	
Clamator glandarius	PM	
Cuculus canorus	PM	
Bubo bubo	R	
Ketupa zeylonensis	R	
Otus scops	O	B_1
Athene noctua	R	B_3
Apus pallidus	SB	B_3
Apus melba	SB	B_1
Apus affinis	R	B_3
Merops apiaster	SB,PM	B_1
Coracias garrulus	SB	B_1
Halcyon smyrnensis	R	B_1
Ceryle rudis	R	B_1
Upupa epops *	PM	
Dendrocopos syriacus	R	B_3
Calandrella cinerea	PM	
Ammomanes deserti **	O	
Melanocorypha calandra	?R	?B_1
Lullula arborea	WV	
Alauda arvensis	WV	
Galerida cristata	R	B_3
Hirundo rustica	R	B_3
Hirundo daurica	SB	B_1
Hirundo rupestris	WV	
Delichon urbica	PM	
Anthus trivialis	PM	
Anthus pratensis	WV	
Anthus similis	R	B_3
Motacilla alba	WV	
Motacilla cinerea	WV	
Motacilla flava	PM	
Pycnonotus barbatus	R	B_2
Lanius excubitor	R	B_3
Lanius nubicus	PM	
Lanius senator	SB	B_3
Lanius collurio	PM	
Prunella modularis	WV	
Cettia cetti	R	B_3
Cisticola juncidis	R	B_3
Prinia gracilis	R	B_2
Hippolais pallida	SB	B_3
Sylvia communis	SB	B_2
Sylvia curruca	PM	
Sylvia atricapilla	PM	
Sylvia melanocephala	R	B_2
Phylloscopus collybita	WV	
Phylloscopus bonelli	PM	
Muscicapa striata	SB	B_1
Saxicola torquata	WV	
Monticola solitarius	R	B_3
Oenanthe oenanthe	PM	
Oenanthe isabellina	PM	
Oenanthe hispanica	SB	B_3
Cercomela melanura	R	B_3
Phoenicurus ochruros	WV	
Phoenicurus phoenicurus	PM	
Erithacus rubecula	WV	
Cercotrichas galactotes	SB	B_2
Turdus merula	WV	
Turdus iliacus	WV	
Turdus philomelos	WV	
Nectarinia osea	R	B_2
Parus major	R	B_3
Troglodytes troglodytes	WV	
Emberiza calandra	R	B_2
Emberiza cia	WV	
Emberiza melanocephala	PM	
Emberiza hortulana	PM	
Emberiza caesia	SB	B_2
Emberiza cineracea	PM	
Fringilla montifringilla	O	
Fringilla coelebs	WV	
Carduelis carduelis	R	B_3
Carduelis spinus	WV	
Carduelis chloris	R	B_2
Acanthis cannabina	WV	
Serinus serinus	WV	
Passer hispaniolensis	SB	B_1
Passer domesticus	R	B_3
Petronia petronia	WV	
Sturnus vulgaris	WV	
Garrulus glandarius	O	
Corvus corone cornix	R	B_1

Annotations in month chart: Quercus ithaburensis forest, Apus pallidus row: "recently - no records"; Stream and Stream banks, Ketupa zeylonensis row: "faeces, pellets, food remnants"; bar marks S, SV, SU, Y, B along bars.

* [illegible] (1970)

** Ilany, G. (1970) - personal information

——	-	rare (0-2 birds along route / 0 bird appearing outside the 50 m range)
═	-	common (3-8 birds along route)
≡	-	frequent (more than 9 birds along route)
O	-	occasional
V	-	visitor (breeding in the region - visitor in reserve)
PM	-	passing migrant
WV	-	winter visitor
SB	-	summer breeder
R	-	resident
B_3	-	breeding certain
B_2	-	breeding reasonably certain
B_1	-	breeding doubtful

Note: Several species are not listed as breeding, despite the fact that they were heard singing, since they may have been singing - as they tend to do - outside the season. These are: *Otus scops*, *Cuculus canorus*, *Sylvia curruca*, *Phylloscopus collybita*, *Phylloscopus bonelli*.

4.2 Discussion

4.2.1 *General Survey*

The survey presents a considerable variety of species: 5 fishes of classis *Osteichthyes*, 3 *Amphibia*, 24 *Reptilia*, 111 *Aves* (see 4.2.3) and 29 *Mammalia* (for rodents see 4.2.2).

The preparation of a check-list such as this is of considerable importance in itself, given the fact that no fundamental surveys of the area were ever made, and the little material that was collected has never been concentrated in one check-list.

Since our research is concerned first and foremost with the vegetation of the Yahudia Forest and the effects of animals on it, great importance attaches to the distribution patterns of several animal species whose activities are likely to have significant effects on the structure of the vegetation landscape. These are: *Acomys cahirinus*, *Apodemus mystacinus*, *Apodemus sulvaticus*, *Procavia capensis*, *Sus scrofa*, *Gazella gazella gazella*. Distribution of small rodents'

habitats is closely connected with arborous vegetation (see 2.2).
The distribution of *Procavia capensis* is connected more closely with rockfall habitats, cliffs and cairns, whence their disconnected distribution pattern. As against this, the wild boar (*Sus scrofa*) occurs in all the reserve habitats, where it has a more or less uniform distribution, showing some preference however for habitats with denser vegetation. The gazelle occurs in flatland habitats and appears to be less dependent on particular types of vegetation.

It should be pointed out that the size of the gazelle population (estimated to be 200-350) is due to a transfer of gazelles from Ramot Issakhar (37 km south-south-west), where they had been multiplying and causing considerable damage to agriculture. The transfer was effected between May 1970 and March 1971, when 444 gazelles were brought to Yahudia - a region where gazelles had previously been completely exterminated (Ilani, G., personal information). Observations showed that the transferred gazelles dispersed throughout the reserve and also outside it. In January 1973, 41 tagged gazelles were sighted within the reserve area, and an additional 10 tagged specimens were observed up to 1978 (some of them on several occasions). There can be no doubt that the presence of this gazelle population in the reserve is proof of the success of their reintroduction.

While the extermination of *Gazella gazella gazella* within the reserve had been a matter of just a few decades (their continued existence within a radius of tens of kilometres outside it being assured), opinions are divided with regard to the occurrence of *Capra ibex* in this region. The sub-species occurring in Israel in the Negev and the Judean Desert is *Capra ibex nubiana*, whose distribution extends down to the Sudan. This sub-species is in danger of worldwide extinction, although in Israel its population is now recovering, and today numbers ca 1800 (Ilani, G., personal information).

While there is no confirmation of *Capra ibex* occurring in the Golan area in former times, there is striking proof of *Capra aegagrus* having existed there in the past. Tchernov (1979) claims that as far as Israel is concerned, "*Capra aegagrus* and *Capra ibex* being contemporaneous throughout the Pleistocene never overlapping in distribution and shared the land in such a way that *Capra aegagrus* occupied the mediterranean rocky landscapes, while *Capra ibex* exploited the arid zone. *Capra aegagrus* disappeared in the Holocene". Remains of the latter have been found in excavations of the Neolithic age. Some believe that *Capra ibex* occupied the arid southern slopes of the mediterranean region and that there had been an overlap of distribution (Ilani, G., personal opinion). These habitats are populated nowadays also by desert species such as the lark

Ammomanes deserti and the desert plant *Salsola vermiculata*, but this circumstance by no means constitues absolute proof of the correctness of the contention.

Four *ibexes* (two male and two female) brought in 1970 to the Yahudia Reserve from the Judean Desert by the Nature Reserves Authority, formed the nucleus of the small population existing in the reserve today. It is our view that if the decision on reintroduction had been made in favour of *Capra aegagrus*, this would have been the wiser choice.

The controversy among Israeli zoologists about whether the transfer to the reserve of *ibexes* should be regarded as an unwelcome "introduction" or a welcome "reintroduction), will no doubt continue.

4.2.2 *Rodent Survey*

4.2.2.1 Evaluation of results. The qualitative survey gave us a picture as to the distribution of rodent species in the forest, and showed up the fact that the *Quercus ithaburensis* vegetation type houses all the species listed (7 species) while the *Ziziphus lotus* vegetation type houses 4, and the *Ziziphus spinachristii* vegetation type only 3 species.

The quantitative dynamics survey pointed to a significant distribution of *Acomys cahirinus* and a less significant distribution of *Apodemus mystacinus*, but gave no results to speak of with regard to other species. With regard to population size and distribution range, calculations could only be made concerning *Acomys cahirinus* - and even these with reservations. The marked standard deviations point to scarcity of data, and the figures should therefore be regarded as mere estimates, although it was found (Ritte, 1964) that three consecutive days in the Judean Hills were enough for collecting adequate data on *Acomys cahirinus*. Ritte (1964) also found that three consecutive days were not sufficient for collecting satisfactory statistical data as far as *Apodemus sylvaticus* was concerned.

4.2.2.2 Habitat occupation. We only recorded data regarding *Acomys cahirinus* and *Apodemus mystacinus*. These animals' marked preference for cairns is conspicuous. While the majority of the *Acomys cahirinus* population is to be found on cairns but does not appear to prefer cairns with *Quercus ithaburensis* to treeless cairns, *Apodemus mystacinus* definitely favours cairns girdling a tree, although it also occurs on treeless cairns, and to a not insignificant extent can be found near trees that are not encircled by cairns, and also on open ground. Although we found the distribution of *Apodemus mystacinus* to be closely linked only with the *Quercus ithaburensis* forest, the fact is that all the forest biotopes are inhabited by this species, though clear preference is shown for cairns encircling trees. *Acomys cahirinus* on the other hand also inhabits biotopes with other vegetation types such as *Ziziphus lotus* and *Ziziphus spinachristii*, though showing an obvious preference for cairns.

4.2.2.3 Rodents and *Quercus ithaburensis* interrelationships. We found that there was a great deal of acorn consumption and hoarding by rodents, as well as gnawing of seedling root-necks. We discovered (see 7.2) that where wild boars were absent acorn survival was considerable; that is to say that while acorns may be an important factor in the diet of rodents the effect these animals have on the degree of acorn survival is insignificant.

This assumption may be supported also from a different angle: i.e., on the basis of an approximate calculation of the acorn consumption potential of small rodents. Grodzinski (1971) found that 1080 gr (fresh weight) rodents in the Alaskan Gaiga Forest consume annually 60 kg (dry matter) vegetable food. Notwithstanding the different circumstances, we made use of these figures in order to arrive at a likely rate of approximate acorn consumption. We found (see 7.2) that the mean production per year of a *Quercus ithaburensis* tree was 807 acorns, with mean content of dry matter being 59.1%. For the purpose of our calculation the average weight of an acorn was assumed to be 12 gr (see 7.3.2).

Mean tree density in forest was found to be 30 *Quercus ithaburensis* per hectare(see 5.3.4). If we take it that an *Apodemus mystacinus* weighs approximately 40 gr and an *Acomys cahirinus* about 30 gr (Ritte, 1964), a weight of 35 gr per rodent would appear to be a good approximation for the purpose of our calculation. Even if we assume that during nine months these rodents feed exclusively on acorns (Grayevsky, 1978) - with regard to *Apodemus mystacinus* - no doubt an exaggerated assumption - the resulting number of small rodents that, in the absence of other acorn consumers, could be sustained by the area would be:

$$\frac{807 \times 30 \times 0.012 \times 59.1}{100} \times \frac{1080}{60 \times 35} \times \frac{12}{9} = 118 \text{ rodents per hectare}$$

Annual consumption of acorns per ha in dry weight	Annual reciprocal consumption per rodent	Reciprocal part of year in which food consists mainly of acorns

This figure considerably exceeds the actual number of rodents found in the area: the estimated density of *Acomys cahirinus* was 18 per ha, while that of *Apodemus mystacinus* appeared to be lower.

The following conclusions can be drawn from this:

a) The germinating potential of *Quercus ithaburensis* is not jeopardized by the rodent population.

b) Food is not a factor in the restriction of the reserve's rodent population.

Unlike acorn consumption, the gnawing of root-necks may be a phenomenon of significance (see 8.3.2), and could lead to the destruction of 2.5% of the total seedlings each year. On the other hand, it was found in several instances that hoarding of acorns had resulted in concentrated sprouting (see 8.3.1). There is no doubt therefore that rodents do play a certain rôle in the burying of *Quercus ithaburensis* acorns and their subsequent germination, taking into consideration the rapid decrease in the acorns' germination potential when they are exposed to the atmosphere (see 7.3.1), and their slim chances of surviving the teeth of the wild boars.

The complexity of the interrelationship of *Quercus ithaburensis* and rodents is also discovered through the relationship between rodents and wild boars. A substantial increase took place in the number of rodents in general, and in that of *Apodemus mystacinus* in particular, in an area that had been free of wild boars during the three years preceding this survey. Given the fact that during the eight years of this research we did not come upon any rodent burrows that had been destroyed by wild boars (with the exception of *Spalax holes*), it would appear that it had been mainly the absence of competition on food which accounted for the increase of rodents in the plot fenced off against wild boar, taking into consideration the extremely low rate of acorn survival in the presence of wild boars (see 7.1; 8.3.2.1).

The possibility should not be excluded that the absence of predations and disturbances also contributed somewhat to the population increase. The impact on vegetation of the big herbivores: wild boars, gazelles and cattle, will be dealt with in Chapter 10.

4.2.3 *Conclusions on the distribution of birds breeding in the reserve*

Of the 44 species shown as breeding under different degrees of breeding certitude, 24 species occur in the forest habitat and 31 in the stream and stream-bank habitats, with 11 species occurring in both habitats. Of the latter species, 5 occur mainly on the border between the two habitats (and are listed in parentheses in the following table):

Species breeding in the Tabor Oak (*Quercus ithaburensis)* Park forest habitat:

B_3	B_2	B_1
Alectoria chukar	(Anthus similis)	Muscicapa striata
Streptopelia decaocto	Pycnonotus barbatus	Passer hispaniolensis
(Dendropocus syriacus)	Prinia gracilis	Corvus corone cornic
Galerida cristata	Sylvia communis	
Hirundo rustica	Oenanthe hispanica	
Lanius excubitor	Cercotrichas galactotes	
Cisticola juncidis	(Emberiza caesia)	
Hippolais pallida	Carduelis chloris	
Parus major		
Carduelis carduelis		
Passer domesticus		

Species breeding in the stream and stream-bank habitats:

B_3	B_2	B_1
Circaetus gallicus	Columba livia	Otus scops
Buteo rufinus	Streptopelia turtur	Merops apiaster
Neophron percnopterus	Pycnonotus barbatus	Halcyon smyrensis
Gyps fulvus	Primia gracilis	Ceryle rudis
Falco tinnunculus	(Sylvia communis)	Dendrocopos syriacus
Columba livia	Sylvia melanocephala	Hirundo daurica
Athene noctua	Oenanhe hispanica	Muscicapa striata
Apus affinis	(Cercotrichas galactotes)	
Hippolais pallida	Nectarinia osea	
Monticola solitarius	Emberiza caesia	

B_3	B_2	B_1
Cercolema melanura	Carduelis chloris	
Parus major		
Carduelis carduelis		
Cettia cetti		

Generally speaking, the occurrence of the species listed is characteristic of these habitats, although it is worth mentioning, for instance, that *Nectarinia osea* can be found in the region of the stream and its banks, while the normal, typical habitats of this bird are open stretches in gardens and inhabited areas. *Streptopelia decaocto* mainly appears in the forest here, while *Streptopelia turtur* is generally to be found around the stream and the slopes leading down to it. The sympatric appearance of the two turtle dove species deserves special mention.

The occurrence and reproduction of *Cercomela melanura* are of particular interest, because this is a tropical species which penetrated through the Afro-Syrian Rift into our region and this is the northern limit of its distribution. There has been a similar process in the past as concerns *Pycnonotus barbatus* and *Nectarinia osea.* An analogous case is that of *Ammomanes deserti* which also penetrates from the desert through the Jordan Valley and occasionally finds its way into the reserve. This bird is known to be breeding regularly east of the Sea of Galilee, some 10 km to the south of the reserve (Boldo, A., personal information).

The absence, or rareness, of a number of species characteristic of the mediterranean maquis, proves that the *Quercus ithaburensis* forest has its place in the more arid mediterranean fringe habitats. Examples that can be quoted are the scarcity of *Turdus merula*, *Troglodytes troglodytes* and *Garrulus glandarius* - birds otherwise typical of mediterranean maquis. Particularly odd is the uncommonness of *Garrulus glandarius* (single sighting only), because this bird is typical to oak forests and, in fact, occurs in the Massadeh Forest on the Golan, a mere 30 km to the north of the Yahudia Forest, and in the Metzar Forest, some 20 km to the south (Mann, 1979). *Sylvia hortensis* does not occur in the reserve at all but is common in the Massadeh Forest and in open mediterranean maquis.

The bird population to be found here in the *Quercus ithaburensis* forest does not differ essentially from that in the mediterranean batha areas, but the stream-bank populationa are more typical for the mediterranean maquis. These facts reflect the connection existing between the location of the forest, from a botanical point of view, in the mediterranean fringe area, and the forest's bird population.

5 YAHUDIA FOREST VEGETATION

5.1 Introduction

5.1.1 *Vegetation of the Past*

The stable climate conditions in our region since the tenth century b.C. have created relative stability in Israel's vegetation, discounting man-caused changes, like felling, fire and over-grazing (Weisel, Liphshitz, 1979). Pollen analysis from the Pleistocene epoch shows traces of *Quercus ithaburensis* in the upper Jordan Valley from the Riss pluvial age (120,000 - 300,000 years before our time). In pluvial periods of the upper Pleistocene the climate in our region was cool and damp and pollen analysis shows that *Quercus ithaburensis* was prevalent until the beginning of the Holocene (12,000 years before our time) (Horowitz, 1971; 1979).

We read about forests of *Quercus ithaburensis* covering large areas in western Israel in the Sharon, Menashe hills and lower Galilee in the 19th century in Eig (1934) as well as Paz (1980), who proves it by quoting Ya'akov Halevi (1854), Jacotin (1799), Thomson (1868), Tristram (1864) and Conder & Kitchener (1881).

The existence of *Quercus ithaburensis* forests in the central and south Golan is also known from early times. Reb Ben Ya'akov Abraham's map from 1696 shows forests in the central and south Golan (Israel Atlas 1956), which are most probably *Quercus ithaburensis* forests. The Kleber & Jacotin map shows forests east of the lake of Galilee (Poulter, 1803). The Assheton map of 1822 also shows forests in wide regions in the central Golan (quoted by Shatner, 1951). A similar picture is described by Porter (1867), Tristram (1877), who even defines the species as *Quercus aegilops* (now known as *Quercus ithaburensis*), and Schumacher (1888) who also describes part of the woody vegetation alongside the streams, like: oleander (*Nerium oleander*), fig (*Ficus carica*), tamarisk (*Tamarix sp.*), plane tree (*Platanus orientalis*), crop bean tree (*Ceratonia siliqua*), vine (*Vitis vinifera*).

The destruction of the forest in the Golan, from the middle of the 19th century and until the twenties of the 20th century, will be widely discussed in chapter 6 (see 6.3.4.2). It will be mentioned here that the areas which were wooded in the Golan in the beginning of the 19th century were narrowed considerably during this time and in the centre and south of the Golan only two forests centres remain: Yahudia forest in the centre and Meitzar forest in the south, which cover together an area of 5,000 ha only.

5.1.2 *The place of the Quercus ithaburensis forest in the local and regional vegetation map*

The prevalence of the *Quercus ithaburensis* is east Mediterranean (Turkey, Syria, Levanon, Israel and Jordan). It is a component in the mediterranean vegetation class *Quercetea*. It prevails in Israel in the following regions: Maritime (north, centre), western hills (lower Galilee, Menashe), Jordan Valley (north), eastern hills (north: Golan, Gilead, Amanus)(Gruenberg - Fertig, 1966).

This prevalence pattern is supported by additional researchers like Post (1896), Aaronsohn (1931), Eig (1934), Etkinson & Beaumont (1971). A comprehensive research on the prevalence of *Quercus ithaburensis* was carried out by Awishai (1967), who draws a map on the prevalence of the species (see map 3.1), from which one can learn that *Quercus ithaburensis* is prevalent in south-west Turkey, along the coast of Syria and Lebanon in a strip no wider than 50 km, and in Israel a widening eastward occurs towards the Golan and the Gilead, with the southern prevalence line at about 32^{o} N.

5.1.3 *Associations of Quercus ithaburensis*

Zohary (1973) defines 4 associations of *Quercus ithaburensis* belonging to *Quercus ithaburensis* alliance, which in turn belongs to *Quercetalia calliprini* order. The defined associations and their regions of prevalence are:

1. *Quercus ithaburensis arenarium*: Sharon on sandy red loam soil;
2. *Quercus ithaburensis Styrax officinalis*: Samaria, lower Galilee, Gilead, Golan, on rendzine and basalt soil;

   Aloni & Orshan (1972) distinguish 3 types of this association:
   - a. typicum
   - b. *Quercus ithaburensis - Styrax officinalis - calliprinosum*, with *Quercus calliprinos*
   - c. *Quercus ithaburensis - Styrax officinalis - bentiscitosum*, with *Sarcopoterium spinosum*
3. *Quercus ithaburensis - Pistacia atlantica*: Golan slopes, Dan Valley, Gilead, on alluvial soils, basalt debris, and inland;
4. *Quercus ithaburensis - Pistacia atlantica - Ziziphetosum loti*: south Golan, Dan Valley, Adana plains, Autakya.

Associates of *Quercus ithaburensis* forest: A *Quercus ithaburensis* forest has no typical batha, and the vegetation is mainly herbaceous, particularly in an adult forest. The absence of *Sarcopoterium spinosum*, typical to the mediterranean maquis and the same soils and the same rock which grows the *Quercus ithaburensis* is particularly conspicuous (Rabinowitz, 1977). Naveh & Kinski (1975) also point out that *Quercus ithaburensis* is accompanied by herbaceous ve getation, mostly annual. Berliner (1971) points out the absence of shrubs and dwarf shrubs in the basalt in the Galilee and that the succession in such cases usually leads from the herbaceous batha to the association of *Quercus ithaburensis*.

Ecological requirements: The prevalence of the

The prevalence of the *Quercus ithaburensis* is wide all over the north of the country and it is unselective as to soil and rock. It grows within the range of 400-600 mm precipitation in altitudes of 0-900 m above sea level (Rabinowitz, 1977). Eig (1934) mentions an altitude range of 0-600 m and geographical regions with rainy winters and dry summers, not too low winter temperatures (above an isotherm of 5^{o} average for January). Eig also points out the unselectivity as to soils and that the root system is shallow and approximately 1 m deep (20-150 cm range).

Support for these ecological requirements are to be found also by Halfon-Meiri (1958), who points out that the range of soils is large, but mineral composition of the leaves represents the difference in soil types. In calcarious soils the calcium in the leaves increases.

5.1.4 *Vegetation of the Golan*

Danin (1968) distinguishes between 4 units of climax vegetation in the Golan:

1. *Quercus calliprinos - Quercus boissieri* (north to centre Golan) asociates with *Pistacia palaestina, Styrax officinalis, Prunus ursina, Pyrus syriaca, Rhus coriaria, Cartaegus sp., Spartium junceum, Lonicera etrusca, Rubia tenuifolia, Rubus canescens, Dianthus polycladus.*
2. *Quercus ithaburensis* (centre and south Golan, mainly below altitude of 300 m) associated with *Pistacia atlantica, Styrax officinalis, Ziziphus lotus, Ziziphus spinachristii, Carlina hispanica, Echinops gaillardoti, Hordeum bulbosum, Gundelia tournefortii, Scolymus maculatus.*
3. *Ziziphus spinachristii*: Savannah type vegetation in regions below *Quercus*

ithaburensis, which are more arid (there is more unwashed chalk in the soil).

4. *Retama raetam, Salsola vermiculata*: association appearing on exposed lime stone and marl in south western slopes of the Golan.

Danin also distinguishes between 4 units of secondary associations, which are:

1. *Crataegus sp., Prunus ursina*: association replacing the association of *Quercus calliprinos - Quercus boissieri* after clearing the forest;
2. *Ziziphus lotus*: from an altitude of 500 m appears as an association which replaces *Quercus ithaburensis* after clearing the forest;
3. *Hypericum triquetrifolium, Echium glomeratum, Eryngium creticum*, unwoody association which is a vicarious association of *Quercus calliprinos - Quercus boissieri*;
4. *Scolymus maculatus, Cynara syriaca*: Unwoody association which is a vicarious association of *Quercus ithaburensis*.

In Danin's opinion the vegetation climax in most of the Golan regions is woody. Fishman (1974), however, finds a connection between the geology and the woody vegetation, so that a *Quercus calliprinos* forest is prevalent in Ein Zivan basalts (BE) (see 3.2) and a *Quercus ithaburensis* forest is prevalent in Dalawe basalts (BD) and in the rocky lava front of Muisa basalt (BM), whereas the remaining Muisa basalt area, which comprises of thick unrocky layers of soil, is completely forest free. This connection, although circumstancial, is most interesting.

The vegetation association of the hygric habitats in the Golan were reviewed by Heyman (1980), who worked in the basin of the Meshushim stream, which takes up a considerable part of the Yahudia reserve and areas north east of it. 20 vegetation associations of the hygric habitats which Heyman mentions belong to 7 alliances:

1. *Adiantum* alliance
2. *Lemna* alliance
3. *Spirodela* alliance
4. *Nasturium* alliance
5. *Vitex* allicance
6. *Phragmites* alliance
7. *Populus* alliance

A comprehensive geobotanical analysis of the Golan vegetation was carried out by Seligman (1973). The different units which were defined will not be mentioned here for lack of space, but the woody and bushy vegetation will be mentioned, divided into the 4 main units:

- *Quercus calliprinos, Quercus boissieri* maquis;
- *Quercus ithaburensis* park forest;
- Savannah type vegetation of *Ziziphus spinachristii, Ziziphus lotus*;
- Spring and wadi vegetation of *Vitex agnuscastus, Rubus sanctus.*

Three researches, relevant to the subject of our project, were referred to above, not for the purpose of comparison, or criticism, or analysis, but in order to acquire general background of the vegetation in the area from the few researches made on the subject.

5.2 Methods

5.2.1 *Interpretation of aerial photographs for the purpose of mapping vegetation and tree density*

Vegetation mapping in Yahudia Nature Reserve was based fundamentally on aerial photo-interpretation. This method is based on stratification of photographic images to classes. The determination of classes is based on image properties in the photo such as tone (or colour), shape, size, texture, pattern, height and shadow of image, topographic location and elements associated (Remeijn, 1972).

Photographs used

For the vegetation mapping vertical black and white stereo-landsat photographs were interpreted. Photographs were taken on 12.12.75, at 13.00 - 14.00 h from a height of about 2,600 m, with 152.10 mm camera's principal distance, which gives a scale of about 1:17,100.

For mapping trees and their density vertical black and white stereo-landsat photographs were interpreted, taken on 7.7.67 at 12.00 - 13.00 h, from a height of about 2,300 m, with 115.42 camera's principal distance, which gives a scale of about 1:19,400.

Comparison of both sets was made both for the vegetation mapping and for the tree density mapping, after separate interpretation.

Further comparison was made with the following black and white stereo-landsats: 21.03.62, 1:10,600; 22.12.65, 1:25,000; 8.11.72, 1:11,000.

Interpretation and mapping were made by the following procedure (after Zonnevled, 1972 a):

1. Preliminary field inspection in which acquaintance with the dominant vegetation units and species was made;
2. Photo perusal, arrangement of photo mosaics, photo analysis and the design of preliminary legend based on photographs only. Analysis was made with "Zeiss" mirror stereoscope with magnifying ratio of 1x24 or 4x24;
3. Preliminary photo interpretation and generalization. At this stage a systematic study of photographs was made. Borders of vegetation units were drawn on photographs with coloured wax pencil. A more detailed hierarchic legend was built, based on stratification to classes of topographic and microclimatic units, to visible life-forms of vegetation and to units differing in their photo-image.

   Data were then transformed to 1:20,000 base map. Using photographs of scale 1:17,100, the minimal unit size which was determined was 5x5 mm. and if elongated - unit minimum width was 1 mm. These units were transferred also to the base map of the scale 1:20,000 and no loss of information occurred;
4. Tracing and colouring of preliminary map. It was important to carry out this step before the intensive field work. Such a map gave an overall picture of the distribution and pattern of the units and enabled to pinpoint errors;
5. Field work correlation and classification. On the base of the coloured preliminary map, the stratified sampling was planned. We used stratified sampling and not random, because random sampling gives too much prominence to the larger areas at the expense of smaller parts, which may be equally important. Photo-interpretation, making use of photo analysis, guarantees the objectivity of sampling on a stratified basis. The efficiency of using aerial photographs is mainly due to the fact that this allows stratified sampling, which enormously reduces the amount of field work necessary for sampling.

   Within the same unit the selection of sample plots was random. The number of samples within each unit was correlated to the number of patches of this unit within the whole area (on sampling plots see 5.2.2 and 5.2.3);

6. Final photo-interpretation mapping. A revised, detailed legend, based on vegetation units as were defined after the field work, was produced. The final map was drawn in accordance with the revised legend and the revised preliminary map.

Tree density

Quantitative forest inventory by means of aerial photo-interpretation is used quite regularly in many countries, by which height, density and timber volume can be measured or calculated (Romeijn, 1972).

Using aerial photographs at scale of 1:5,000 and sampling plots of 100x100 m each, the error in the number of trees ranged from 0.2 to 0,4% only (Stellingwerf & Romeijn, 1973), which means that the accuracy of this method is rather high.

Interpretation for tree density was basically made by the same procedure described above. The units were based on tree density and on dominant tree species. Density units were defined as very dense, dens, moderately dense and sparce. Sampling of photos taken in 1967 were made within the units on transparent millimetric paper with a square hole 5.2x5.2 mm corresponding to an actual area of 100x100 m. The trees in the square were counted after magnifying under the stereoscope, and as far as possible their species was also determined. Any tree or bush discernible on the photo is considered a tree. In the field inspection - any tree or bush over 2 m high and/or whose crown diameter is over 2 m was considered an adult tree. In the photos usually only adult trees were discerned. 130 samples in photos were counted, 61 of which were also counted in the field in summer 1978. The field counting was made after exact localization of the square counted in the photo and the number and names of species were recorded in the field. Separation was made in the field between adult and young trees, which may not have been visible in the photo. A comparison was also made between 32 samples of the set of 1967 with the corresponding site in the photos taken in 1975. Out of the sets from 1962 and 1965 20 comparisons were made of each in the *Quercus ithaburensis* forest area with the 1975 set, also in square of 100x100 m actual size.

Attempts to estimate tree age groups by height and crown size did not succeed, and distinction could only be made very roughly. We also found at Smit (1980) that distinction of age groups from aerial photographs of the forest was impossible.

5.2.2 *Vegetation survey in the Yahudia Nature Reserve ("survey")*

On getting acquainted with the area in advance of the sampling, we recognised a certain problem. The Reserve area was mostly covered with *Quercus ithaburensis* park forest, consisting of wide spread trees with herbaceous grassland in between. Part of the forest has savannoid vegetation of *Ziziphus*, and part is steep slopes and stream ravines.

In the park forest of *Quercus ithaburensis* the vegetation of the tree and its immediate surrounding is different from the grassland vegetation of the open spaces. Dinoor (1962) and Oppenheimer (1951) also point out certain floristic differences in vegetation inside the range of influence of *Quercus ithaburensis* and outside it.

The difference results both from the conditions of the habitat under the tree and from the clear connection between stone cairns and *Quercus* trees. (On this subject see chapter 8). Westhoff (1967) suggests that in such cases the same area should be divided into different associations on the basis of structure and the tree layer and herbaceous layer sampled and described separately. Linked to the system of analysing the vegetation by aerial photo-interpretation (see 5.2.1 above) the sampling was also carried out by the units which were discernible in the aerial photos. That is, the park forest appears as one homogeneous unit both on the photos and on the sampling and its analysis. At the same time, for the specific purpose of investigating the influence of grazing on the herbaceous vegetation, we sampled the herbaceous layer separately (see hereunder).

Following Orshan *et al.* (1971) and Shimwell (1971) we used sampling methods, which changed according to the circumstance in the area, which were as follows:

Method No. 1: Short point transect (s.p.t.). Iron pegs were fixed in the ground 20 m apart. A marked tape was stretched between them. Every 20 cm the species touching the tape was recorded. The proportion of each species out of the total touch-points gave the absolute coverage of the species. All the species within half a metre from the tape were also noted as occurring and having coverage 0. This sampling was done in six replicates with the transects parallel and 10 m apart.

This method was used mainly for sampling herbaceous vegetation in regular follow-up plots, mostly for comparing vegetation in different grazing regimes (see 5.2.3 hereunder), but the data was also utilized for the general vegetation survey.

Method No. 2: Long point transect (l.p.t.). A pointed pole was placed every 2 paces along a transect 200-500 m long, and the species touching the front of the pole recorded. The proportions of each species out of the total of paces in the transect gives the absolute coverage of the species. All species within 1 m of each side of the transect, which did not appear on the transect itself, were also recorded as occurring and with coverage 0. This method was used when the vegetation was more or less homogeneous over a distance of 200-500 m, and it was used in constant transects for comparing vegetation under different grazing regimes, and in single transects for the general vegetation survey. Most of the vegetation samplings in this project were carried out in this manner.

Method No. 3: Quadrates cover estimates (c.qu.). With this method all the species in a selected quadrate were recorded and an estimate was made of their absolute coverage. The size of the quadrate changed according to the vegetation structure, from 50x50 m in woody vegetation to 4x4 m in herbaceous grassland.
This method was used when the vegetation was not homogeneous over a large area, particularly in streams and spring vegetation and in dense maquis on steep slopes.

The sampling method used in each transect is mentioned on the list of vegetation transects (see TABLEF, 5.3.1 hereunder).

5.2.3 *Comparing the vegetation in Quercus ithaburensis forests under different grazing regimes ("cover")* *)

For the purpose of comparing the influence of different grazing regimes on the composition of herbaceous vegetation, constant follow-up plots were determined, in which vegetation sampling was carried out over 3 years (1974-1976), in the months of March-May, using the methods described above (methods 1, 2, see 5.2.2).

---

*) The field work and its primary processing was carried out in collaboration with Nomi Margalit, to whom special thanks are extended hereby.

Follow-up plots in typical *Quercus ithaburensis* park forest were selected, 200 m above sea level, distributed over different regions of the forest.

Cattle and boar foraging plots were square and 1 ha in size, and marked accordingly, but not fenced. The cattle grazes in the Reserve in paddocks larger than the test plots, so the exact grazing pressure was unknown. The average grazing pressure in the test plots was 80-110 cattle grazing days per ha per year, extending cyclically over all the seasons (see 10.2.2 and map 10.2 for detailing per plot and season).

There was even less control over the boar foraging, since these were wild boars, the exact number of which is unknown. On the basis of population estimate (see table 4.1) the average foraging pressure is 22 boar foraging days per ha per year, but in winter, and particularly in the acorn ripeness season (November - December), the activity of the boars in the forest is more intense, and the relative pressure in this season is much higher.

Plots with no cattle grazing (but with boar foraging) were fenced by 4 barbed wires the total height of which was 1.20 m with iron poles 6 m apart. These plots are square and 1 ha in size.

Plots for preventing cattle and wild boar foraging were fenced by barbed wire as above, with an Australian net over it 1.50 m high, with a quarter of its height folded on the ground on the outside of the plot, anchored with iron pegs, to prevent the possibility of digging by the boars and infiltration. For the sake of security a concertina 1 m in diameter of barbed wire was spread outside along the whole of the fence. These plots were only 0.2 ha in size, because of the high fencing costs.

Inside the follow-up plots the vegetation transects were established. Hereunder are listed the treatments, plots and transects made (for pinpointing the plots, see map 3.2).

Treatment	Plot	sampling method	no. of sites	number of replicates
+ cattle + boar	R	1 s.p.t.	1	6
		2 l.p.t.	1	1
	T	2 l.p.t.	1	1
with light cattle grazing	P1	1 s.p.t.	1	6
		2 l.p.t.	1	1
with moderate cattle grazing	P2	1 s.p.t.	1	6
		2 l.p.t.	1	1
with heavy cattle grazing	P3	1 s.p.t.	1	6
		2 l.p.t.	1	1
- cattle + boar	D	1 s.p.t.	2	2x6
		2 l.p.t.	1	1
	K	1 s.p.t.	1	6
		2 l.p.t.	1	1
- cattle - boar	B	1 s.p.t.	1	6
	C	1 s.p.t.	1	6

All the transects were sampled for 3 consecutive years (1974-1976).

5.2.4 *Editing of the vegetation transects ("TABLEF")*

With the aid of a computer program ("TABLEF" modified) kept at the Botanical Department of the Hebrew University in Jerusalem, the vegetation transects were arranged in tables, with the species arranged by groups on the vertical axis: trees, bushes, creepers and herbaceous, and the vegetation transects on the horizontal axis.

For every species the following entries appear:

1. Absolute coverage of the species in every transect (%);
2. Summary of the coverage percentages of the species in the transect group in the table ("total percent");
3. Summary of the number of transects in which the species occurred ("total occurrence").

The data was arranged in 3 groups of tables according to the different purposes of the transects (see 5.3.1).

5.2.5 *Analysing the vegetation data according to the nodal ordination method ("ORDIN")*

Vegetation data analysis was carried out by nodal ordination by component analysis method, which was developed by Noy-Meir (1971). It is detailed in other works (Seligman, 1973; and others). The data is analyzed with the aid of "ORDIN" computer program, kept at the Botanical Department of the Hebrew University in Jerusalem. In the following lines we shall explain in short the principles of the method, and emphasize the basic concepts which were used and which appear in the "ORDIN" program computer output. Records are arranged, in this method, to some *noda*. Each *nodum* is an entity defined by the coincidence of a group of species with a group of sites, where neither the groups nor the nodum are necessarily descretely bounded from, or hierarchically related to other groups or noda. The nodum is homologous, in fact, to the plant community of the classical tradition of Braun-Blanquet, while records and species are continuously organized.

Composition and distribution of each nodum component is characterised by the *affinity* values of species and of sites to the nodum. The affinity of species and of sites to noda vary between 0 and 1. The species and sites which have high affinities (0.8 - 1.0) with a nodum are the typical core of the nodum and may be used to name it, and those with near zero affinities (0 - 0.4) are outside its sphere of influence. The affinity of a species or a site to the nodum is represented by a continuous value and not by belonging or not belonging to a plant association.

Noda may be highly continuous or connected with each other; their sphere of influence may be partially overlapping or conjunct. The *conjunction coefficient* is a measure to the degree of overlap between two noda, so that 1.0 represents identity and 0 represents no overlap at all. The conjunction coefficient between all noda is represented in the *conjunctivity matrix*.

The degree of efficiency of a nodum is the proportion of information it explains and its value varies between 0 and 1.0. The degree of assembly of the nodal components is relative to the nodal axis, expressed in the variable *as-symmetry* which gets values between 0 and 1.0, with high values depicting assembly of most of the nodal components on one side of the axis.

By activating the ordination in different *rotation levels* one can build a system of noda and super-noda, which include several noda, with the super-noda uniting highly phytosociologically related noda, parallel to the association and alliance in the classical method after Braun-Blanquet (1932).

We carried out the quantitative analysis of the vegetation by the ORDIN program in two methods:

1. *Dominance*: The data of absolute cover of species which was transformed into relative cover was used. For the species which occurred in low cover, which was not registered, their cover value was calculated by dividing the difference between the absolute cover and the total cover of the species whose cover was registered by the number of species whose cover was not registered.
2. *Occurrence*: The occurrence or lack of occurrence only was registered for each species in the record, regardless of its relative quantity in the record.

5.3 Results and Discussion

5.3.1 *Vegetation Inventory*

The vegetation inventory in the Yahudia Reserve is presented in the following ways:

1. A list of species by systematic order (appendix 5.1.2 in volume II). This list was extracted from all the vegetation transects carried out during this project. Each species has a 6-letter code, usually based on the first 3 letters of the name of the genus and the first 3 letters of the name of the species. We shall use these codes further on when mentioning names of species. Every species also has a numerical code, with the first number being the code of the family name (list of families - see appendix 5.3.I at the end of this volume), the second - code of the genus, and the third - code of the species.
2. A list of species, alphabetically arranged by their code names (appendix 5.2.I at the end of this volume).

   Altogether 487 species were listed in the Yahudia Reserve in the course of this research.
3. Tables of vegetation transects (TABLEF) (see appendix 5.4.II in volume II). The tables give all the vegetation records made, which are organized in 3 files:

   TABLEF 1: Permanent point transects, a separate table for each sampling site. The sites are marked on map 3.2 (as P, K+C, D+B, T) ("cover" data) (s.p.t. + l.p.t.).

TABLEF 2: Permanent point transects, a separate table for each grazing treatment (for the grazing treatments concerned see above 5.2.3) ("cover" data) (s.p.t. + l.p.t.).

TABLEF 4: Vegetation survey and long point transects recorded in 1976 ("survey" and "cover" data).

In every file the species are arranged in groups of life forms and in every group they are arranged alphabetically. Life forms for this purpose will be: trees, bushes, creepers, herbaceous. The mean absolute cover for every species appears in the records of the same table, expressed in percentage, and also its occurrence, expressed in the number of records in which it appears.

5.3.2 *Definition of Vegetation Units by Record Analysis of Nodal Ordination ("ORDIN")*

For the purpose of establishing vegetation units we were assisted by the vegetation records which were made for the reserve vegetation survey ("survey" - see 5.2.2 above) and by some of the vegetation records made also for comparing vegetation under different grazing regimes ("cover" - see 5.2.3 above).

Since we made many more records in the "cover" series, we selected some of them in the following manner:

ORDIN 1: Long point transects recorded at 1976 + "survey"
ORDIN 8: Long point transects recorded at 1974, 1975, 1976, + "survey".

The transects from 1976 were selected because most of the "survey" transects were made in that year. The long transects were selected rather than the short ones, because they were sampled by an identical method to those of the "survey" records. In 1976-77 long transects were made in the "cover" series, and in the years 1974-76 19 transects were made. Attempts were made to analyse "survey" with a larger number of short transects from the "cover" series, but the preliminary analysis showed that there was over-detailing of units in the *Quercus ithaburensis* forest, and a generalization of units in other habitats of the slopes, the grasslands and the streams. These analyses were, therefore, not submitted here (on this subject see 5.3.5 hereunder and table 5.8). Tables 5.1, 5.2, 5.3 and 5.4 (submitted in appendix 5.5.I at the end of this volume) summarize the analysis ORDIN 1 (occurrence, dominance) ORDIN 8 (occurrence, dominance) respectively, with the species which have close affinity or which are exclusive to it selected for every nodum at each rotation level. The species were selected in the following order. First were registered the species identifying the nodum and species with an affinity to the nodum at the rate of 0.8 - 1.0. Then were registered the species with a rate of affinity of 0.5-0.7, underlining the species which are exclusive to the nodum. In weak noda, where there were not enough species in these categories, species with an affinity of less than 0.5, but exclusive to the nodum, were also registered (but noted in brackets).

Species with a larger affinity than 0.5 to two or more noda were noted accordingly.

Trees were emphasized, and in any case all the trees belonging to any of the above categories were registered.

The full analysis of ORDIN 1 and 8 is submitted in appendix 5.6.II (volume II).

The data from the 4 analyses mentioned above were summed up in table 5.5. Two, three of the most characteristic species were found for each nodum. The hierarchical connection between the noda was stressed in the table when rotation levels 3 and 15 were emphasized. We found that we could not always locate hierarchical connection between 3, 6 and 15 noda, and in some cases it seemed meaningless. We, therefore, selected rotation level 3 as depicting the major formations of the vegetation and then descended to the detailing levels of 15 noda. In table 5.5 we set out similar formations under similar noda for comparison.

From table 5.5 we find that only a small part of the defined noda repeats itself in all 4 analyses. In the occurrence analysis there is sensitivity in defining noda in alliance *Avena sterilis - Hordeum bulbosum*, especially in grassland and also in noda of the calcarious part of the Reserve: *Salsola vermiculata - Salvia horminum* and *Salvia dominica - Astragalus macrocarpus*, whereas the hygric habitats vegetation is not detailed enough.

On the other hand, in the dominance analysis there is generalization in the grasslands, but detailing of the hygric habitats vegetation, formation *Salix acmophylla - Nerium oleander*. We ascribe this "defect" to the low number of samplings relative to the variety of vegetation in the area.

We used table 5.5 for defining the units and determining the hierarchical connection between them. We summed up table 5.5 vertically, to extract all the vegetation units distinguished in the 4 analyses. A summary of the vegetation units is presented in table 5.6. The units in this table are noted in an

Table 5.5: A summary of nodal ordination analysis with characteristic species for each nodum. Lines represent hierarchic relations between super noda and noda written under. For meaning of species code names see appendix 5.2.I.

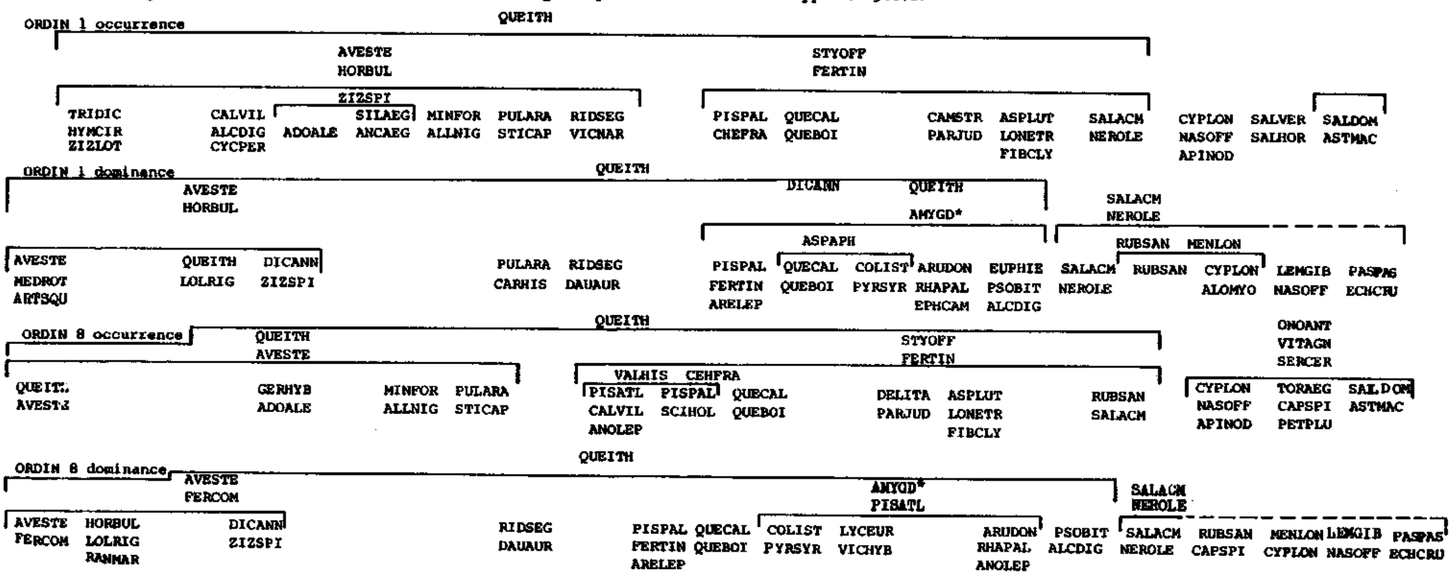


Table 5.6: Vegetation units in Yahudia Nature Reserve, their structure and physical environment

Unit Code	Vegetation unit / Floristic unit	Vegetation structure	physical environment / main landscape	texture, land form, lithology	Representation records
Q	formation: Quercus ithaburensis				
QA	alliance : Avena sterilis - Hordeum bulbosum				
QA1a	assoc.: Quercus ithaburensis - Avena sterilis typical	park forest with grassland	rather flat area with moderate south-western slope	very stony, cover basalt	11621, 34621
QA1b	variant: Ziziphus lotus	grassland with shrubs	rather flat area	very stony, cover basalt	14
QA2a	assoc.: Quercus ithaburensis - Lolium rigidum typ.	park forest with grassland	steep stream banks declivities	stony, rocky, cover basalt	4, 9
QA2b	variant: Hordeum bulbosum - Lolium rigidum - Ranunculus marginatus	park forest with grassland	plateaus	quite deep soil, cover basalt	34521, 34621
QA3a	assoc.: Ziziphus spinachristi: var: Dichanthium annulatum-Adonis aleppica	savannoid vegetation	stream banks declivities facing east, west and south	stony, rocky, cover basalt	1, 11
QA3b	var. Silene aegyptiaca-Anchusa aegyptiaca	savannoid vegetation	plateaus, wide stream beds	stony alluvium, cover basalt	27
QA4a	assoc.: Minuartia formosa-Allium nigrum	grassland	relatively high altitude plateaus (ca.+400 m above sea level)	shallow stony soil, cover basalt	18
QA4b	assoc.: Pulicaria arabica-Stipa capensis	grassland	relatively high altitude plateaus (ca.+400 m above sea level)	very stony, cover basalt	24
QA5	assoc: Ridolfia segetum-Daucus aureus	weedy grassland with sparse trees	small flat valleys badly drained	deep soil slightly stony, cover basalt	26
QS	alliance: Styrax officinalis-Ferula tingitana				
QS1	assoc.: Pistacia atlantica-Calycotome villosa-Anogramma leptophylla	mesic woodland with cliffs vegetation	facing north stream bank cliffs	cliffs with soil pockets, cover basalt	29
QS2	assoc.: Pistacia palaestina-Ferula tingitana - Arenaria leptoclados	woodland with cliffs vegetation	top stream bank cliffs	cliffs with soil pockets, cover basalt	16
QS3	assoc.: Asphodeline lutea-Lonicera etrusca-Fibigia clypeata	maquis	top stream bank cliffs	shallow soil in pockets, cover basalt	17
QS4	assoc.: Arundo donax-Rhamnus palaestina-Ephedra campylopoda	maquis and reed thicket mosaic	very steep stream banks declivities and cliffs	cliffs, travertin, layer spring, cover basalt	15
QS5	assoc.: Parietaria judaica - Delphinium ithaburensis	dense park forest	facing north stream banks declivities and stream beds	stony, rocky, cover basalt	10, 4
QS6a	assoc.: Asparagus aphyllus, var: Quercus calliprinos-Quercus boissieri	entangled maquis	facing north steep declivities	very stony, cover basalt	25
QS6b	variant: Colutea istria-Pyrus syriaca	maquis and garigue mosaic	facing north very steep declivities	rocky, cover basalt	20
QS7	assoc.: Euphorbia hierosolymitana-Psoralea bituminosa-Alcea digitata	shrubby batha	declivities and rock terraces of shallow stream banks and geological faults	rocky, cover basalt	13
SN	formation: Salix acmophylla-Nerium oleander				
SN1a	assoc.: Salix acmophylla- Nerium oleander	woodland and hygric vegetation	perennial streams	stony alluvium, cover basalt	2, 22, 31
SN1b	variant: Fraxinus syriaca - Platanus orientalis	woodland and hygric vegetation	perennial streams	stony alluvium, cover basalt	5
SN2a	assoc.: Rubus sanctus - Mentha longifolium var: Rubus sanctus-Capparis spinosa	shrubby hygric vegetation	springs and slow flowing perennial streams	deep stony soil, cover basalt	7, 8, 33
SN2b	variant: Mentha longifolium-Cyperus longus-Alopecurus myosuroides	shrubby hygric vegetation and wet grassland	slow flowing perennial brooks	deep stony soil, cover basalt	12
SN3	assoc.: Lemna gibba-Nasturtium officinale	wet grassland with sparse trees	springs	very stony, cover basalt	28
SN4	assoc.: Paspalum paspaloides - Echinochloa crusgalli	wet grassland with sparse trees	swampy areas	deep basalt soil	34
SS	formation: Salsola vermiculata - Salvia dominica				
SS1	assoc.: Salsola vermiculata - Salvia horminum	grassland with shrubs	xeric south facing slopes	Neogenic limestone with outcrops of basalt soil	23
SS2	assoc.: Salvia dominica - Astragalus macrocarpus	grassland with shrubs and sparse trees	moderate slopes	Neogenic limestone with outcrops of basalt soil	21

hierarchical order, so that the high level, the formation, was usually defined by the noda in a rotation level of 3 noda, and marked by code letters by the species characterizing the whole formation. The second level, the alliance, was usually defined by the noda in a rotation level of 6 noda, and marked by the formation code letter together with a letter of the species characteristic to the alliance. The detailed level, the association, was usually defined by the rotation level of 15 noda and marked by adding the serial number of the association within the alliance. In some cases the same alliance was marked differently following different ordination analyses, and we decided to consider them as variants of the same association. These were marked by adding "a" or "b" to the association code.

The classification system used follows Rubel, as quoted by Shimwell (1971)

We defined the vegetation formation characteristic to every unit, and its physical environment. We also recorded the representative vegetation to each unit, the details of which may be found in TABLEF 4 (appendix 5.4.II). The vegetation units which were defined are:

(Q) Formation: *Quercus ithaburensis*, includes most of the reserve area and most of its vegetation units, excluding hygric habitat vegetation and the calcarous regions in the lower Daliot stream.

(QA) Alliance: *Quercus ithaburensis* - *Avena sterilis*, includes the *Quercus ithaburensis* park forests, the savannoid vegetation of *Ziziphus spina-christii* and *Ziziphus lotus*, and grasslands. The habitats are usually plains, or moderate slopes.

(QA1a) *Quercus ithaburensis* - *Avena sterilis* typical: a typical *Quercus ithaburensis* park forest. Tree density of 1-60 trees per ha, but usually 10-30 trees per ha. This forest has as associates a few *Pistacia atlantica* trees and herbaceous grasslands and is almost free of bushes.

(QA1b) *Ziziphus lotus*: a variant of the *Quercus ithaburensis* forest, with the *Ziziphus lotus* replacing it. The floristic relationship between the two units strengthens the argument that the *Ziziphus lotus* association replaces the *Quercus ithaburensis* association, following its clearing by man (Zohary, 1973; Danin, 1968)(see also 5.1.4), and there really is a close floristic affinity in the herbaceous vegetation between the *Quercus ithaburensis* forest and the savannoid vegetation of *Ziziphus lotus*.

(QA2a) *Quercus ithaburensis - Lolium ridigum*: *Quercus ithaburensis* park forest, usually in rocky and sloping regions.

(QA2b) var. *Hordeum bulbosum - Lolium ridigum - Ranunculus marginatus*: *Quercus ithaburensis* park forest in high plains with quite deep soils and heavy grazing.

(QA3) *Ziziphus spinachristii*: savannoid vegetation of *Ziziphus spinachristii*, usually in plains or moderate slopes in altitudes no higher than 200 m above sea level, and usually in altitudes of -100 - +100. In herbaceous grasslands the *Avena sterilis* and *Hordeum bulbosum* dominate.

(QA3a) var. *Dichantium annulatum - Adonis aleppica*: a variant with slopes on stream banks.

(QA3b) var. *Silene aegyptiaca - Anchusa aegyptiaca*: a variant in plains and wide stream beds.

(QA4a) *Minuartia formosa - Allium nigrum*: high grassland vegetation with shallow soils and seasonal water flow scattered in small brooks. There is hardly any woody vegetation, with the exception of few *Pistacia atlantica* and *Ziziphus spinachristii* trees.

(QA4b) *Pulicaria arabica - Stipa capensis*: high grassland vegetation with a high degree of stoniness and shallow soil, creating here and there quite arid habitats (appearance of *Erodium deserti*).

(QA5) *Ridolfia segetum - Daucus aureus*: grassland vegetation of deep soils, most of which were cultivated in the past. Few trees and bushes of *Ziziphus spinachristii* and *Ziziphus lotus*.

(QS) Alliance: *Quercus ithaburensis - Styrax officinalis*, park forests, maquis and slope forests, usually stream slopes. *Quercus ithaburensis* usually dominates and is usually associated by *Styrax officinalis, Pistacia atlantica* and *Amygdalus* sp..

(QS1) *Pistacia atlantica - Calycotome villosa - Anogramma leptophylla*: stream cliffs and north facing slopes, which usually retain a comparatively high humidity. Here and there exposed rock with arid rock vegetation, like *Valantia hispida* and *Rumex cyprius*. Several ferns are in this unit, like *Anogramma leptophylla, Ceterach officinarum* and *Chlilanthes fragrans*.

(QS2) *Pistacia palaestina - Ferula tingitana - Arenaria leptoclados*: a unit of cliff tops in streams.

(QS3) *Asphodeline lutea - Lonicera etrusca - Fibigia clypeata*: maquis of cliff tops in streams, which includes a variety of trees and creepers. *Echium viscosus*, appearing in this unit, includes 2 subspecies: *ssp. viscosus* and *ssp. gamlensis*, which, as far as is known, were found in this region only.

(QS4) *Arundo donax - Rhamnus palaestina - Ephedra campylopoda*: cliff and steep stream slopes vegetation, including reed thickets, which grow in small springs in stream cliffs.

(QS5) *Parietaria judaica - Delphinium ithaburense*: dense park forest on slopes descending into streams, mainly on northern facing slopes and in stream beds in places far from the influence of running water.

(QS6a) *Asparagus aphyllus, var. Quercus calliprinos - Quercus boissieri*: tangled forest of *Quercus calliprinos, Quercus boissieri, Cercis siliquastrum, Ceratonia siliqua*, on steep north facing slopes. This is the only place in the northern and central Golan where these *Quercus* species appear.

(QS6b) *Asparagus aphyllus, var. Colutea istria - Pyrus syriaca*: steep north facing slopes with *Colutea istria* bushes and trees like *Pyrus syriaca, Quercus ithaburensis* and *Styrax officinalis*.

(QS7) *Euphorbia hierosolymitana - Psoralea bituminosa - Alcea digitata*: rocky slopes and rock terraces on shallow river banks, basalt lava fronts, or geological fault lines with *Euphorbia hierosolymitana* bushes.

(SN) Formation: *Salix acmophylla - Nerium oleander*, hygric habitat vegetation of running streams, springs and swamps.

(SN1a) *Salix acmophylla - Nerium oleander* , typical vegetation of most of the running streams which create tangles of *Salix acmophylla* and *Nerium oleander*, sometimes associated with *Pistacia atlantis, Quercus ithaburensis* and *Fraxinus syriaca*.

(SN1b) *var. Fraxinus syriaca - Platanus orientalis*: variant of unit SN1a with concentrations of many *Fraxinus syriaca* trees and *Platanus orientalis* trees.

(SN2) *Rubus sanctus - Mentha longifolium*: bushy vegetation of hygric habitat with water flowing constantly in shallow streams.

(SN2a) *var. Rubus sanctus - Capparis spinosa*: appears mostly in streams and springs.

(SN2b) *var. Mentha longifolia - Cyprus longus - Alapecurus myosuroides*: appears mostly in ever flowing shallow tributaries.

(SN3) *Lemna gibba - Nasturtium officinale*: hygric meadow and spring vegetation with sparse *Ficus carica* trees and occasionally also *Quercus ithaburensis*.

(SN4) *Paspalum paspaloides - Echinochloa crusgalli*: hygric meadow and swamp vegetation with sparse *Ficus carica, Ziziphus spinachristii* and *Quercus ithaburensis* trees.

(SS) Formation: *Salsola vermiculata - Salvia dominica*, vegetation of calcarous neogenic slopes in the Daliot stream bottom in the south of Yahudia Reserve.

(SS1) *Salsola vermiculata - Salvia horminum*: bushy herbaceous batha of arid south facing slopes with semi-desert-like appearance.

(SS2) *Salvia dominia - Astrogalus macrocarpus*: moderate slopes and herbaceous grassland with sparse trees or concentrations of *Styrax officinalis*, *Amygdalus sp.* and *Ziziphus spinachristii*.

5.3.3 *Yahudia Reserve Vegetation Map*

In fig. 5.1 a stereopair photo is presented, which depicts a typical *Quercus ithaburensis* forest, with a stream with its slopes and cliffs. Map 5.1 depicts the graphic description of the Yahudia Reserve vegetation. The unit definition is based on table 5.6, on the basis of which several generalizations were made. These generalizations were made for several reasons:

1. A unit too small to map - mostly in cliff and cliff top vegetation, where the variety of habitats is large and changes occur over small distances. Several units spread over cliffs (like QS4) seem on a vertical projection on the map smaller than they are in reality, and cannot be mapped. Therefore vegetation unit QS1 was united with QS2, and QS3 with QS4. Units SN1a and SN1b were also united.
2. Units which are indiscernible in aerial photos and the difference between them on the ground is mostly a light difference in the floristic composition, with no difference in structure. Therefore unit QA1a was united with units QA2a and QA2b, which represent a typical *Quercus ithaburensis* park forest. QA4a and QA4b were also united, as well as SN2a with SN2b, and SN3 with SN4, concerning which no difference was discerned even in some of the ORDIN analyses.
3. Units where transition from one to another is not clear and sharp and are very similar in the ecological conditions of the habitat and form by themselves a mosaic of sub-units, which gradually change from one vegetation unit to another. Therefore unit QS6a was united with QS6b, and SS1 with SS2.

The aerial photo interpretation was done, as mentioned, from photos in the scale of 1:17,100 and transferred to a map of 1:20,000. Although such a scale is considered as detailed for the purpose of vegetation mapping (Zonneveld, 1972 b), even in this scale we had to make several generalizations. The smaller the scale, the less homogeneous the unit.

Figure 5.1: A stereopair of a representative plot of Yahudia Nature Reserve Forest and a stream with its slopes (site L vicinity on map 3.2; photo was taken at 12.12.75; for a three dimensional view use a pocket stereoscope).

Vegetation transformation based on comparing aerial photos from the years 1962, 1967, 1975

No significant changes in the vegetation were discerned from the aerial photos. In some cases we found transformation from herbaceous grassland (QA4) to sparse savannoid *Ziziphus lotus* (QA1b), or moderately dense savannoid *Ziziphus spinachristii* (QA3), and mostly in areas cultivated until 1967. In few cases transformation from savannoid *Ziziphus lotus* (QA1b) to a sparse complex of *Ziziphus lotus - Quercus ithaburensis* park forest were distinguished (QA1a-QA1b).

In vegetation comparison between 1962 and 1975 we found 2 cases where a part of a mixed *Quercus ithaburensis* and *Ziziphus spinachristii* maquis was cleared and there was a transformation to herbaceous vegetation.

Vegetation belting

From map 5.1 it can be discerned that the belting is clearly connected with altitude, with the *Ziziphus spinachristii* forming the lowest belt in the forest, which changes around sea level to *Quercus ithaburensis* park forest, with mixed regions within the altitude range of 0-120 m above sea level. This forest reaches 180-200 m above sea level, where *Ziziphus lotus* replaces it.

Zohary (1973) mentions that the primary habitat of the *Ziziphus lotus* association is on the slopes of the Samaria to the Jordan valley, and its distribution in other places in Israel is in secondary habitats of cleared forests and abandoned fields, according to which outlook the upper belt in the reserve and outside it is secondary after clearing *Quercus ithaburensis*.

It is pointed out that on the stream slopes the *Quercus ithaburensis* forest extends offshoots both to the *Ziziphus spinachristii* region and to that of the *Ziziphus lotus*. The infiltration to the *Ziziphus spinachristii* area is more extensive on the northern facing slopes, and can be explained by the more favourable ecological conditions to the *Quercus ithaburensis* prevailing in the more humid and shaded slopes, in spite of the lower altitude and higher temperatures.

More favourable conditions can also explain the offshoots of the *Quercus ithaburensis* on the stream slopes into the *Ziziphus lotus* area. Possibly, too, the *Quercus* trees were cleared to a lesser extent on the slopes because of lack of interest in the areas for cultivation and harder accessibility, whereas in the plains the forest was cleared and the *Ziziphus lotus* replaced it.

5.3.4 *Tree Density in Yahudia Forest*

Tree density by vegetation type is given in table 5.7. The table also presents vegetation units, as defined in table 5.6, which are included in vegetation density types. Very dense *Quercus ithaburensis* forest areas are connected to vegetation units of *Quercus ithaburensis* forest, *Styrax officinalis, Quercus calliprinos* and *Quercus boissieri* (QS5, QS6) and in cliffs of *Quercus ithaburensis* and *Styrax officinalis* (QS1, 2, 3, 5) and in *Quercus ithaburensis* park forest in plains and moderate slopes (QA2, QA1a). *Quercus ithaburensis* in moderate density and sparsity is usually connected with *Quercus ithaburensis* park forest only (QA2, QA1a).

Ziziphus spinachristii and *Ziziphus lotus* in all densities are connected with their typical units (QA1b and QA3) as well as with grasslands with sparse trees (QA5). The complexes of *Quercus ithaburensis* with *Ziziphus spinachristii* or *Ziziphus lotus* usually connected with the margins of the *Quercus ithaburensis* park forest in its low or high regions respectively.

The dense hygric vegetation is connected with units of *Salix acmophylla* and *Nerium oleander* and *var. Fraxinus syriaca* and *Platanus orientalis* (SN1a, b).

From table 5.7 one can see that in the comparison of the 1967 photos with the field count of 1978 there is a tendency towards a 25% increase in the density of *Quercus ithaburensis* trees. However, the main contribution towards this increase comes from young trees which were not counted in the photos. In the *Ziziphus sp.* there is no separation in the photo-count between *Ziziphus spinachristii* and *Ziziphus lotus*, because of the difficulty in distinguishing between them. However, compared with the field count, there is also a tendency towards a 45% increase, with the contribution towards increase emanating both from the number of adult trees and bushes and the young ones. These increases are not significant, however, since there is a large variability between the counts in the different samples for the same vegetation types.

Comparing identical sites in the 1962, 1965, 1967 and 1975 photos

Because of the facts that hardly any differences were discerned between the aerial photos taken in 1965 and 1967 and that they were taken in the leave-shedding-season, the comparison data concerning them were not taken into account.

In the dense *Quercus ithaburensis* park forest vegetation type there is a tendency towards increased density from 1962 to 1967 and 1975. The increase from 1967 to 1975 was significant and was expressed by 17.3%, mostly on the slopes (units QS2, QS5).

Table 5.7: Tree density in Yahudia Park Forest. A comparison of density in aerial photographs taken in 1967, with density recorded in the area in 1978

VEGETATION TYPE	vegetation units included (Table 5.6)	Mean number and S.D. of specimens per species per 1 ha [in ( ) - no. of samples figures are calculated from] photograph counts: total mean	photograph counts: QUEITH	photograph counts: ZIZPH*	photograph counts: unidentified	field counts: total mean	field counts: QUEITH A	field counts: QUEITH Y	field counts: ZIZSPI A	field counts: ZIZSPI Y	field counts: ZIZLOT A	field counts: ZIZLOT Y	Others
QUEITH very dense	QS6 QS5	65.7±12.9 (14)	58.4±7.6 (10)		47.4±30.5 (4)	78.2±9.3 (6)	57.2±16.8 (5)	23.3±13.7 (4)					STYOFF 4.7±1.5 (4) QUECAL 48.0 (1) QUEBOI 6.0 (1) PISATL 2.0 (1) AMYGD* 6.0 (1) CERSII 6.0 (1) CERSIL 6.0 (1)
QUEITH dense	QS5,QS3,QS1 QS2,QA1a,QA2	38.9±8.6 (17)	40.0±8.2 (15)	1.0 (1)	20.3±15.9 (3)	50.3±9.7 (10)	33.6±6.4 (9)	13.4±10.3 (9)	4.0 (1)	1.0 (1)	3.0 (1)		PISATL 7.5±0.7 (2) AMYGD* 6.0 (1)
QUEITH moderate	QA1a QA2	15.7±4.8 (18)	15.4±4.8 (18)	1.0±0 (3)	2.0 (1)	19.1±3.8 (10)	13.4±5.3 (10)	5.2±3.1 (8)	1.0±0 (2)		1.0±0 (2)		PISATL 1.0 (1)
QUEITH sparse	QA1a QA2	7.3±3.0 (9)	7.1±3.0 (9)	1.0 (1)		10.0 (1)	8.0 (1)				2.0 (1)		
ZIZIP* dense	QA1b, QA3	34.5±8.5 (9)		35.7±9.3 (7)	30.5±4.9 (2)	68.4±33.1 (5)	1.0 (1)		43.6±48.9 (5)	42.3±35.9 (3)	25.5±12.0 (2)	18.0±12.7 (2)	
ZIZIP* moderate	QA1b QA3	15.3±5.7 (17)	2.0 (1)	14.6±4.4 (12)	20.8±1.7 (4)	19.3±4.6 (9)	2.5±0.7 (2)		8.2±6.1 (9)	4.5±1.9 (4)	12.3±9.5 (3)	6.7±6.5 (6)	
ZIZIP* sparse	QA1b QA3 QA5	6.1±2.1 (14)	1.0±0 (2)	6.0±2.1 (14)	1.0 (1)	6.7±2.0 (6)	1.0 (1)	1.0 (1)	4.8±1.6 (5)	2.0 (1)	4.0±1.4 (2)	4.0 (1)	
complex QUEITH moderate ZIZIP* sparse	QA1a + QA1b QA2 + QA3	20.0±8.6 (7)	12.3±5.2 (7)	7.6±4.4 (7)		29.3±8.4 (3)	12.5±0.7 (2)	16.0±13.0 (3)	2.3±2.3 (3)	3.0±0 (2)	1.0 (1)	1.0 (1)	
complex QUEITH sparse ZIZIP* sparse	QA1a + QA1b QA2 + QA3	17.7±9.1 (10)	5.5±3.1 (10)	10.6±8.0 (9)	16.0±4.2 (2)	18.6±9.4 (5)	3.5±2.1 (4)	1.5±0.7 (2)	6.0±6.0 (5)		3.3±2.1 (3)	8.3±8.3 (4)	
SALACH very dense NEROLE	SN1	73.8±17.0 (4)	uncountable, represented in total cover percent			70.0±19.6 (4)							SALACH 60.0±0 (3) NEROLE 15.0±8.7 (3) FRASYR 20.0±14.1 (2) PICCAR 10.0 (1) PLAORI 5.0 (1)

Remarks:

1. A - an adult tree: height ≥ 2 m and/or crown diameter ≥ 2 m
   Y - a young tree: height ≤ 2 m and/or crown diameter ≤ 2 m

2. For meaning of species code names see appendix 5.2 I.

In moderately dense *Quercus ithaburensis* park forest vegetation type a slight tendency towards increased density is also recognized, mostly from 1967 to 1975, but here it is not significant.

In sparse *Quercus ithaburensis* forest no differences in density were noted between the 3 series of photos.

In the savannoid *Ziziphus spinachristii* contrasting tendencies were noted in different samples. Usually there is a tendency towards increased density, particularly from 1967 to 1975, which in one case reached an increase of about 200%. On the other hand, in one sample we found a decrease of 75% in density of *Ziziphus spinachristii* trees in 1967 as against 1962, following the unification of agricultural fields and clearing the trees between them, a condition which remained static until 1975.

In the *Ziziphus lotus* type we saw a general tendency towards increased density, particularly from 1967 to 1975 and even the growth of several *Ziziphus lotus* bushes in grassland areas. In one case *Quercus ithaburensis* trees appeared and a mixed stand of *Ziziphus lotus* and sparse *Quercus ithaburensis* trees was created. These changes occurred mostly as a result of neglecting agricultural fields and near villages, where the high pressure of activity was stopped after 1967.

In comparing photos taken in different years, data collected by the same method was compared. However, comparing data from photos to those from the field taken several years later, raises the question whether the change is real or results from the method. Since we observed a certain tendency towards increase in comparing photos taken until 1975, one can assume that this tendency continued also until 1978. The main change in the count of 1978 is in that a considerable part of the increase results from counting young trees, which could not possibly be discerned from photos taken in 1975, even if they existed. A part of the increase probably results from an actual increase in the number of adult trees.

There is also a measuring error based in the method itself, the sources of which are:

- inexact placing of the counting square in different aerial photos, or inexact identification in the field of the site in the photo;
- a steep slope is measured in the field in its realistic size, whereas in the photo it is measured in its vertical projection;
- difference in the scale of the photo caused by different altitude of the field and the aeroplane's tilt;
- seasonal influences, especially leave-shedding in winter, which complicate

the photo count;

- errors in species identification in the photos.

The change in density and distribution of trees in the 16 years between 1962 and 1978 can be summed up by saying that no significant changes were noted in the density and distribution of trees in the reserve from 1962 to 1967, excepting for a few cases of savannoid *Ziziphus spinachristii* clearing for field cultivation. There is a slight tendency towards density increase of *Quercus ithaburensis* from 1962 to 1978, particularly in the slopes and forest margins, a tendency which becomes more conspicuous after 1967. This tendency proves an inclination towards expansion of the *Quercus ithaburensis* forest to the margins, particularly after ceasing to cultivate fields and man's intensive activity, which expressed itself perhaps in overgrazing and clearing the forest margins. In the savannoid *Ziziphus spinachristii* and *Ziziphus lotus* there is a certain tendency towards increased density in agricultural areas and grassland, where man's activity ceased. So units which were defined as grassland in photos taken in 1962 are defined in the vegetation map as sparse savannoid *Ziziphus spinachristii* or *Ziziphus lotus*, and in some cases even as complexes with sparse *Quercus ithaburensis*.

At the same time it should be pointed out that all the increases noted are slight, and mostly statistically insignificant, and were focused in a few special sites only, like steep slopes, areas of cultivation and activity near abandoned villages, whereas most areas of the *Quercus ithaburensis* forest remained stable. A part of the tendency towards increase resulted from young trees and from trees which were opressed until 1967 and developed thereafter.

5.3.5 *Analysis of herbaceous vegetation in typical Quercus ithaburensis forest*

5.3.5.1 Comparing sampling methods

As mentioned above (5.2.3), we used two methods for sampling vegetation in constant transects: long point transects (l.p.t.) and short point transects (s.p.t.). For comparing the methods, we ran through the computer a nodal ordination program of all the long (19) and short (126) transects made in the same plots.

The analysis showed that on the basis of occurrence, in the long transects more species appeared and widespread species were not especially prominent in these transects. In the dominance analysis there is a similarity between the long and the short transects, since the many species occurring in the long transects have minimal cover.

Since this difference between the methods results from their actual definition, we only wanted to refer to this point here, and considered bringing the full data superfluous.

The long point transects seems suitable for a more comprehensive survey. So we used it for defining vegetation units in the reserve and mapping them (see 5.3.2). However, for the fine analysis of the delicate differences in vegetation composition within the same vegetation unit (*Quercus ithaburensis* forest - *Avena sterilis* typical) the long point transect system is too crude, and we usually used the short ones.

5.3.5.2 Herbaceous vegetation analysis in typical *Quercus ithaburensis* forest under different grazing regimes

Quite a clear affinity of the sampling sites (plots) to noda were found when we inspected the long transects, as can be seen from table 5.8 (ORDIN 3; the full analysis is presented in appendix 5.3.II). In an analysis of species occurrence we found that nodum 1 represents faithfully plot P, representing cattle grazing, nodum 2 - plot T, which is free of cattle grazing, and nodum 3 - plots K and R, which are adjoining (see map 3.2) and which are free of cattle grazing and under moderate cattle grazing respectively. This affinity of plots to nodum is not expressed in the analysis on the basis of species dominance, presented in the same table. Here it is conspicuous that nodum 1 is connected to the lack of cattle grazing or moderate grazing, and species like *Avena sterilis, Hordeum spontaneum* and *Psoralea bituminosa* are characteristic, whereas nodum 2 represents heavy grazing, with characteristic species like *Hordeum bulbosum, Centaurea iberica* and *Silybum marianum*.

In the vegetation analysis on the basis of all the short transects made (table 5.9 and appendix 5.3.II) on the basis of species dominance (ORDIN 4 dominance), it seems that there is no affinity of the plots to noda. No affinity to noda was seen, neither by the sampling years, nor of the replicate numbers, so they were not detailed and only the number of transects from the same replicates was registered. In a division on the basis of 3-noda, nodum no. 1 represents the grassland characteristic of the *Quercus ithaburensis* forest, and it is characterized by *Avena sterilis, Carlina hispanica* and *Linum pubescens*. Nodum 2, characterized by *Quercus ithaburen-*

Table 5.8: Long point transects analysis by nodal ordination on the basis of species occurrence and dominance.
For location of plots see map 3.2.
For menaing of species code names see appendix 5.2.I.
B = boar foraging; C = cattle grazing.

ORDIN 3

Rotation level		3			3	
No. of nodum	1	2	3	1	2	3
Characteristic species	SCOMUR TETPAL OCHAEG	PISATL PIPMIL	TORTEN FILDAV AEGPER	AVESTE LINPUB	HORBUL OCHAEG	MEDROT TRIPIL HYMCIR
Species affinity to nodum 0.5-1.0	TRIGLA ARTSQU BISPEL SCAPAA RANMAR GERMOL SINARV BUPNOD	ALYNIN SEDHIS PRAMAJ PSOBIT MEDSCU SILBEH RUMCYP VALITA	QUEITS DAUBIC RHAPAR ANOALO HYPHIR ALLNEA PLALAG SONOLE	UMBINT HORSPO TRIDIC SYNCAR PSOBIT QUEITS BROMAD PIMMIL	PHABRA RANMAR SILMAR LOLRIG TRIPUR RAPRUG RAPROS CENIBE	GYNSIS BISDID SCOMUR SCAPRO TRIGLA RICLUN THRTUB POABUL
Common species for all noda with affinity ≥ 0.5	AVESTE TRIPUR SCOMAC	QUEITH HYMCIR DIAPOL	HORBUL SCAPRO RICLUN		none	
No. of transects with affinity 0.8-1.0						
plot treatment						
D +B −C				1		
K +B −C			2	1		
T +B −C		2		3		
P +B +C light	1					
P +B +C moderate	2			1		1
P +B +C heavy	3				3	
R +B +C moderate			1	2		

Table 5.9: Short point transects analysis by nodal ordination on the basis of species dominance. For location of plots see map 3.2. B = boar foraging; C = cattle grazing. For meaning of species code names see appendix 5.2.1.

ORDIN 4 Dominance									
Rotation level		3				6			
No. of nodum	1	2	3	1	2	3	4	5	6
Characteristic species	AVESTE CARHIS LINPUB	QUEITH	TRIPIL HORBUL MEDPOL	AVESTE CARHIS LINPUB	QUEITH	HYMCIR MEDROT	HORBUL OCHAEG	TRIPUR CICPUM	
Species affinity to nodum 0.5-1.0 or exclusive species	(TRIBOI) (SEDHIS) (PAPPOL) (FILDAV) (RANMIL) (LATMAR) (BRYSYR)	(ALLNEA) (PIPMIL) (CEPJOP) (ONOHIR) (CATRIG)	MEDROT HYMCIR SCAPRO TRIARG TRIPUR CICPUM LOLRIG (SINARV) (OCHAEG) (CENIBE)	(RANMIL) (LATMAR) (BRYSYR)	(ALLNEA) (PIPMIL) (ONOHIR)	(AJUCHI)	LOLRIG MALNIC (SINARV) (VACHIS)	(ZIZSPI)	
No. of transects with affinity 0.8-1.0									
plot treatment									
D -B -C	5	9		5	9	2			
K -B -C	6		3	11		1		2	
D +B -C	14	8	1	12	10	3			
K +B -C	10		1	10		2			
P +B +C light	1	8		1	9				
P +B +C moderate	1		4			4			
P +B +C heavy	1	1	2				9		
R +B +C moderate	10		4	10				2	

sis, represents the vicinity of the tree and cairn. There is no clear affinity of grazing treatments of plots to these noda. The third nodum represents the grasslands rich in legumes (*Papilionaceae*), and *Hordeum bulbosum*, as well as several ruderal species like *Ochthodium aegypticum*, *Sin Sinapis arvensis*, and *Centaurea iberica*, which are characteristic of heavy grazing and are exclusive to this nodum. This division is even more outstanding in nodum 4 in rotating level 6. The transects with the strongest affinity to this nodum are from heavy grazing regime (plot P, +boar +cattle heavy grazing treatment).

In analysis on the basis of occurrence the species' affinity to noda is weak and no such clear division into sub vegetation-units is apparent. On the other hand, many species occur as multi-noda species, like *Avena sterilis*, *Hordeum bulbosum*, *Anthemis bornmuelleri*, *Carlina hispanica*, *Scabiosa prolifera*, *Linum purbescens*, *Isatis lusitanica* and *Urospermum picroides*, whereas in analysis on the basis of dominance there are no multi-nodal species.

A similar division into sub vegetation-units was reached in analysis of the short transects of plot P only (table 5.10, ORDIN 6. Full analysis in appendix 5.3.II). In this plot, 3 sub-plots represented 3 levels of cattle grazing intensity: light, moderate and heavy. In an analysis by species dominance, nodum 1 represents the herbaceous areas between the trees subject to moderate and light grazing, represented by *Avena sterilis*, *Medicago rotata* and *Hymenocarpos circinnatus*, and containing many grasses (*Gramineae*) and legumes (*Papilionaceae*). Nodum 2 represents the *Quercus ithaburensis* and its close vicinity in areas subject to light and moderate grazing and represented by *Quercus ithaburensis*, *Theligonum cynocrambe* and *Crucuanella membranacea*. The third nodum represents grasses and legumes and other ruderal species, characteristic of heavy grazing. The transects with strong affinity to this nodum are from heavy grazing regime. The species characteristic to this nodum are *Hordeum bulbosum* and *Rapistrum rugosum*. In higher rotation levels (6 and 10 noda) no significant division was added to the sub vegetation-units.

In the analysis by occurrence there was also a similar affinity of species and grazing regimes to noda, which is especially prominent in rotation level 6, nodum 2, where all the ruderal species with a high affinity to any nodum appear, and also the affinity of transects from the heavy grazing area to this nodum is unequivocal.

Table 5.10: A comparison of 3 levels of cattle grazing intensities by short point transects, by nodal ordination analysis on the basis of occurrence and dominance of species. (For location of plot P see map 3.2; B - boar foraging; C - cattle grazing; QUEITS = Quercus ithaburensis seedling; For meaning of species code names see appendix 5.2.I).

ORDIN 6	OCCURRENCE									DOMINANCE		
rotation level	3			6						3		
no. of nodum	1	2	3	1	2	3	4	5	6	1	2	3
characteristic species	CARHIS LINPUB	BROSCO VICNAR OCHAEG	QUEITH	HORSPO QUEITH	VICNAR OCHAEG	RICLUN QUEITH	DIAPOL LATAPH	LAGCUM TRIDIC		AVESTE MEDROT HYMCIR	QUEITH THECYN	HORBUL RAPRUG
species affinity to nodum 0.5-1.0 or exclusive species.	QUEITS LATAPH EUPOXY PICLUN UMBINT TRISUB	HIRINC TRIARG BETVUL MALNIC AMMVIS SILMAR SINARV CENIBE	THRTUB CONPEN LATGOR TORTEN DAUBIC GERMOL	QUEITS CONPEN	LOLRIG RAPRUG MALNIC AMMVIS NOTSYR SILMAL CENIBE SINARV	THRTUB POABUL HEDRHA ADOANN	TRIPAU TRICAM CARGLA PLAAFR	GERMOL LATHIE PAPPOL TRISUB ANECOR CATRIC	DAUBIC	TRIPIL CICPUM SCAPRO TRIARG EUPOXY	(FILDAV) (CATRIG) (CRUMEM)	LOLRIG TRIPUR ECHJUD VICNAR OCHAEG MALNIC SILMAR (CENIBE)
Common species to all noda with affinity ≥0.5	AVESTE, MEDROT, HYMCIR,	HORBUL, TRIPIL, SCAPRO,	LOLRIG TRIPUR CICPUM	none						none		
no. of transects with affinity 0.5-1.0 plot | treatment												
P | +B+C light	7	1		6		2		3	1	8	9	
P | +B+C moderate	6	1	5			4	8	1	1	11	1	
P | +B+C heavy		12	3		12							14

This analysis of transects from 3 sub plots of cattle grazing in different levels emphasized the different floristic composition of areas under heavy grazing, whereas it did not prove transformation gradient of vegetation composition with easing off of the grazing regime.

5.3.5.3 Vegetation sub-units in typical *Quercus ithaburensis* forest

We saw, then, that in a detailed analysis of constant transects, made in a typical *Quercus ithaburensis* forest, we used nodal ordination to divide the vegetation into 3 basic sub-units:

1. *Quercus ithaburensis* and vegetation characteristic of its immediate vicinity and cairns;
2. grasslands between the trees not subject to heavy grazing regimes and characterized by grasses (mostly *Avena sterilis*) and legumes;
3. grasslands of heavy grazing areas, characterized by *Hordeum bulbosum* and ruder 1 species such as *Ochthodium aegypticum, Rapistrum rugosum, Centaurea iberica, Silybum marianum* and *Sinapis arvensis*.

We saw that heavy grazing alters the floristic composition, but no difference was noted between lower levels of grazing or lack of grazing, which may be credited to the grazing regime.

On the other hand, some floristic differences were apparent between plots not necessarily on the basis of grazing regimes, mostly with the aid of long constant transects which cover a wide range of area and species. These differences become almost negligible in the detailed analysis of the short transects, which depicts the finer floristic differences.

These floristic differences are local and do not justify the division into different vegetation units, neither in table 5.6 nor in map 5.1. These sub-units belong to the same unit of typical *Quercus ithaburensis* forest (QA2, QA1a).

It has already been pointed out (5.2.2) that certain researchers have a tendency to divide into small sub-units, or to sample them separately, but in our opinion there is no justification to a division beyond what we have already mentioned, since these sub-units are intertwined in such a way that they are indivisible in the large extent of the reserve and the scale of its vegetation mapping.

6 PHENOLOGY OF QUERCUS ITHABURENSIS

6.1 Introduction

6.1.1 *Systematics of Quercus ithaburensis*

Quercus ithaburensis Decne, fam. *Fagaceae*, was first collected by Bové on Mount Tabor, Israel, and first described by Decaisne in 1835 (Decaisne, 1835).

Further descriptions in literature are:

Kotschy, Eichen, tab. 12 (1862)
de Candolle Prodromus 16 (2): 44 (1864)
Schwartz, Notizbl. 13 (116): 19 (1936)
Zohary, Bull. Res. Counc. Israel D, 9: 168 (1961)
Zohary, Fl. Palaestina 1: 32 (1966)
Mouterde, P. Fl. nov. Lib. et Syr. 1: 365 (1966)
Boiss, Fl. 4: 1172 (1879): *Quercus aegilops L. var. ithaburensis.*

Morphological description

Deciduous 5-6 metres tree. Branches divaricate - ascending, forming a globular or broadly ovoid crown. Buds crowded, ovoid with appressed scales. Leaves usually 5-8(10) x 3-6 cm varying in size and shape on the same tree, with 6-9 (11) lateral nerves ending in triangular, often aristate or long-mucronate teeth. Flowers green, unisexual usually in different inflorescences on the same main twig. Staminate catkins 5-6 cm, flowers' perianth of 4-6 lanceolate lobes, Pistillate catkins with 1-3 flowers on short pedicels; styles 3-4. Acorns solitary or in pairs, maturing in the second year; cupule 1.3 - 2 cm in diameter; long gland; scales thick rather woody, spreading (Zohary, 1966).

Zohary (1966) distinguishes five varieties differing in structure of cupule and gland. These are: var. *calliprinoides*, var. *subcalva*, var. *subinclusa*, var. *dolicholepis*, var. *ithaburensis*. Since we found the population in the Yahudia Forest mixed and variable, these vareities could not be distinguished and no further distinction between them has been made in this research.

6.1.2 *Phenology of Quercus ithaburensis*

We consider the study and description of the phenology of *Quercus ithaburensis* to have been a valuable exercise in itself and also a means of describing the rhythm of seasonal changes in the ecological system.

The description of the rhythm of cambial ring formation furnishes us with a gauge for measuring the age of a tree - a gauge which is of considerable importance for studying the forest's history and drawing conclusions with regard to management of the forest as a nature reserve in the future. The cambial rings themselves reflect the phenological rhythm and its connection with the mediterranean climate.

6.2 Methods

The phenology of *Quercus ithaburensis* has been described on the basis of measurings of a number of parametres. Foliage has been described by giving the respective percentages of leaves breaking out, green leaves, dry leaves, autumn-coloured leaves, and leaves shed. These parametres represent leaves at all stages during the different seasons. We also examined growth- and lignification stages in young twigs. Of reproductive parts, we recorded the flowering of the male organ - an easy task with the long, staminate catkins - and also the diameter, length and number of acorns.

For all these examinations we selected trees in typical *Quercus ithaburensis* forests, 200 m above sea level (see chapter 5). Follow-up was carried out in single forest plots and on single branches therein. The forest plots yielded much information and showed up variability in trees, but more precise and detailed information was gleaned from the single branches.

6.2.1 *Phenological Follow-up in Forest Plots*

During the period September 1976 - March 1979, we made regular monthly control visits to 3 particular forest plots (Y.D.K., see map 3.2). In each plot we established a point from which observations were made within a radius of about 50 m.

The parameters we assessed have been described by two figures:

1. Percentage of trees in which the estimated parameter was found to exist;
2. Percentage of estimated parameter in trees in which it occurs.

Percentage was assessed from tree's overall parameter potential.

3. The percentage of leaves breaking out is calculated as percentage of buds, from opening until full growth, out of total number of leaf buds;
4. Percentage of green leaves out of total number of leaves on tree;
5. Percentage of dry leaves out of total number of leaves on tree;
6. Percentage of autumn-coloured leaves out of total number of leaves on tree;
7. Percentage of leaves shed out of total number of leaves that were on tree.

Where phenomena could not be gauged, a (+) was recorded instead of percentage. In cases of distribution of phenomena percentages in the different trees extending over a continuous range of percentages, a mean percentage was recorded, but in cases of distribution extending over a discontinuous range of percentages the trees were divided up into several groups, the phenomenon percentage of each of which was recorded, and so was the group percentage out of the total number of trees in the plot. Each of these groups has been described in a separate graph.

We also made estimates of the following parameters:

- length of youngest twig (in cm)
- stage of lignification of young twig (1 - green and soft; 2 - green and hardening; 3 - brownish and hardening; 4 - brown and hard)
- length of acorn (in cm), from stalk to tip
- diameter of acorn-cupule (in cm).

6.2.2 *Phenological Follow-up of Permanent branches*

The general appearance of a three-years old branche is presented schematically in figure 6.1.

In October 1975, we selected 10 branches growing 2 m from the ground on the trunks of 10 different trees. The trees were growing from the lower third of the cairn, as is characteristic for most of the trees in this forest (see figure 8.1). The trees were chosen from two forest plots separated by a distance of about 1 km (D,Y on map 3.2), and with a 50-100 m distance between trees in both plots. The branch was marked off into sections, each representing a growth period. 5-8 parts were marked off initially, and an additional 4 in the course of the follow-up, according to growth periods observed.

The following parameters were recorded each month (up to March 1979):

1 Male flowering - estimated number of catkins on branch;

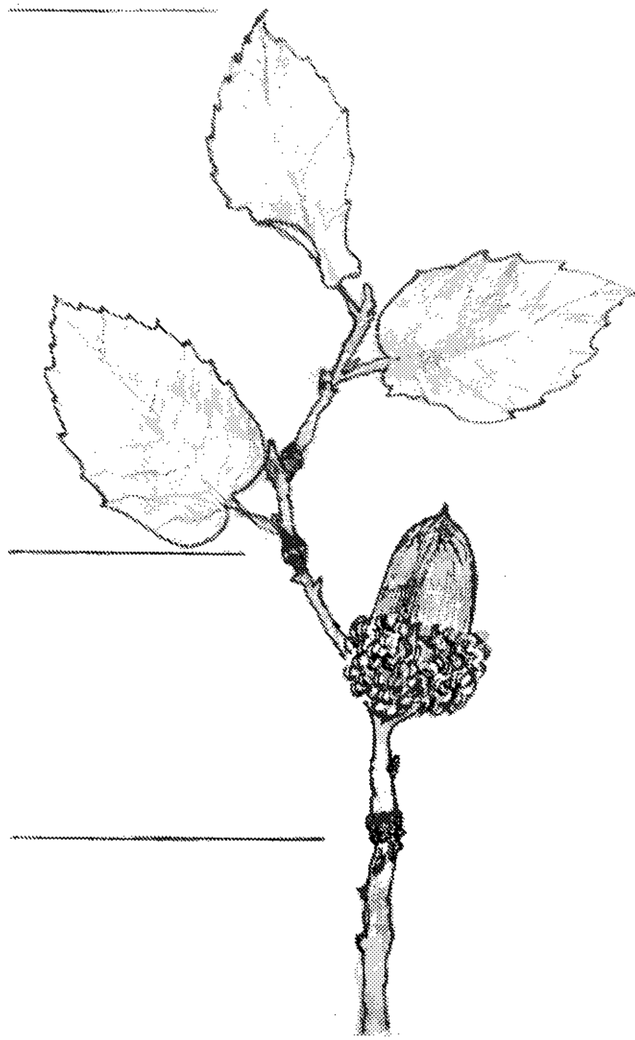


Figure 6.1: A three-years old branch of *Quercus ithaburensis*. Figures represent the first, second and third year of the branch.

2 Acorns - number of acorns and ripening stage;

3 Development stages in leaves - 5 stages were diagnosed: budbreak, green colour, drying up, autumn colour, shedding.
An estimate was made of the total number of leaves on the branch and the number of leaves in each phase, and expressed by % of the total number of leaves. At the break-out stage we also included buds that had not yet opened, and at the shedding stage leaves that had already been shed were also taken into account;

4 Lignification stages of branch sections (1 - green and soft; 2 - green and hardening; 3 - brownish and hardening; 4 - brown and hard).

At the close of our observations (April 1979), all the branches were sawed off and cut into segments. The number of cambial rings in each segment was established with the aid of a binocle.

Since by that time a number of branches had either been shed or partly eaten, only partial data were collected on these, with due note being taken of time and cause of damage.

6.2.3 *Cambial rings in adult trees*

6.2.3.1 Collection and handling of woody material: Examinations of cambial rings were carried out on felled trees as well as on living trees.

1. Examination of cambial rings on felled trees: we examined two *Quercus ithaburensis* trees in the Yahudia Reserve that had been felled to make room for a road. These were felled in a typical *Quercus ithaburensis* forest plot, 200 m above sea level, in summer 1978. Section, sliced off from the trunk bases, were planed, smoothed, and their cambial rings counted. Ring-widths along two radiuses were measured, with the aid of a binocle, to a precision of 0.1 mm.
2. Examination of rings by drilling: in the autumn of 1973, we examined 13 *Quercus ithaburensis* trees in a typical forest at 200 m altitude *). The examination was carried out with the aid of a 20 mm-diameter, hollow mechanical drill. Drilling was effected 70-90 cm above ground, piercing

*) Examinations were carried out by Professor J. Felix of the Bar-Ilan University conjointly with the author, who hereby wishes to express his gratitude.

the centre, or near-centre of the tree trunk. The number of cambial rings in the cores extracted was counted, and the tree's circumference at the drilling point measured. In one of these cores we measured the width of rings down the long radius. Two of the trees were found to be hollow, and hence their data are incomplete (see photo 6.1).

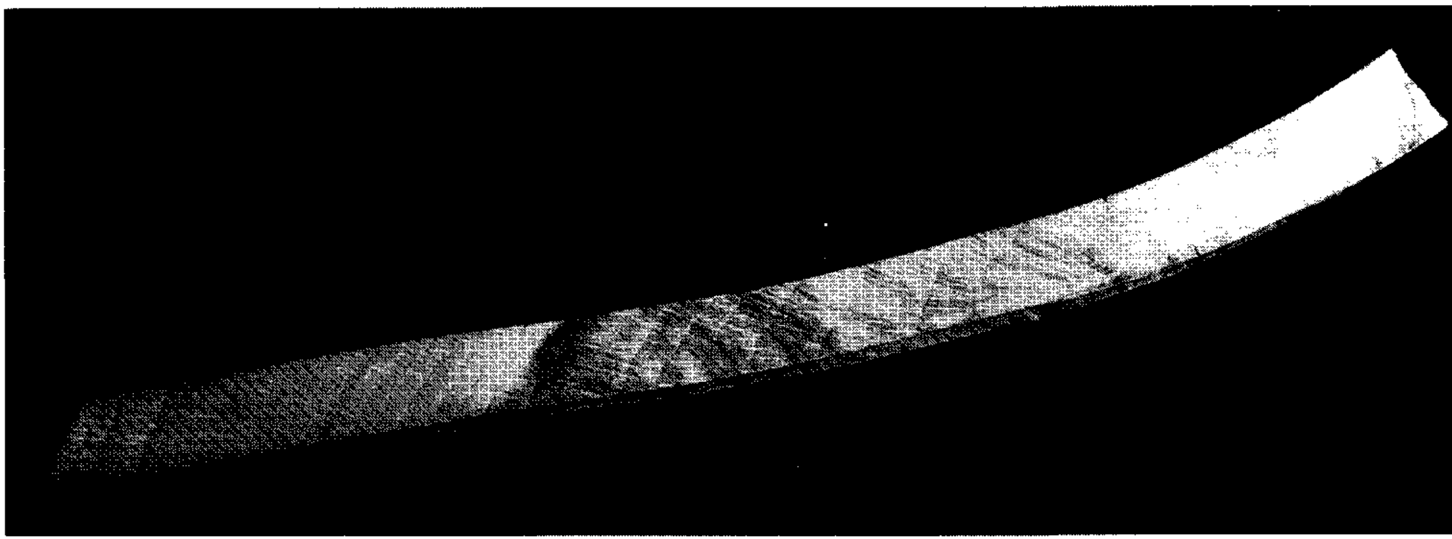
6.2.3.2 Determination of age: In estimating the age of a tree we employed two methods:

1. Cross-dating (modification of Zeuner, 1958). In accordance with which a graphic-visual resemblance between annual precipitation graphs and cambial ring widths is established, the basic assumption being that the variations in quantity of annual precipitation are proportional to the variations in annual ring widths. Given the fact that the graphic-visual method was used by us, the results should be regarded with reservations. We used the following precipitation data:

	Distance from Yahudia (km)	Direction from Yahudia (degrees north)	Average annual precipitation (mm)	Data years	Source
Yahudia			544	1872-1980	Personal measurement
Ayelet Hashahar	15	307	434	1921-1977	Meteorological Service, Israel
Mikve Israel	133	221	553	1915-1977	Meteorological Service, Israel
Kuneitra	24	22	857	1935-1977	Meteorological Service, Israel
Beirut	110	350	893	1877-1960	Felix, 1968

2. Determination of age based on tree circumference: the 12 trees, whose cambial rings we counted, were also measured for circumference, and from this we arrived at an estimate of the average radius of the trunk. We examined the linear correlation between the square of the radius (proportional to the section surface) and the number of rings, and found that there was satisfactory correlation. A correlation graph was drawn up accordingly.

Photo 6.1: A core drilled out of a *Quercus ithaburensis* trunk for the determination of annual cambial rings.



The circumferences of 400 adult trees in four forest plots (G, P, D, Y in map 3.2) were measured - 100 trees in each plot. The circumference was measured with the aid of a measuring tape, at a height of 80 cm from the ground. Tree radii were calculated on the basis of circumference, and number of rings estimated on the basis of the correlation-graph formula.

6.3 Results and Discussion

6.3.1 *Foliage Development Stages*

Figure 6.3 is a schematic illustration of the various stages of foliage development the data of which are based on the mean of single trees and plots examined. Figure 6.7 on the other hand presents foliage development data from one forest plot only, showing separately the percentage of trees in which the phenomenon under discussion was observed, and the percentage of its occurence among the trees (see 6.2.1), and stresses the variability obtaining among the trees.

6.3.1.1 Growth Break-Out: In the majority of cases bud break-out occurred in one-year old twigs. This is a fast process, normally terminating within one month. Initial growth break-out in every one of the ten branches examined in each year was in February. In two branches a second break-out was recorded in March-April. This break-out, which occurred in the extension of the twig which had been the first to bud, had its source in the same bud but did not form an additional cambial ring during that year. A second break-out was recorded in another twig, in May, and this, too, had come from a bud which had broken out first, but this break-out did form an additional cambial ring. The phenomenon of late spring break-out occurs only on a small scale, as can be seen from figures 6.3 and 6.7. The percentage of trees breaking out in secondary budding in May in minimal, and so is the rate of break-out in the trees concerned.

If autumnal break-out occurs, it does so on a very small scale (figure 6.7 a, September-October 1978), albeit in most trees. The phenomenon, however, does not repeat itself year after year, and its causes are not in general sufficiently clear to us.

In the wake of a forest fire there may be a late summer break-out, or else a more significant autumn break-out (see figure 6.7 a, September and Novem-

Fig. 6.2: Lignification phases of a *Quercus ithaburensis* branch (schematic mean data).

Fig. 6.3: Leaf development and shedding phases of *Quercus ithaburensis*, each phase being expressed in percentage of total number of leaves.

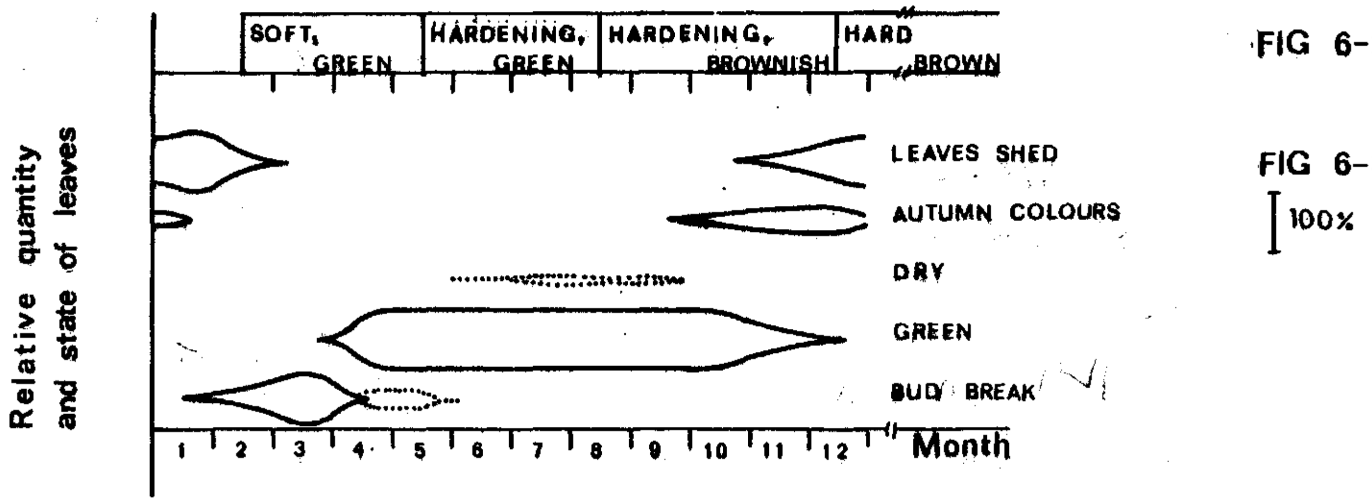


FIG 6-2

FIG 6-3

Figure 6.4: Growth and lignification phases of an upper branch of *Quercus ithaburensis*.
Lower curve - youngest branch; Upper curve - older branch.
.... soft, green; -.-.-.-.-.-.-. hardening, green; --------- hardening, brownish; ———— hard, brown.

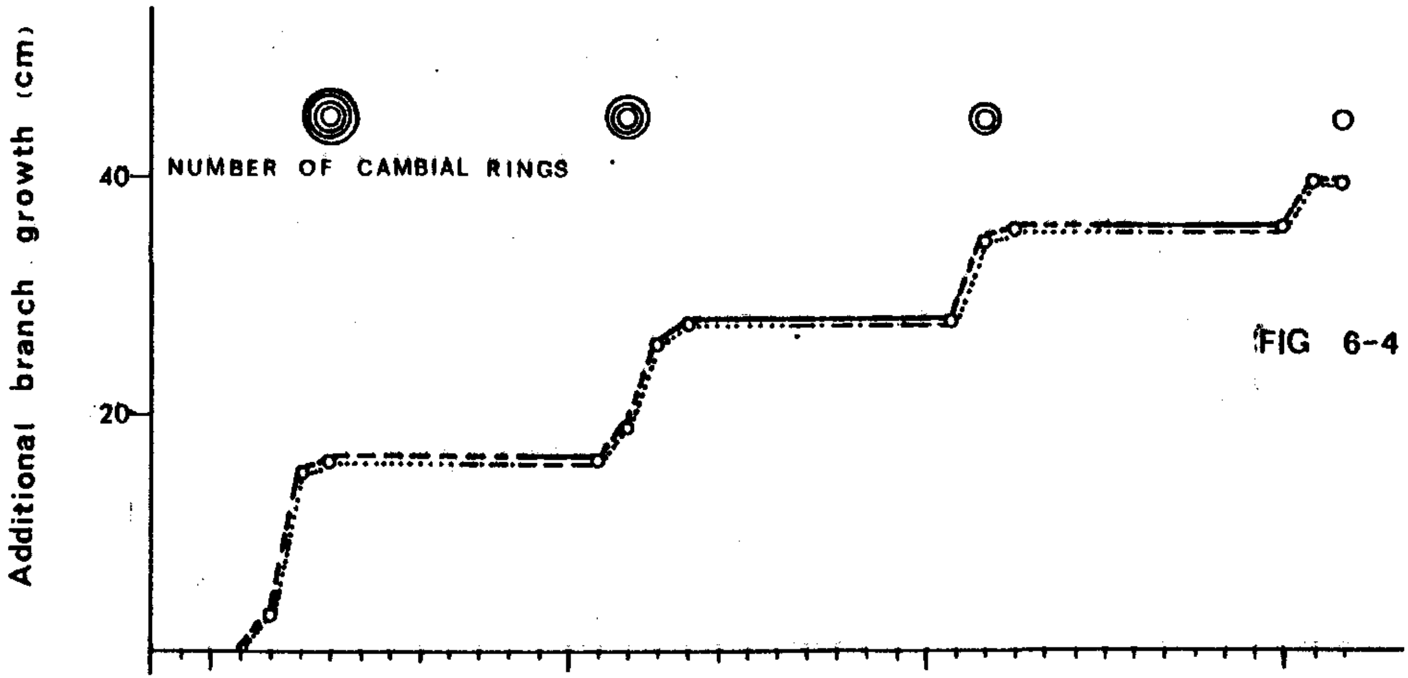


FIG 6-4

Figure 6.5: Staminate flowering of *Quercus ithaburensis*.

Figure 6.6: Development and ripening of *Quercus ithaburensis* acorns. 0 : unripe; ● : ripe; I : shedding. Figures represent the number of acorns on the branch.

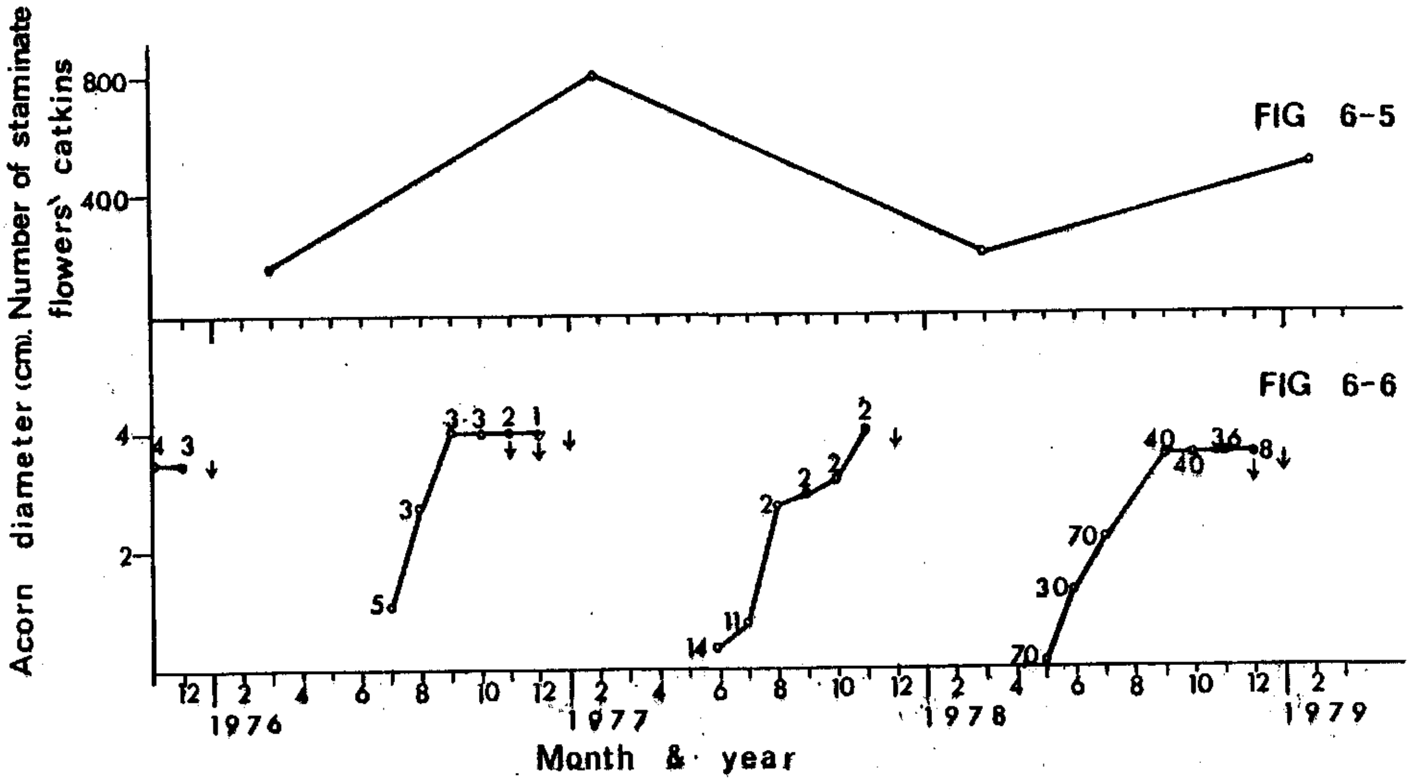
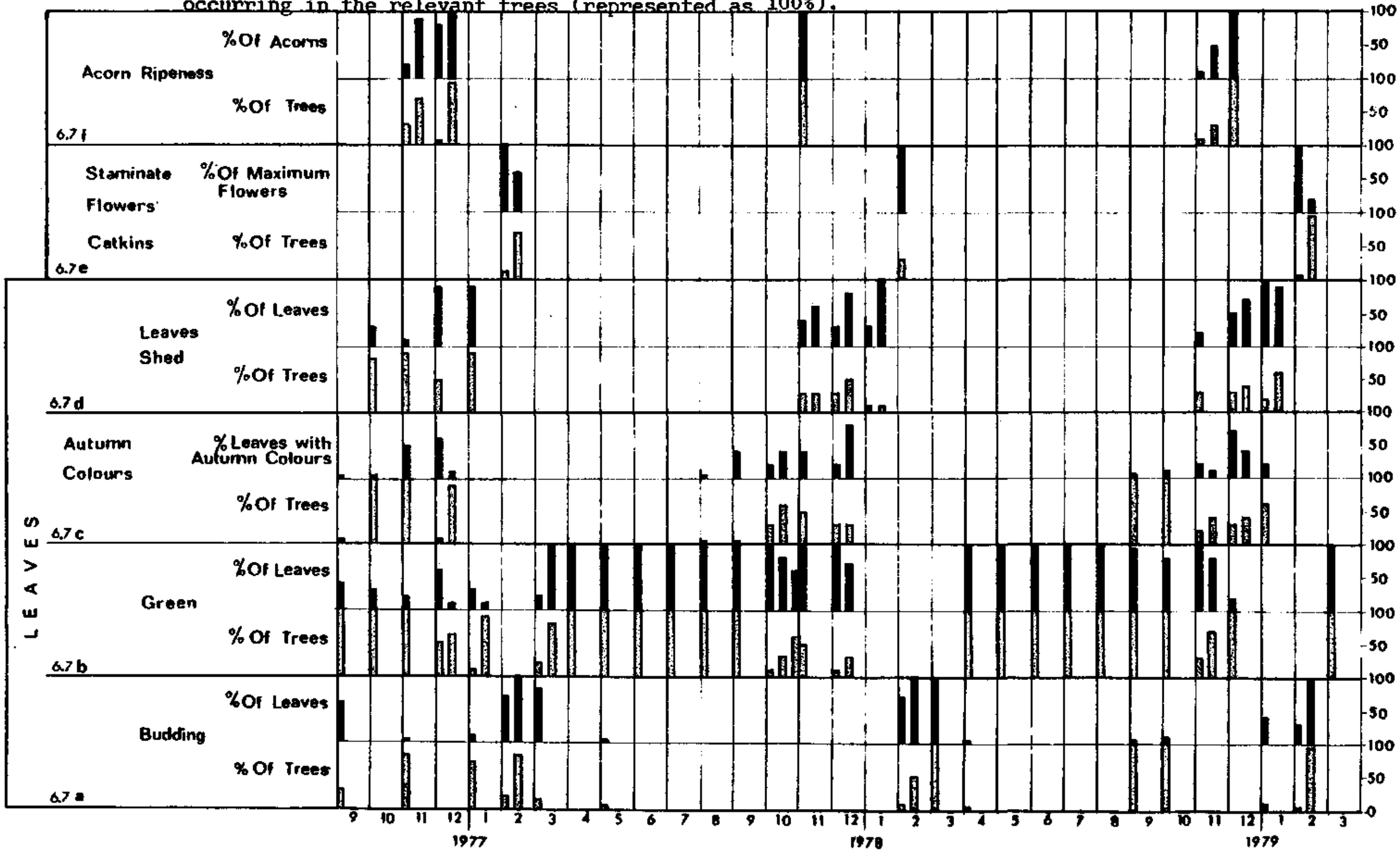


Figure 6.7: Quantitative representation of life cycle of leaves, flowering and acron ripening in a representative plot of *Quercus ithaburensis* forest. Dotted diagram represent percentage of trees having the phenomenon; full diagram, above the dotted diagram, represent percentage of phenomenon occurring in the relevant trees (represented as 100%).



ber 1976).

Fahn (1951), too, points out that *Quercus ithaburensis* occasionally produces autumn rings; these are false rings having their origin in autumn break-outs occurring after a pause in cambial activity at the beginning of summer. Katzenelson (Katzenelson, J., 1975, personal information) examined *Quercus ithaburensis* trees in the Mt Tabor region, Israel, that were felled first in 1945, and again in 1954, and found that in each trunk there were only 9 rings, and that no additional rings had been formed in consequence of summer break-outs occurring in the wake of grazing or fires.

6.3.1.2 Green leaves: A description of the appearance and disappearance of green leaves is given in figures 6.3 and 6.7 b which show that the tree bears green foliage during a period of 8 months. The transition from young leaves to green adult leaves is relatively quick and uniform (see figure 6.3, April; figure 6.7 b, March 1977, April 1978, March 1979). The transition to autumn colouring is slower, lasting from October to December (figure 6.3), although the rate of process varies from tree to tree (see figure 6.7 b, October-December 1977, November 1978).

6.3.1.3 The shedding process: Shedding, from the first appearance of autumn colouring until completion of process, occurs between the end of September until January (see figure 6.3), there being no uniformity in trees with regard to the rate of the process (see figure 6.7 c, d, September-January). Shedding itself usually begins in November, though after a fire this may be advanced to September.

6.3.1.4 Drying-up of leaves: The drying-up of leaves is an accidental process, caused by outside factors not always transparent enough, and noticeable in the summer months (see figure 6.3). The majority of cases we observed were results of fires. We should stress here that this is a tree's normal reaction to fire. In many cases, dried-up leaves remain on the tree also in winter. It can be assumed that the shedding processes are halted and no absiccion tissues formed in such cases.

Figure No. 6.7 accentuates the variability in trees' leafing phases. During transition periods between phases, groups of trees may be found at different transition stages - a phenomenon which is one of the expressions of genetic variability obtaining in the *Quercus ithaburensis* tree species (see 1.1).

6.3.2 *Branch-growth and maturation*

6.3.2.1 Branch growth: A graphic description of the growth of a representative branch of a *Quercus ithaburensis* tree is given in figure 6.4. We have shown only one representative branch because, so far as annual branch-growth was concerned, no significant differences between plots, or years, could be detected - and this because of the considerable variability in annual growth. Mean annual growth registered in single branches was 4.4 ± 3.9 cm. In calculating annual growth for plots, we found that minimum growth was 1.1 ± 0.3 cm, and maximum 4.4 ± 0.6 cm per year, with no significant differences between years or between plots. Branch-growth in that year took place during February-April, in which latter month the annual branch attained its maximum length (figure 6.4).

6.3.2.2 Lignification of branches: In figure 6.4, the stages of branch-lignification appear parallel to the growth-graph of the single branch. The figure shows the two youngest branch sections, from initial growth to full lignification. Figure 6.2 completes these data on the basis of observations in the plots and of single branches. It follows from these two figures that the metamorphosis from green, soft twig to green, hardening twig occurs in the month of May; the transition to brownish, hardening twig in the month of August, and transition to mature, brown and lignified twig in the month of December, the young branch having passed these phases concurrently throughout its whole length.

6.3.2.3 Shedding of branches: This phenomenon was recorded in 5 out of 10 branches. In four cases this was a one-time occurrence, with the youngest, one-year old twig being shed, whereas in one case the phenomenon repeated itself during two consecutive years, causing the shedding of an adult branch (some 10 years old). In all these cases, shedding was accompanied by the formation of absiccion tissue between the point of growth termination of one year and that of growth commencement of the next.
Shedding occurred in different months (January, February, March, July, September), and it is difficult to relate it to any defined outside factor. We can only assume that branch-shedding represents an auto-mechanism for keeping a balance between height of tree and mass of foliage. Given the fact that *Quercus ithaburensis* is a shallow rooted, water-wasting tree (Littbach, 1953; Eig, 1935; Oppenheimer, 1950), such a mechanism is likely to safeguard

a positive water balance (see also further on in chapter 11).

6.3.3 *Flower and fruit development*

6.3.3.1 Flowering: The numbers of male catkins flowering on a single branch during 4 seasons are shown in figure 6.5. Figure 6.7 e represents the percentage of flowering trees in a representative forest plot. The percentage of male flowering being calculated on the basis of tree's flowering potential in that year. It follows from these two figures that the brief flowering period was limited to the month of February. Flowering occurred prior to, during, or after leaf bud-break (compare figures 6.7 a and 6.7 b), with considerable variability in flowering intensity between trees.

Annual intermittency in flowering intensity, as expressed with regard to on single branch (in figure 6.5), is representative of the majority of single branches examined and data on which have not been given. As against this, the phenomenon does not find expression in the mean flowering-intensity calculation regarding forest plots (e.g. figure 6.7 e). It can be said therefore that the intermittency in question is an extant phenomenon in *Quercus ithaburensis* which, while not occurring in all trees simultaneously, keeps pace with the rhythm of each individual tree.

6.3.3.2 Acorn-development and ripening: Figure 6.6 shows the thickening progress of acorns on a single branch. From flowering in February until May in the following year, acorns are too minute to be measured. Hence, data in figure 6.6 represent acorn-thickening from May in second year until full ripeness. Measurings in the forest plots showed that the growing period extends from June-July (at which time acorn-diameter is 1.1 ± 0.5 cm) until September-October, when acorn attains diameter of 3.6 ± 0.4 cm (mean measurings from 3 plots over 3 years). Since the rate of acorn-lengthening in May-October was found to be similar to the rate of acorn-thickening during that period, we abstained from giving data on this here.

Ripening of acorns generally begins in November (figure 6.6 - dark dots; figure 6.7 f). Ripeness is expressed by darkening and shedding of acorn. Shedding is at its height in December, continuing sometimes until the beginning of January. This process varies from tree to tree, as shown in figure 6.7 f, November-December 1976; November-December 1978).

The percentage of acorns attaining full ripeness varies considerably from branch to branch and from year to year, reaching 32 ± 20% of the number of acorns in May. Since this percentage was not found to differ significantly from year to year, or from plot to plot, the data given can only express an approximation. Each observation in figure 6.6 is annotated with the number of acorns that were on the branch. Furthermore, it follows from this figure that shedding of the majority of unripe acorns takes place until September, after which time there is virtually no more shedding of unripe acorns.

Ripe acorns appear exclusively on two-year old branches (see figure 6.1), and have their origin in flowering which occurred 21-22 months prior to full ripeness of acorn. All the same, we found no parallel between male-flowering intermittency and acorn yield in the following year.

6.3.4 *Cambial rings and establishment of tree age*

6.3.4.1 As already stated above, we found that generally one annual ring (see 3.1) was formed in branches examined by us, with the exception of rare cases of false rings appearing as a result of autumn budding. A number of researches were made of Israel's wild flora, regarding the correlation of annual ring widths and precipitation (Waisel and Liphshitz, 1968; Liphshitz and Waisel, 1967; Felix, 1968). Figure 6.8 gives sketches of cambial ring width and number of rings in mature trees examined by us, paralleled by graphs of annual precipitations. Given the small number of false rings having possibly been included in the ring measurings, and a number of particularly fine rings that may not have been included, we abstained from seeking for a precise quantitative correlation between a ring's width and that year's amount of precipitation, and made comparisons on a purely visual basis. We established that graph sections showing relatively similar fluctuations corresponded with the same year-group.

Figure 6.8 presents the graphs in such a way as to show the last ring matching the year of felling. Here, we compared the shift of the ring-width curves with the matching precipitation-curve sections, and found deviations of 1.1 ± 1.3 rings as compared with years. Given this circumstance, the number of rings can safely be taken to represent a tree's age by way of reasonable approximation.

The imperfection of correspondence between ring-width curves and precipitation curves may be related to omission of a fine ring rather than to imprecise measuring or inclusion of a false ring. It is also possible that,

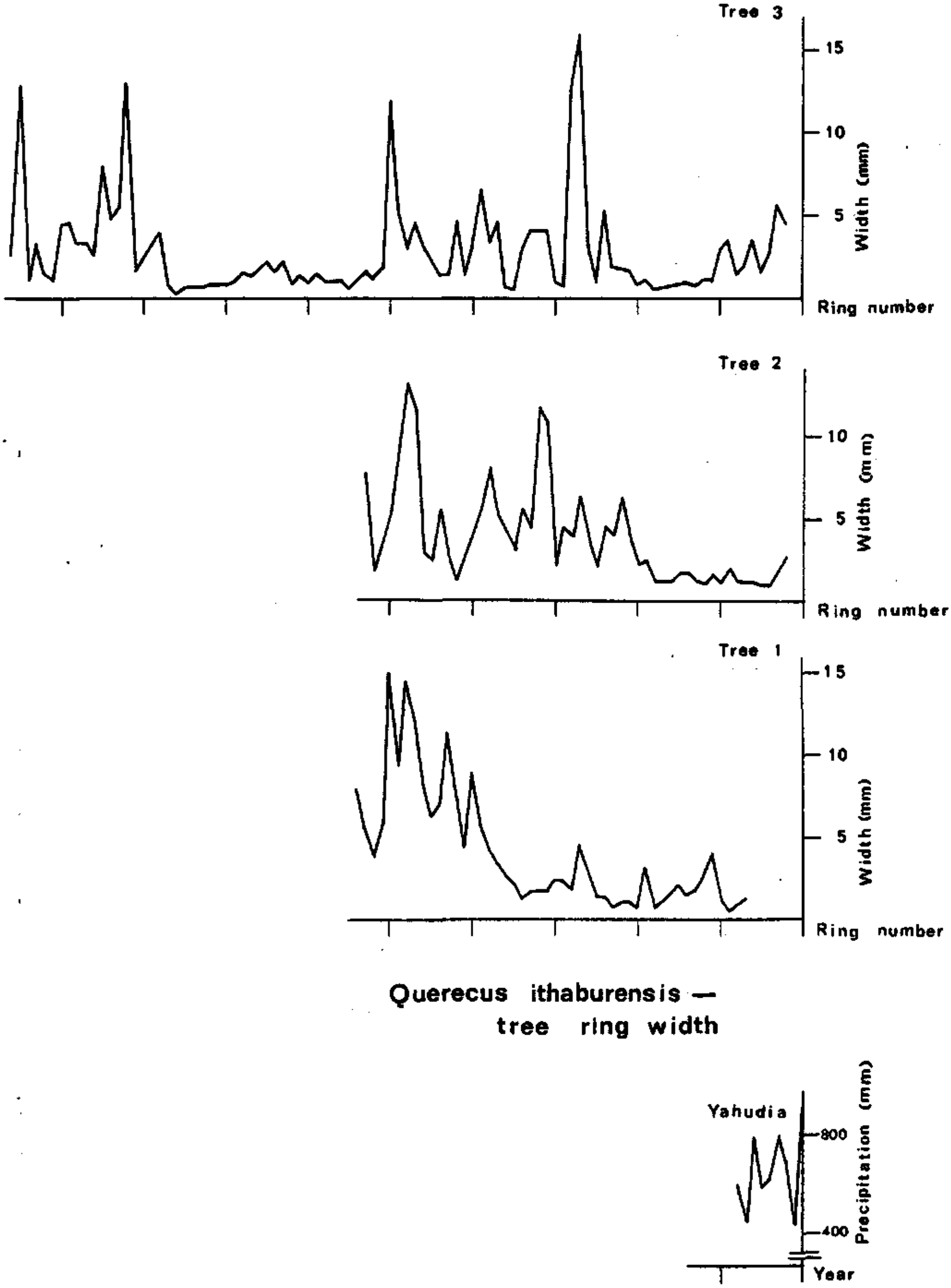
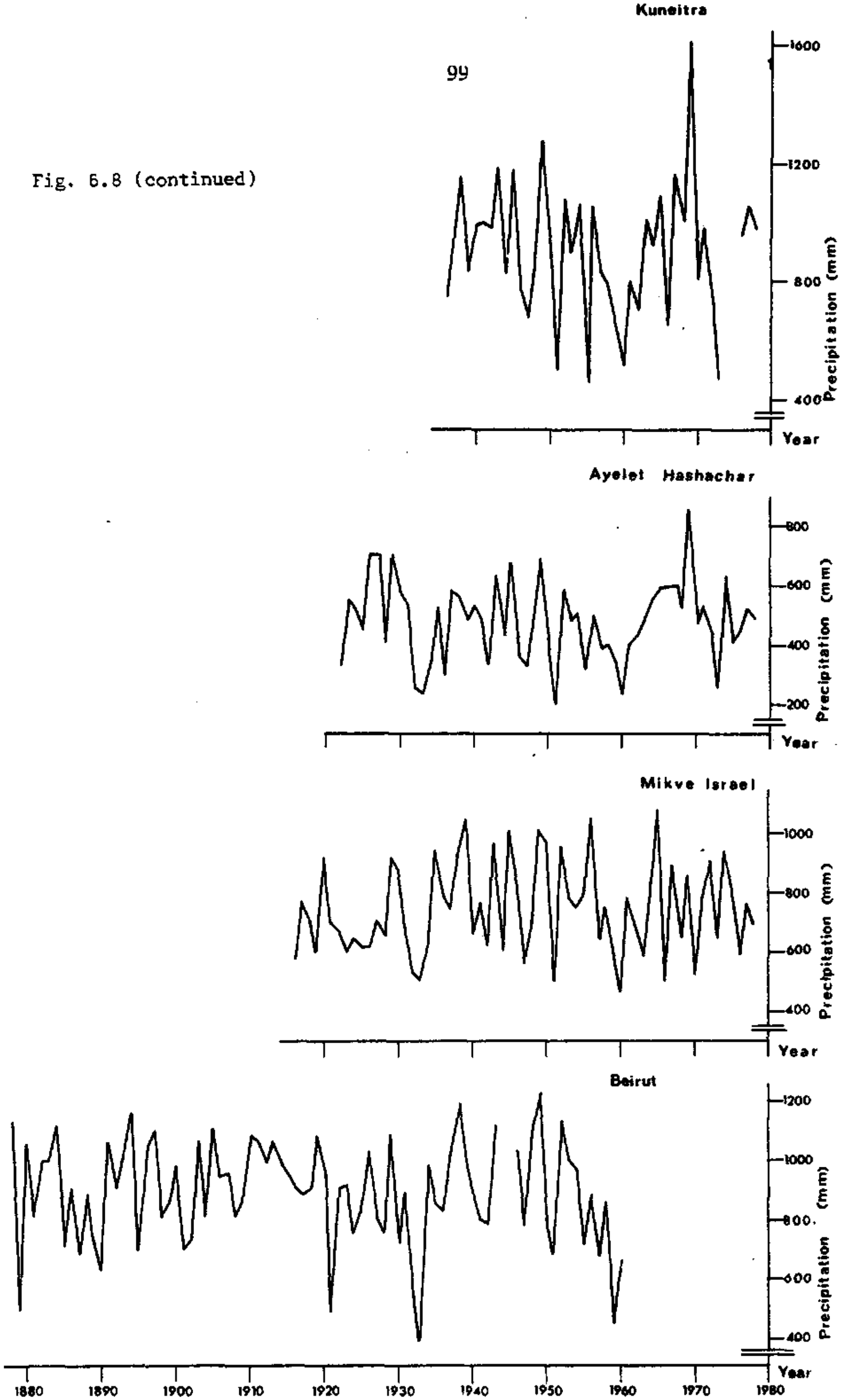


Figure 6.8: Cambial ring width and numbers in 3 mature trees, paralleled by graphs of annual precipitation in Beirut, Mikve Israel, Ayelet Hashachar, Kuneitra and Yahudia.

Fig. 6.8 (continued)



Yearly precipitation

under certain conditions, a tree will react to changes in precipitation with a year's retardation.

Figure 6.9 represents the linear interdependence of age of tree and the square of the trunk radius. Notwithstanding the scantiness of points on which the graph is based, the correlation coefficient is high ($R = 0.926$), thus enabling us to express age as a function of the square of radius in the following manner: $age = 0.05348r^2 + 35.24477$.

The broken lines in the figure represent the confidence range of calculated age in accordance with the correlation curve. This confidence range increases with the lengthening of the radius, thus reducing measuring reliability with regard to higher ages.

The ages of the 400 trees whose circumferences we measured were calculated on the basis of the graph formula, resulting in the age distribution shown in figure 6.10. Distribution is limited to trees above the age of 30, in accordance with the correlation curve on the basis of which it was calculated. 72% of trees from the 35-55 age group were found to have re-grown from stumps, so that the measurings made were actually those of the ages of branches which had re-grown after felling.

6.3.4.2 Discussion: The ascertainment of a linear connection between age of tree and square of trunk radius affords us an important means in estimating age of trees in the Yahudia Forest simply by measuring a tree's circumference. Measuring accuracy error-margin is ± 10 years up to age of 90, diminishing to ± 35 years in ages of 150-190.

The age distribution which has been calculated on the basis of this connection and is represented in figure 6.10, shows that 73.5% of the trees are 35-55 years old, although the fact that most of these are regrowths from stumps indicates that they are actually much older and that the relatively young appearance of the forest is the result of felling.

From a reconstruction of the principal periods during which tree-felling was carried out in the region from the 19th century onwards (see 3.4, 5.1), we learn that trees were felled by Bedouins for their charcoal industry in mid-19th century (Porter, 1967), but that the really massive tree-felling was effected by the Circassians, who inhabited the Golan Heights in the

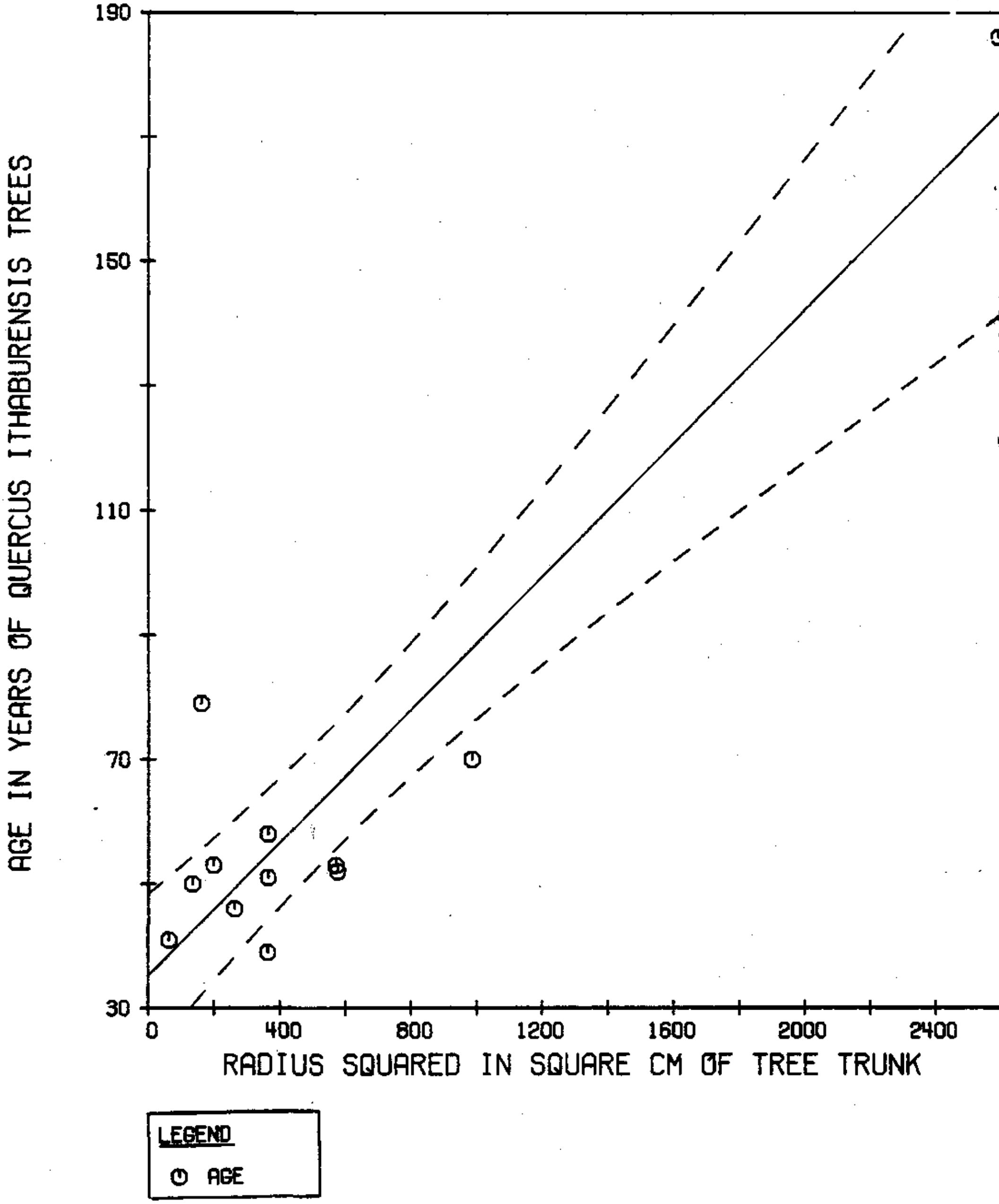
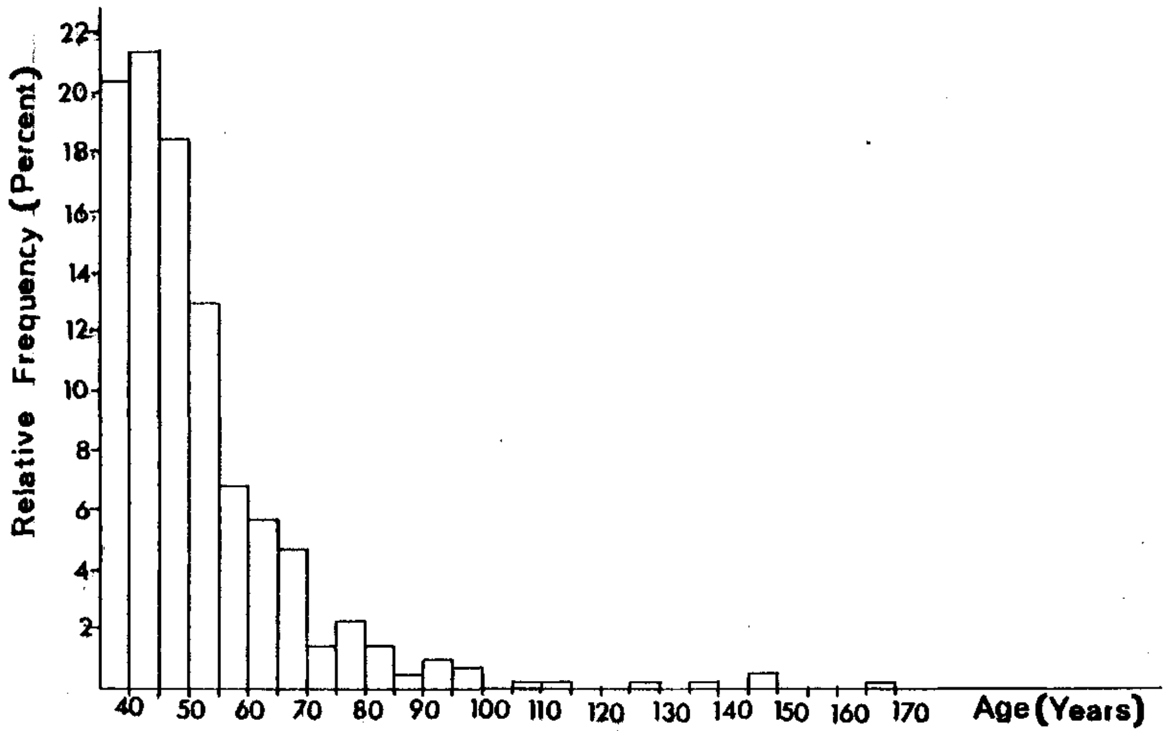


Figure 6.9: Age of adult *Quercus ithaburensis* trees in the Yahudia Forest as dependent on square radius of trunk. The two broken lines represent the confidence range of calculated age in accordance with the correlation curve. Age = 0.05348 r^2 + 35,24477; Correlation R = 092648; Significance R = 0.00001.

Figure 6.10: Age distribution of adult *Quercus ithaburensis* trees in Yahudia Forest represented in relative frequency.



Seventies of the 19th century, as witnessed by Schuhmacher (1888): "..... these same Circassians are rapidly lessening the oak woods, as they cut down the fine trunks and carry them on their horribly squeaking, two-wheeled carts drawn by oxen, to sell as timber."

No doubt, the modernisation introduced by the Circassians with their carts played a major rôle in the felling of oak trees on the Golan.

An additional wave of tree-felling on the Golan began in 1905, with the construction of the Haifa-Damascus railway through the southern Golan, lasting until the end of World War I in 1918, during which period the Turkish army's timber requirements were huge, and the lack of regular supplies from abroad resulted in considerable numbers of trees being cut down (Gishon, 1969).

If we look at figure 6.10 again, we shall see that only few trees have survived from the period of Circassian settlement (about 100 years ago), and a small number of trees from the period of World War I (upwards of 60 years). After this period, a recovery can be discerned and the number of trees, some of which are mere regrowths from stumps, increases.

It appears that trees continued to be felled, although on a smaller scale, also during the period of the French Mandate, which came to an end in 1946. The Syrian Government prevented tree-felling (Gal, 1978), and thus a further recovery from tree stumps is discernible after this period.

As a result of the many fellings, figure 6.10 does not show the natural age distribution in the forest. Such distribution would probably show a record of 55-65 year-agers, if we discount trees regrown from stumps and try to estimate their true ages, though it must be remembered that there is no well-founded basis for such estimate. We shall be discussing this subject again after going into the question of germination and establishment of *Quercus ithaburensis* (see chapters 8 and 11).

7 ACORN YIELD, COMPOSITION, GERMINATION CHARACTERISTICS, AND THEIR APPLICATIONS

The fruit of *Quercus ithaburensis*, the acorn, plays an important rôle in the ecological system of the Yahudia Forest, constituting as it does the source of the forest's continued existence, and providing sustenance for the animals, and in particular for rodents, wild boar, and cattle grazing in the reserve.

In this chapter, we shall be looking at the tree's acorn yield, the acorn's chemical composition, its survival in the forest area, and some of its germination characteristics.

7.1 *Quercus ithaburensis* acorn yield and survival

7.1.1 *Methods*

The numbers of acorns produced by the *Quercus ithaburensis* trees, of acorns eaten by animals, and of acorns which survived in the area, were checked methodically over a period of three years. Counts were made twice a year - first at the time of maturation when the acorns had grown to their full size (end of October), and again at the time of full ripeness when acorns had turned brown and were being shed (mid-December). Counts were made in three plots representing also three different types of grazing regimes: a plot being grazed by cattle and foraged by wild boar - a plot free of cattle grazing, but foraged by wild boar - a plot free of cattle grazing of wild boar foraging (Y, D, B respectively on map 3.2).

In each plot we selected 8 adult *Quercus ithaburensis* trees. Counting, which was effected on the trees as well as on the gound, also included the acorn cupules of that season (easily distinguishable by their lighter colour). The difference between the number of cupules and the number of acorns on the ground gave us an indication as to the number of acorns consumed (this on the basis of observations of cattle, wild boar and rodents which do not eat the cupules - excepting cattle that consume them in negligible quantities - see 10.3.2.2.2).

Where the number of acorns exceeded 300, no accurate count was taken but a mere estimate made in the following manner: on the tree, we selected representative branch units bearing a certain, regular number of acorns; the branch units were counted and their number multiplied by the number of acorns in a unit. On the ground, the estimate was made in a similar fashion, by taking squares of varying sizes, but containing a fixed number of acorns, and multiplying the number of squares by the number of acorns they contained.

7.1.2 *Results and discussion*

Table 7.1 presents the results of observations made in the fixed plots under different grazing regimes.

The left part of the table shows productivity of the trees in the three plots, according to counts taken over three years. The right part shows the percentages of acorns consumed by animals up to mid-December, calculated from the yield.

7.1.2.1 Acorn Production: From an analysis of the results in table 7.1, the following conclusions can be drawn with regard to the differences between trees as far as their acorn production is concerned.

Trees differ greatly in their fertility. Differences are expressed even in order of magnitude, some trees producing thousands of acorns per year while others bring forth only a few dozens.

Differences between years: the fertility of a tree changes from year to year - at times even in one or two orders of magnitude. The low acorn production in 1976 was significant in comparison with that in 1974 and 1975 (at a level of 0,01 at least) while no significant difference in the rates of production in 1974 and 1975 was recorded (Rank test of Wilcoxon-Mann-Whitny). At the same time, however, there is no indication of bi-annual alternation such as we found with regard to the flowering of *Quercus ithaburensis* (see 6.3.3.1). Fluctuations in fertility and individual differences between trees were noted by us also in chance observations recorded over a number of years.

7.1.2.2 Effects of grazing on acorn production and survival: From table 7.1 it follows that there are no significant differences between the various grazing regimes as far as acorn yields are concerned. On the other hand, with regard to the percentage of acorn consumption (calculated as the percentage of acorns consumed out of a tree's total acorn yield in that year), differences were found between types of regimes. The percentage of

Table 7.1: Acorn yield of fixed trees in fixed plots under different grazing regimes in the Yahudia Forest, and percentage of yield consumed by animals.

	Productivity (number of acorns)								
Grazing regime	+ cattle + boar			- cattle + boar			- cattle - boar		
Year	1974	1975	1976	1974	1975	1976	1974	1975	1976
	3500	1800	250	95	1420	50	1180	580	3
	12	100	22	0	24	10	33	325	2
	540	180	300	1550	40	4	3512	1250	12
	25	0	2	25	35	1	4	550	13
	37	3000	350	1800	150	20	402	1000	40
	218	65	350	1800	7800	0	1480	3400	86
	4300	2300	45	0	620	4	0	140	0
	1100	2100	1200	4700	1300	12	0	850	4
Yearly mean	1217	1193	315	1246	1424	13	826	1012	50
grazing regime mean		908			894			619	
Total mean					807				

	Consumption up to December 15 (% of productivity)								
Grazing regime	+ cattle + boar			- cattle + boar			- cattle - boar		
Year	1974	1975	1976	1974	1975	1976	1974	1975	1976
	14	28	72	42	14	48	0	12	0
	83	0	82	—	42	80	0	12	0
	56	83	57	97	50	75	0	20	58
	80	—	50	0	50	100	0	56	46
	41	33	71	14	50	57	0	30	100
	5	23	26	100	83	—	0	24	34
	10	22	18	—	32	50	0	50	—
	45	43	21	57	15	75	0	32	75
Yearly mean	42	33	50	52	42	69	0	30	45
Grazing regime mean		43			55			24	

acorns consumed in a plot free of cattle and wild boar was significantly lower than that in the two plots under different grazing regimes (significance level 0.01; Rank test of Wilcoxon-Mann-Whitny), while no significant difference was recorded between the plot under cattle grazing and the plot free of cattle grazing.

When comparing the differences between the years with regard to the rate of acorn consumption, a tendency towards increase is discernible only in the plot free of cattle and wild boar. The acorn consumers in that plot are rodents. The plot concerned was closed to grazing in 1973, since when it appears there has been a rise in the rodent population. The Rodent Survey, too, (see 4.1.2.3.2) shows a bigger population in that particular plot. The tendency towards a rise in the consumption of acorns by rodents in this plot reinforces our assumption (see 4.2.2.3) that the absence of wild boar as a competitive factor in the matter of food, as well as devourer of rodent young, leads to a rise in the rodent population.

In our observations of animal acorn consumption, we discovered that rodents also eat acorns that are still on the trees, and we even found rodents' 'dining tables' on rocks, with as yet unripe acorns (4 October 1974, see also 4.1.2).

Acorn consumption by wild boar usually takes place during a brief period and is almost total. At the ripening season, the wild boar disperse among the oak trees, and wherever they go they finish off most of the acorns lying on the surface of the ground, sometimes returning to the same plot once again at the end of the ripening season.
At the beginning of January there generally remain no acorns on the trees, and none openly visible on the surface of the ground.

Acorn consumption by cattle is more moderate. Although we did observe that the cattle look for acorns and eat them while passing from tree to tree, comsumption is not absolute. On the subject of acorn consumption by cattle, see 10.4.2.2.

Table 7.1 does not show any significant differences either between plots under cattle grazing and plots free of such grazing, while the absence of wild boar was seen to have a definite effect on the number of surviving acorns.

7.1.2.3 The impact of fire on acorn yield and ripening: In our observations of acorn crops following conflagration, we found that the tree and its acorns suffer damage up to a height of 2-3 metres from the ground in the same year, while acorns growing higher up remain unaffected and will reach maturity (see also 9.3.2). However, in the following year there is a conspicuous lessening in the number of acorns in all the conflagration areas of the forest. A fire broke out in July 1975 in plots where acorns counts had been made by us (table 7.1). It appears that the low acorn yield in 1976 was the result of this fire. The young acorn forming in February, suffers from a fire the most in its first summer, but less in the second.

7.2 Composition of *Quercus ithaburensis* acorns

7.2.1 *Methods*

Ripe acorns of *Quercus ithaburensis* were collected in 4 sampling batches, in a typical *Quercus ithaburensis* forest plot, on three different dates (Y, see map 3.2). Each batch was collected at the peak season of acorn shedding, the acorns being fresh and easily detachable from their cupules while still on the tree. Each sampling batch weighed 500 gr and contained acorns with shells, without cupules, from 10 different trees. The samplings were analysed by three different laboratories [*)], and examined for their percentages of dry matter, protein, fat, ash, cellulose and nitrogen-free extracts. One of the samplings was also examined for its percentage of tannins and for its digestibility in an artificial rumen. In another sampling the shell was removed from the pulp, and each component examined separately. A sampling of maize corns was also examined for comparison. Composition was determined by the standard methods of the Association of Official Analytical Chemists (1975), and digestibility according to Tilley and Terry (1963).

---

*) I am grateful to: the Michael Laboratories, Gush-Etzion
the Volcani Centre Animal Research Institute
the Zemach Fodder Institute.

7.2.2 *Results*

Table 7.2 registers the results of laboratory analyses of *Quercus ithaburensis* acorns.

Table 7.2: Chemical composition of *Quercus ithaburensis* acorns.

		Composition						
		Percentage of dry matter						%
Date	Dry matter %	Protein	Fat	Ash	Cellulose	Nitrogen-free extracts	Tannins	Digestibility
Dec. 1975	57.1	3.5	5.3	1.9	11.0	78.3		
Nov. 1978	60.0	5.0	5.0	2.2	10.8	77.0		
Nov. 1978	61.9	5.0	5.2	1.7	10.1	78.1		
Nov. 1979	57.4	4.4	4.2	2.0	9.4	80.0	4.1	71.0
Mean	59.1	4.5	4.9	2.0	10.3	78.4	4.1	71.0
S.D.	2.3	0.7	0.5	0.2	0.7	1.2		
Nov. 1978	63.3	5.1	5.8	1.5	6.6	81.2	Pulp only	
Nov. 1978	52.8	4.7	1.5	3.1	33.7	57.0	Shell only	
Nov. 1978	87.0	7.4	5.5	2.0	4.0	77.0	Maize corns	

7.2.3 *Discussion*

The chief components of the acorn are nitrogen-free extracts which make up 78% of the seed's dry matter. In view of the high digestibility of the acorn, it can be assumed that the greater part of the nitrogen-free extracts are carbohydrates with smaller molecules than those of the cellulose whose quantity has been defined separately. The principal storage tissues of the seed are therefore the carbohydrates, while fats constitute only 5%.

Acorns as animal food: On the basis of the seed composition, a higher digestibility percentage might have been expected. Tannins being retarding factors in the development of micro-organisms, it is possible that their presence to a certain extent reduces digestibility (Dr. D. Ben-Gedaliah, personal information). But all in all, it appears that the acorns are a concentrated food of the highest value, in composition almost comparable to that of the maize corns. And indeed, the acorns are a significant component of the diet of rodents, wild boar and cattle in the Yahudia Forest (see also 7.1.2; 10.4.2.2).

7.3 Examination of germination and establishement of *Quercus ithaburensis* acorns in nursery experiments, and reflections on applicability

7.3.1 *Vitality*

7.3.1.1 Methods: For the purpose of testing *Quercus ithaburensis* acorn vitality, we used ripe acorns, collected at the peak ripening period when, while still on the tree, they can easily be detached from their cupules. The acorns were collected in a forest plot located 200 m above sea level (plot Y, see map 3.2). In a preliminary test, acorns from 5 places in the Yahudia Forest were examined and shown in soil deriving from 4 different sources within the forest (all in all 20 combinations). As we found no significant differences in germination percentages either as far as the various acorn sources of the various sources of soils were concerned, we made do with acorns and soil taken from a single source. The acorns were sown in pairs, in black perforated polyethylene bags containing about 1 kilo soil. They were sown 2 cm deep, with their longitudinal axis in horizontal position.

7.3.1.2 Results:

1. Seed vitality - nursery experiment: Sowing was effected immediately upon collection of seeds, and percentage of seedlings recorded on two different dates: first - at the end of the germination period (April), and second - about one year after sowing (December), when seedlings are already established, after having survived the summer, and are ready to shed their leaves.

   Herebelow are shown in detail the checking dates, numbers of seeds and seedlings, and percentage of seedlings.

		Quantity of seeds/seedlings	Percentage of seedlings
29.11.73	Collection & sowing of acorns	1012	
21.04.74	Seedling count	993	98
17.12.74	Established seedlings count	870	86 of seeds 87.5 of seedlings

2. Seed vitality - time of sowing, and preservation conditions: Fresh, ripe seeds, collected in forest plot (Y, see map 3.2), were sown 2, 4, 8, 14, 22, 32, 44 and 58 days respectively after collection, 10 seeds being sown on each occasion. One batch of seeds was stored in a net-covered plastic container which was placed in a permanently shady spot in the forest, remaining there from the time of collection until the sowing date. The second batch was stored in a similar container, for the same length of time, but in an exposed spot in the forest. The numbers of seeds that germinated in the different batches and on different dates are recorded in table 7.3.

Table 7.3: Germination of *Quercus ithaburensis* acorns, following delayed sowing after ripening, under shade and exposure conditions. 10 acorns were contained in each sample batch on each date.

Period of delay (days)	2	4	8	14	22	32	44	58
Number of seeds germinating under shade conditions	10	10	10	10	0	10	0	10
Number of seeds germinating under exposure conditions	10	10	3	2	0	0	0	0

Difference between batches was found to be significant at the rate of at least 0.01 (Rank test of Wilcoxon-Mann-Whitny).

3. Seed vitality - effects of *Quercus ithaburensis* leaves: In view of the tendency of *Quercus ithaburensis* leaves to inhibit the growth of certain species (see 7.3.1.3 below), we examined the effects of these leaves on *Quercus ithaburensis* acorn germination. Since in nature conditions the acorns of *Quercus ithaburensis* germinate in beds containing leaves of their own species, we tested germination under similar conditions but

with a number of different concentrations of shed leaves.
Fresh *Quercus ithaburensis* seed collected in forest plot (Y, see map 3.2) were sown in 3 concentrations of shed *Quercus ithaburensis* leaves mixed up with soil. Of each concentration 20 bags were sown.

Leaf concentration is expressed in percentages of soil weight, and the germination percentages in each leaf concentration were as follows:

(%) Leaf concentration	0.6	3.6	21.6
(%) Germination	92.5	85.0	90.0

No significant difference was found between the various leaf concentrations as to number of germinations (Chi-square test).

7.3.1.3 Discussion:

We found that the sowing of fresh *Quercus ithaburensis* acorns under nursery conditions resulted in a high germination percentage (98%), with 87.5% surviving at least until the age of one year. This is in contrast to what we found was happening under natural conditions (see below 8.4.3). There is no doubt that the lack of competition for water from herbaceous plants contributes to so high a percentage of germination and survival rate in nursery conditions as compared to nature conditions.

Under shade and moisture conditions the germination potential is preserved for at least two months. If exposed, the majority of the seeds lose their germination potential after one week; some manage to germinate after two weeks, but no more. Also with regard to *Quercus calliprinos* seeds it was found (Harif, 1974) that they retain their germination potential for 33 days under shade and moisture conditions, while in exposure conditions it lasts only some 8 days, and that the cause of forfeit of germination potential is the loss of water from the acorn.

In examining the possibility of *Quercus ithaburensis* germination inhibition by leaves of adult *Quercus ithaburensis* trees shed in the winter, we obtained a completely negative result. A similar conclusion can be drawn, too, from our observations of natural germination (see below 8.4.3.1), given the fact that most of the seedlings grow near the adult trees within the shedding range of most of their leaves. As against this, it was found that

Quercus ithaburensis leaves do contain germination inhibitors and that, in massive concentration, they caused germination inhibition in 8 species of herbaceous plants that were examined (Dinoor, 1962). Rabinovitch, too (1977) found that extracts of *Quercus ithaburensis* leaves tended to inhibit germination of *Sarcopoterium spinosum*. Our own tests, made without such extracts, but in maximum imitation of natural conditions, showed, as stated, an absence of inhibition as far as *Quercus ithaburensis* acorns were concerned.

7.3.2 *Root and shoot growth in Quercus ithaburensis seedlings*

From a nursery bed sown in December 1975, 10 seedlings each were chosen at random, 1, 2, 3 and 4 months after the sowing date (altogether 40 seedlings), and their root and shoot lengths measured. The results appear in table 7.4.

Table 7.4: Shoot and root lengths of *Quercus ithaburensis* seedlings, and their ratio, 1, 2, 3 and 4 months after sowing.

Date	January 1976		February 1976		March 1976		April 1976	
	shoot	root	shoot	root	shoot	root	shoot	root
mean length (mm)	0	95	30	289	129	321	199	446
S.D.	0	70	22	83	61	93	73	126
shoot/root ratio	0		0.097		0.433		0.465	
S.D.	0		0.08		0.22		0.19	

From this table we learn that the root starts growing earlier and has a faster growth rate than the shoot. Even at the end of the growing season the root is still twice as long as the shoot. Thus no significant linear correlation between shoot and root length was found throughout the entire measuring period.

Examination of the shoot/root ratio did indeed show differences between the first and second, and between the second and third period (at the significant level of 0.005 t test), but no significant difference was found to exist between the third and fourth period. In that season (March-April) the growth rates of shoot and root are slower and the ratio is more or less stable.

There is a conspicuous variability in the different seedlings with regard to their shoot and root lengths, which finds expression in the high standard deviations for shoot and root lengths in all of the 4 measuring seasons.
Ten acorns each were collected from three weight groups in forest plot Y (see map 3.2) in December 1976. The fresh acorns were sown in a 95 cm high seed box. After completion of root growth (observed through glass screen of seed box) in June, the seedlings were carefully removed by soil-flooding and the lengths of their roots measured. All the roots were found to have grown straight down to the bottom of the box. The results of this experiment are recorded in table 7.5. [*]

Table 7.5: Root lengths of *Quercus ithaburensis* seedlings which germinated from 3 weight-batches of acorns.

mean weight of acorn (gr)	5.4	12.7	34.3
S.D.	0.5	0.6	0.9
mean length of root (mm)	648	1078	1263
S.D.	90	129	94

We found a significant difference between root lengths from the first and the second batch, at the significant rate of 0.001 in t-test, and also between those from the second and third weight groups, though at a rate of 0.01 in t-test. It therefore follows that the length of the root clearly depends on the weight of the acorn.

In summing up these two experiments it will be found that whereas root growth starts immediately after sowing, shoot growth is delayed for about two months. Although there is no evident correlation between shoot and root lengths, the ratio between them augments from the date of sowing until March, at which time it more or less stabilizes. There is no doubt that the deflection of the seed's entire resources to the growing of the root during the first stage, affords the seedling an obvious advantage that will make itself felt with the onset of the drying-up of soil at the beginning of May (see also 8).

[*] The experiment was carried out with the gracious help of the late Dr. Yitzhak Harif.

The bigger the acorn the greater the advantage, because until the soil starts drying up the seedling has better prospects to reach damper layers and to thus survive until the winter. A similar connection between the weight of an acorn and its root length during the first year exists also in *Quercus calliprinos* (Harif, 1974).

7.3.3 *Examination of methods of growing Quercus ithaburensis seedlings, and suggestions as to their application*

7.3.3.1 Methods and Results: Ripe acorns were sown in a nursery in 25 cm long, perforated polyethylene bags of 10 cm diameter, in December 1974. After 14 months, the seedlings were transferred to a natural area, free of *Quercus ithaburensis* tress (M, see map 3.2). Prior to transplantation of the seedlings the area was cleared of grasses, and the polyethylene bags were removed. Another seed-batch was sown straight into an area protected against cattle and wild boar activities. Germination results and survival of seedlings one year after sowing or planting in open ground are recorded in table 7.6.

Table 7.6: Propagation of *Quercus ithaburensis* by sowing direct in open ground, and by seedling transplantation.

	Number of seeds	Germination %	% of survival in open ground after one year
Direct sowing in open ground	64	100	89.5
Sowing in bags and subsequent transplantation	480	98.5	60.9

Whereas there is no significant difference between the two breeding methods' germination percentages, the direct sowing method has a significant lead in survival percentage after one year (significance level 0.005, chi square test). All the seedlings grown in polyethylene bags during a period of 14 months were found to have twisted roots, whereas roots of seedlings whose bags were opened two months after sowing, had not yet twisted although they had started growing horizontally at the bottom of the bag. Transplantation of seedlings to the open ground at this stage proved generally successful, though transplanting of two-months old seedlings was not repeated often enough to enable us to draw unequivocal conclusions.

7.3.3.2 Discussion and Conclusions:

1. Propagation by direct sowing or transplanting of seedlings

We found that direct sowing into the soil affords the seedling a distinct advantage and enhances its survival potential after the period of one year. In our measurings of root lengths (see 3.2) we had already found that the roots grow fast, attaining a length of 65 cm in small acorns and up to 125 cm in big acorns in the first year. The growing of seedlings in polyethylene bags does nog enable deep penetration of the root and on the one hand causes growth suppression, and on the other a twisted growth that is likely to impair the seedling and hinder the tree after transplantation. Transplantation of the seedling during its first growth period, before the root starts twisting, is likely to afford the tree the advantage of developing in the desirable habitat without any hindrance, in protected and controlled conditions during its germination and further root penetration.

In experiments of *Quercus ithaburensis* propagation in nursery conditions (Biran, 1977), several weeks old *Quercus ithaburensis* seedlings were transferred to 1-litre volume polyethylene bags, and after 4 months to 15 litre volume containers. In each transplantation the roots of several seedlings were pruned. It was found that pruning before the second transplantation resulted in root ramification and a greater height of the seedling which was ramified in its upper part, without impairing the continuation of its apical growth. As against this, mere pruning before the first transplantation caused ramification, but also considerable twisting, of roots, as well as ramification of branches attended by stoppage of apical growth. Where no pruning had been effected the result was a single, twisted root, and only little ramification of branches which were distributed throughout the whole length of the seedling. Biran concludes that late pruning of roots improves the root system and causes weakening of the apical domination and an increase in apical control.

2. Suggestions for application of *Quercus ithaburensis* propagation methods

The fact that the Yahudia Forest is a remnant of the *Quercus ithaburensis* forests that once covered large tracts of the Golan (see 5) compels us to try and conclude from the ongoing processes in it what techniques had best be applied by us to rehabilitate these forests. This objective we consider to be an important part of our work.

The experiments carried out by Biran referred to above (7.3.3.2.1) no doubt show us a direction for propagating *Quercus ithaburensis* in nursery conditions. However, in order to grow *Quercus ithaburensis* in nature conditions without irrigation, the root of the seedling requires to reach a maximum depth during the first year, to enable the tree to survive its first summer without suffering desication. This cannot be achieved if the seedling has its root pruned at the age of 4 months. Desication of seedlings is a critical problem in the first dry seasons (more on this subject in 8.4.3.6).

We recommend the following propagation methods for *Quercus ithaburensis*, in order of priority:

1. Direct sowing into open ground after clearing area of grasses, at least in first year (either by hand or by spraying with germination inhibitors)
2. Sowing in nursery, and transplanting of seedlings in open ground at the end of winter (at age of 2-3 months). (Clearing area of grasses is desirable.) This method is worth adopting wherever acorns are at risk of being consumed by rodents or wild boar
3. Sowing in nursery and subsequent transplanting of seedlings in open ground with the onset of the second winter (at age of 12-14 months), with roots being pruned above the twist. This method should be adopted where young seedlings face risk of being trampled on by cattle or wild boar.

Collection of acorns: The acorns selected should be as big as possible, and should be collected when brown, and while still on the tree but easily detachable from cupule. In a large-scale operation, it is worth cleaning the ground around the tree of acorns already shed, and picking the ripe acorns off the tree in the way olives are picked - either by shaking the branches of beating them with a stick.

Sowing: Acorns should be sown 2 cm deep, with longitudinal axis in horizontal position, within a few days of collection.

Preparation of sowing or transplantation area: ground should be cleared of grasses and kept clear during 2-5 seasons.

8 GERMINATION AND ESTABLISHMENT OF THE QUERCUS ITHABURENSIS IN THE YAHUDIA FOREST

8.1 Introduction

This chapter will deal with the natural conditions which bring about or inhibit germination as well as conditions of establishment and commencement of the development of *Quercus ithaburensis* seedlings in the Yahudia Forest.

Examination of conditions was made both by observation of seedlings in the field and by sowing and planting in various habitat conditions and grazing regimes.

As we have seen above (7.3.1.3) the germination potential of *Quercus ithaburensis* acorns depends upon the amount of water they retain. This was discovered in the *Quercus calliprinos* by Waisel and Friedman (1960) and Harif (1974) and confirmed by us with regard to the *Quercus ithaburensis*. Waisel and Friedman maintain that the germination bed of the *Quercus calliprinos* seeds is of prime importance and the more protected it is from dehydration or the more deeply embedded in the soil the greater its germination potential. They contend that the essential inhibitor of the growth in the species is germination and not establishment. However, Harif (1974) shows that the *Quercus calliprinos* has many establishment problems and only about 20% of the seedlings which have survived their first year actually reach the age of seven years. He draws several conclusions regarding the natural conditions under which the *Quercus calliprinos* establishes itself:

- in humid habitats such as northward facing slopes or stone terraces the percentage of establishment is 65% greater than in more arid habitats in the same area such as southern facing slopes.
- competition over water with herbaceous plants completely inhibits establishment of the *Quercus calliprinos* and establishment is more successful among shrubs than in exposed areas.
- seedling mortality is directly dependent upon the amount of water available in summer and by supplementation of irrigation it was possible to prevent mortality.
- distribution of seeds in suitable habitats also influences establishment.

It has been found that about 90% of the seedlings are situated at a distance of up to 10 metres from the parent plant. Rodents were found to be distributors of seeds and even if they had gnawed part of the acorn its germination potential was still maintained. The larger the remaining piece of acorn, the greater its establishment potential.

Section 7.1.2.2 has already dealt with the effect of wild boar and rodents on the number of remaining *Quercus ithaburensis* acorns in a plot. Mellanby (1968) states that those animals which are acorn consumers and destroy most of them, are also a significant factor in regeneration of the oak. Long-range distribution is mostly carried out by birds. The Jay (*Garrulus glandarius*) carries the acorn to a distance of up to several hundred metres and buries it in the soil. Some of the acorns germinate and are established; in some cases the cotyledons are consumed after germination, and in some cases they are consumed as acorns (Bossema, 1979).

The distribution areas of the *Quercus ithaburensis* indicate that its germination and establishment is possible over quite a wide range of precipitation and soils (see above 5.1.3), but they offer no indication of the factors within the natural conditions, which determine the extent to which germination and establishment of this species can succeed.

The establishment of a seedling does not necessarily ensure the continuation of the species, it is only ensured once the plant has reached the reproductive stage. According to Shmida (1980) the reproductive stage in the *Quercus* species depends more on height than on age, with genetic divergence from species to species. The *Quercus calliprinos* yields fruit at a height of 2½ metres and the *Quercus boissieri* at an even greater height.

Mellanby (1968) states that rabbits and hares gnaw the young oak shoots in England, but these are able to withstand the damage. Cattle and sheep eat seedling right down to the root and most of these do not regenerate. Deer in sparse numbers do not prevent establishment of oaks. Jones (1959), however, maintains that in England, deer have caused damage to 60-90 cm high oak seedlings. Boar also cause damage to seedlings by burrowing into the ground for remains of acorns. According to Harrington (1978) although cattle sever the apex of the seedlings, they do not destroy them. However, because they are prevented from reaching any great height they are rendered available to goats which have great influence over the existence of the seedlings.

Dense populations of herbivores affect the seedlings not only by actually eating them. Trampling both directly affect the shoots and also compresses the soil which inhibits germination (Howard, 1967).

We have seen, therefore, that the effect of these animals on germination and establishment processes are debatable. Their contribution to these processes can be either positive or negative in different situations.

We shall deal with the impact of conflagration on seedling later on (9.1.1), but shall mention here that fire causes the trees to remain at a low height because of the destruction of the above-ground parts and sprouting of new branches from the base of the plant (Rocky Mountains, 1960; Trabaud, 1977) and that the survival potential of young seedlings following conflagration is much lower than that of more mature trees (Humphrey and Mehrhoff, 1958).

8.2 Methods

8.2.1 *Plots and main treatments*

In 1973 nine plots in the Yahudia Forest were fenced off and labelled, each representing a different grazing regime and varying types of vegetation. In section 5.2.3 above we have described the type of fencing and degree of grazing whithin each plot. We shall just mention that the cattle grazing was not strictly supervised and amounted to 80-110 days of cattle grazing per hectare per year. Boar foraging was estimated at an average of 22 days foraging per hectare per year, although in winter, particularly during the acorn season, the pressure was temporarily greatly increased. A list of plots and treatments is recorded in table 8.1.

Examination of germination and establishment in natural conditions was made in two separate experiments in the same plots:

1. Natural germination: marking, mapping and follow-up of all natural seedlings within the main plots.
2. Sowing and planting of acorns and seedlings which had germinated in a nursery in the main plots of various habitats.

Table 8.1: A list of plots, their size and main treatments which they represent for purposes of following up germination and establishment of *Quercus ithaburensis* in the Yahudia Forest (see map 3.2 for marking of plots).

vegetation type	grazing regime	plots	ha
Quercus ithaburensis	+cattle + boar	R, P	1.0
" "	-cattle + boar	K, D	1.0
" "	-cattle - boar	C, B	0.2
Ziziphus lotus	+cattle + boar	A	1.0
" "	-cattle + boar	L	1.0
" spinachristii	-cattle + boar	S	1.0

8.2.2 *Natural germination*

Note: During all the years of observation we found no *Quercus ithaburensis* seedlings among vegetation of the *Ziziphus lotus* type, so that these plots were excluded from the data processing system and analysis. However, this fact is significant in itself.

8.2.2.1 Observation and recording

Mapping of parent trees in each plot: in each plot an exact mapping was made of all mature trees (a tree above the height of 1.5 metres is considered mature) and of the cairns within the plot.

Time of observation: Each plot was observed annually and the *Quercus ithaburensis* seedlings measured. Observation was effected during June-October when the green seedlings stand out against the surrounding yellow grass, since at this time the oak does not undergo any significant phenological changes. The observations were carried out over the course of four years (1974-1977).

Recording of seedlings: As concentrations of seedlings were found to be in the near vicinity of a mature *Quercus ithaburensis* or group thereof, recording of the seedlings was effected in relation to the tree, or group of trees which the seedling was near, but no farther than, 6 metres. Each seedling received an "identity number" related to the parent tree and to its serial number within the group of seedlings in the proximity of the parent tree. Seedlings found a distance of more than 6 metres from any tree were listed accordingly and marked on the map. The seedling number was recorded on an aluminium label in wax pencil and the label was wound round the stem so as to enable the stem to thicken without hindrance, by expansion of the aluminium band.

8.2.2.2 Measured Parameters

1. Parameters measured once during the first year of observation for each seedling (parameter signs such as those used for data processing appear in parentheses).

(IT) Number of trees in the parent tree group.

(LOC) Location of each tree in relation to the cairn nearest to it or upon which it grows: the cairns upon which or near to which most of the trees grow, were divided into "zones" (see figure 8.1); top of cairn, slope of cairn, bottom of cairn and flat open area outside the cairn (marked 0, 1, 2, 3 respectively).

(IST) Number of seedlings in proximity to the parent tree group and at a distance of up to 6 metres from them.

Parameters describing the seedlings

(DEG) Location of seedling in relation to the tree: the area surrounding the "parent tree" was divided into eight segments of a circle with the tree in the centre. The segment in which it grew was recorded for each seedling. The segments were marked according to the compass, north, north-east, east, south-east, south, south-west, west and north-west (0, 45, 90, 135, 180, 225, 270, 315 degrees respectively).

(LS) Location of seedling in relation to the cairn: as with the trees (see above) a recording was made of the location of the seedling at the cairn's top, slope, bottom or outside (marked 0, 1, 2, 3 respectively).

(AGE) Minimum age of seedling during its first observation year: an estimate was recorded of the age of the shoot in its first observation year. The estimate was based upon the number of internodes in the stem of the shoot from the neck of the root until the leaves. This estimate provides the minimum age only, since if there

Figure 8.1: *Quercus ithaburensis* seedlings in a typical cairn system in the Yahudia Forest, on which most of the trees grow. For our purposes, the cairn was divided into sections: top of cairn, slope of cairn, bottom of cairn and flat open ground outside the cairn (3, 2, 1, 0, respectively).

has been rebudding from the neck of the root following damage to the entire stem, this is difficult to identify on the new stem. On the other hand, it is difficult to distinguish between internodes after the age of four years and all the shoots above this age were placed in one group of a minimal age of four years and over. The age at each year is, therefore, the initial estimated age plus the number of observation years of the seedling.

2. Annually measured parameters

Date of observation: marked in four numerals (two for the month and two for the year).

(IB) Number of branches on the seedling on the day of observation. All seedlings whose branches totalled more than 14 were grouped together.

(IBB) Number of branches on regenerated seedlings following damage. Following fire, gnawing, breakage etc., regeneration sometimes occurs outside the normal season for budding in spring.

(HT) Height of seedling in centimetres above ground level.

(HTB) Height of seedling as above after regeneration following damage.

(BS) Site of seedling regeneration: each year, with the exception of the first year of the seedling's life, at least one wave of budding occurs, which issues from a basal bud, a lateral bud or an apical bud and sometimes from several buds simultaneously. The highest location was recorded and numbered with the following code numbers: 3 - apical budding, 2 - lateral budding, 1 - basal budding.

(BSB) Site of seedling regeneration following damage as above.

(F,H) Conflagration: if the seedling had been damaged by fire, record was made of total damage (F) (desiccation of all the leaves) or partial (H), (desiccation or scorching of some of the leaves). A recording was also made of whether or not there was budding after conflagration and if so, the site of regeneration (BSB), height (HTB) and number of branches after regeneration (IBB).

REMARKS

Remarks on phenological changes and various damage to the seedling: these remarks are qualitative, dichotomous variables and were recorded only if the phenomenon was observed. The remarks recorded were:

Y - appearance of budding

X - appearance of shedding signs (change in leaf colour to autumn colours) or actual shedding

W - appearance of leaf desiccation signs

Z - dry seedlings, all leaves dried

C - seedling trampled by cattle (identified by footprints)

V - seedling, or parts thereof, consumed by cattle

E - seedling uprooted by wild boar (identified by footprints)

O - partial gnawing of seedling (excluding neck of root and apex) by rodents (identified by gnawing signs)

T - gnawing of root neck by rodents

U - gnawing of seedling apex by rodents

M - seedling germinated from acorn partially gnawed by rodents

N - seedling whose leaves have been partially or wholly consumed by insect larvae

K - seedling uprooted by animals (excluding wild boar)

8.2.2.3 Primary processing of raw data

Raw data was fed into the computer and filed according the plots, treatments and measured parameters. Processing was carried out with the aid of SPSS programmes file (Nie *et al.*, 1975) utilizing mostly "Frequency" and "Scattergram" programmes.

In addition a number of new parameter were defined, which were calculated from the raw data.

The following is a complete list of calculated parameters:

(MIT) - Average number of leaves per seedling for all the observation years

(MIBB) - MIT following damage (fire, breakage, trampling, gnawing etc.)

(MHT) - Average height of seedling over all observation years

(MHTB) - MHT following damage as above

(BS1) - Frequency of occurrence of basal budding during the life of the seedling

(BS2) - Frequency of occurrence of lateral budding during the life of the seedling

(BS3) - Frequency of occurrence of apical budding during the life of the seedling

(BS1-3) - BS1-3 following damage as above

(BSY1-4) - Location of budding from the first calendar year (1974) until the fourth (1977) accordingly

(YRMC) - Survival of seedling. Number of calendar observation years during which the seedling was observed alive

(FG) - Total conflagration frequency of seedling during observation years

(HG) - Partial conflagration frequency of seedling during observation years

(YG) - Frequency of occurrence of budding in seedling during observation years

(XG) - Frequency of appearance of autumn colours or shedding during observation years

(WG) - Frequency of appearance of shedding process in seedling during observation years

(ZG) - Frequency of appearance of total desiccation in seedling during observation years

(WZG) - Frequency of appearance of partial or total desiccation during observation years

(CG) - Frequency of appearance of trampling by cattle during observation years

(VG) - Frequency of appearance of eating of seedling by cattle during observation years

(CVG) - Frequency of appearance of damage by cattle to seedling during observation years

(EG) - Frequency of appearance of uprooting of seedling by wild boar during observation years

(OG) - Frequency of appearance of gnawing of seedling by rodents during observation years

(TG) - Frequency of appearance of gnawing of root neck by rodents during observation years

(UG) - Frequency of appearance of gnawing of seedling apex by rodents during observation years

(MG) - Frequency of appearance of seedling which has germinate during observation years from a gnawed acorn

(ORG) - Frequency of appearance of damage by rodents during observation years

(NG) - Frequency of appearance of seedling whose leaves are consumed by insect larvae during observation years

(KG) - Frequency of appearance of uprooting of seedling by animals during observation years

(NKG) - Frequency of appearance of damage by animals (excluding damage identified as damage by cattle, wild boar and rodents) to seedling during observation years

(DAMG) - Frequency of appearance of damage by any animals to seedling during observation years.

8.2.2.4 Analysis of data on natural germination

Data was analysed with the aid of a computer using SPSS programme file (Nie *et al.*, 1975), using mainly "Frequency", "Scattergram", "Crosstabs" and "Anova" programmes.

Examination of connection between two variables was made by means of scattergram and linear regression, but generally by means of a chi-square test.

Whenever distribution of the variable occurred over a wide range, it was either recategorized or turned into a dichotomous variable taken the value 1 if the phenomenon had taken place and the value 0 if it had not. Analysis of several variables together was done by stepwise logistic regression (LR), programme file BMDP (Dixon and Brown, 1979).

8.2.3 *Sowing and planting of the Quercus ithaburensis*

8.2.3.1 Description of experimental system

Within the main plots and in accordance with main treatments (see 8.2.1), acorns were sown or seedlings transplanted from nursery to three natural habitats (HAB). Letter in parentheses indicate codes for variables used in data processing.

(FLAT) - Outside cairn on flat, open surface (site 0 in fig. 8.1)

(CAIRN) - The lower part of the cairn (site 2 in fig. 8.1)

(TREE-CAIRN) - The lower part of the cairn and in the shade of the *Quercus ithaburensis* (or *Ziziphus spinachristii* in plots S, L, A).

Sowing of seedlings (SEED, SD2) took place during the course of three years, 1973, 1974, 1975 (B.YEAR), in the month of December which is the acorn ripening time. For purposes of sowing, ripe acorns were collected from the trees at a stage where they are easily detached from the cupule. They were collected from at least ten different trees in plot Y (see map 3.2), and the acorns well mixed before being sown. (With regard to significance of seed source, see 7.3.1). Each replicate plot, which was 1x1 metre in size, was marked and either 100 acorns (in 1973, 1974) or 50 acorns (in 1975) sown therein. In each habitat (HAB) at least four replicates were sown in each main plot. In those plots where over 20 seeds germinated record was made accordingly as well as thinning out down to 20 seedlings only, in the month following germination.

In addition, two secondary treatments were carried out:

(IRR) - Irrigation: supplementary irrigation given to replicate plots which, for this reason, were sown in three habitats in main plot B (grazing treatment: - cattle and - boar) during 1975. The water was collected by means of a gutter network and barrels which drained the rainwater during the course of the winter of 1975, and irrigation was carried out by watering can at the end of May, in an amount equivalent to 70 mm of rainwater.

(WEED) - Weeding: during 1973 and 1974 a number of plots were sown, from which herbaceous plants were weeded. In the 1975 sowing, all replicate plots were weeded, with the exception of four replicate plots for inspection purposes.

Planting (SEEDLING, SD1) of 2-3 month old seedlings transplanted from a nursery was carried out in the main plots during February-March. The seedlings were nursery-grown from acorns which had been collected and sown in December of the previous year. Eight seedlings were transplanted to each replicate plot 1x1 metre in size. Planting in habitats and treatments was effected as with the plants sown directly into the open ground

Table 8.2 gives a list of treatments and replicates carried out.

Table 8.2: Number of replicate plots in sowing and planting of Quercus ithaburensis experiments according to combinations of treatments, habitats and sowing years.

HAB			flat						cairn						tree-cairn							
Grazing Treatment	Vegetation Type	B Year / Plot	1973		1974		1975		1973		1974		1975		1973		1974		1975		Total No. Sd.	Total No Sding.
			Sd	Sding	Sd	Sding	Sd	Sding	Sd	Sding	Sd	Sding	Sd	Sding	Sd	Sding	Sd	Sding	Sd	Sding		
-C-B	QUEITH	B	1		8 4I 4W	2	4 8IW 4W	1	4		5 4I	1	8IW 4W	1	4		5 4I	1	8IW 4W	1		
		C			4		4W 4				4		4W				4		4W			
SUB-TOTAL			1		20	2	24	1	4		13	1	16	1	4		13	1	16	1	111	7
-C+B	QUEITH	D	7		8	6	4W	6	4		4	4	4W	4	4		4	4	4W	4		
		K			4		4W				4		4W				4		4W			
	ZIZSPI	S				3	4W	2				2	4W	2				2	4W	2		
	ZIZLOT	L			4	3	4W	1			4	2	4W	2			4	2	4W	2		
SUB-TOTAL			7		16	12	16	9	4		12	8	16	8	4		12	8	16	8	103	53
+C+B	QUEITH	P	16		8	5	4W	4	8		4	4	4W	4	8		4	4	4W	4		
		R			4		4W				4		4W				4		4W			
	ZIZLOT	A			4	3	4W	2			4	2	4W	2			4	2	4W	2		
SUB-TOTAL			16		16	8	12	6	8		12	6	12	6	8		12	6	12	6	108	38
TOTAL			24		52	22	52	16	16		37	15	44	15	16		37	15	44	15	322	98

+/- C : with/without cattle grazing
+/- B : with/without boar foraging
QUEITH : *Quercus ithaburensis* vegetation type
ZIZLOT : *Ziziphus lotus* vegetation type
ZIZSPI : *Zizphus spinachristii* vegetation type

(GRAZ) : grazing treatments: -C -B; -C +B; +C +B

(VEGT) : grazing treatment according to main tree types were:

QUEITH -C -B : -C -B in *Quercus ithaburensis* forest (identical to -C-B under "GRAZ" treatments)
QUEITH -C +B : -C +B in *Quercus ithaburensis* forest
QUEITH +C +B : +C +B in *Quercus ithaburensis* forest
ZIZLOT -C +B : -C +B in *Ziziphus lotus* vegetation type
ZIZLOT +C +B : +C +B in *Ziziphus lotus* vegetation type
ZIZSPI -C +B : -C +B in *Ziziphus spinachristii* vegetation type
TIPUL = GRAZ + VEGT treatments

There was, therefore, a total of 322 plots containing seedlings which had been sown and 98 plots containing seedlings which had been transplanted. The seedlings were observed from December 1973 until August 1978, a total of 57 observation months. Observation was terminated of those plots, when no live seedling was seen for 14 continuous months.

8.2.3.2 Measured Parameters

Each replicate plot in the field was marked and an index card opened containing details of treatment and secondary treatment, habitat and number of replicate.

The following parameters were recorded for each monthly observation:
Date of observation

(NSEED) - number of live seedlings in replicate plot
(S) - number of seedlings before thinning out. This note only appears if over 20 seedlings germinated and the seedlings had been reduced to 20
(NSBUDS) - number of seedlings budding in replicate plots
(MNL) - mean number of leaves per seedling per replicate plot
(BS) - site of spring regeneration (excluding year of germination)

(BS1) - number of seedlings in replicate plot regenerating from basal bud

(BS2) - number of seedlings in replicate plot regenerating from lateral bud

(BS3) - number of seedlings in replicate plot regenerating from apical bud.

In cases where the seedling had regenerated from several buds record was made of the highest.

(F) - number of seedlings in replicate plot totally damaged by conflagration (desiccation of at least all of the leaves)

(H) - number of seedlings in replicate plot partially damaged by conflagration (desiccation of part of the leaves)

(REMARKS)- various remarks were recorded on shoots in phenological condition and of damage, particularly by animals. The variables are quantitative and record was made of the number of seedlings per replicate plot, to which this damage had occurred. This list of remarks is identical to that given above (8.2.2.2) with regard to natural germination.

8.2.3.3 Primary data processing

Raw data was processed by computer. Data was "filed" according to plots, treatments, months of the year and measured parameters, while retaining the identity of the replicate plot from which the data had been collected. Processing was done with the aid of programme file SPSS (Nie *et al.*, 1975) using mainly "Frequency" and "Scattergram" programmes. In addition, several new parameters were defined, some of which had been calculated on the basis of the measured parameters. These parameters are:

PGERM : germination percentage in sown seedlings ("SEED"), or percentage of those which had taken root of seedlings transplanted from a nursery ("SEEDLING").

PLIVE : Survival percentage of seedlings calculated on the basis of the number of seedlings from the previous year, thus:

$$\text{PLIVE } i = \frac{\text{number of seedlings alive at year } i}{\text{number of seedlings alive at year } i\text{-}1} \times 100$$

$$\text{PLIVES} = \sum_{i=2}^{5} \text{PLIVE } i$$

PLIVE was calculated in percentages for each replicate plot. In order to process data this variable was classified in two ways:

1. Dichotomous variable taking the value either 1 or 0 for survival, or non-survival, respectively, of seedlings in replicate plot;
2. Quantitative variable in following divisions of survival percentage: 0, 1-25, 26-50, 51-75, 76-100.

T.PLIVE : Survival percentage of seedlings calculated on the basis of number of seedlings in replicate plot during first year following germination.

$$\text{T.PLIVE } i = \frac{\text{number of seedlings alive at year } i}{\text{no. of seedlings alive at first year after germination}} \times 100$$

DML : Difference in maximum mean number of leave per replicate plot from one year to the previous year.

DML i : (maximum mean number of leaves at year i) - (maximum mean number of leaves at year i-1).

At each observation the mean number of leaves per seedling per replicate plot was recorded (MNL). The yearly maximum MNL was usually after springtime budding during February-March. DML was calculated with regard to each replicate plot. For purposes of data processing DML was divided into the following groups:

-100% : seedlings had lost all their leaves
-99 - -21% : significant decrease in number of leaves
-20 - +20% : no significant change in number of leaves
+21 - +99% : significant increase in number of leaves
≥100% : number of leaves at least doubled.

8.2.3.4 Analysis of data on sowing and planting experiments

Data was analysed with the aid of a computer using programme file SPSS (Nie *et al.*, 1975). Mainly used were "Frequency", "Scattergram" and "Cross-tabs" programmes.

Examination of the connection between two variables was made by X^2 test. Whenever the variable was distributed over a wide range it was recategorized or turned into a dichotomous variable taking the value 1 if the phenomenon had taken place and the value 0 if it had not. t-Tests and median tests were made to compare treatments over several years and to compare distribution of variables over the months of the year.

8.3 Results

8.3.1 *Natural germination of the Quercus ithaburensis in the Yahudia Forest*

8.3.1.1 Description of primary parameters measured in seedlings and their inter-relationships

In figure 8.2 the frequency of various measured parameters is described. (IT) Number of parent trees in group: Approximately 60% of the trees stand singly and about 28% in groups of 2-3 trees. Group of 0 trees in group signifies seedlings found in the area not in proximity to a "parent tree".

(IST) Number of seedlings surrounding a group of "parent trees": About 15% of the trees had no seedlings in their immediate vicinity and about 12% of the trees had one seedling in close proximity. It was sometimes possible to find several tens of seedlings surrounding some groups of trees. On one case 66 seedlings were found round one group of "parent trees". The figure does not show low frequency of seedling group within the range of 25-40 seedlings per group.

(LOC) Location of tree in relation to cairn: (see figs. 8.1, 8.2) About 74% of mature trees grow on the cairn slopes and another approximately 16% on the lower part of the cairn. The least number of trees are situated at the top of the cairn or outside it.

We found that there was a most significant correlation (sig. $X^2 = 0.0005$) between the location of the parent tree and its number of surrounding seedlings, so that more seedlings were found to be growing near trees on the slope of the cairn.

There was also a significant correlation (sig. $X^2 < 0.0001$), between the location of the "parent tree" and the number of trees in a group, showing that more trees grow in a group when they are situated on the slope of the cairn.

(DEG) Position of seedlings round the "parent tree", in relation to the compass: The seedlings did not tend towards any particular direction, as we had previously assumed, believing that there may be some advantage to the more shaded northward direction. We therefore dealt no further with this parameter during analysis of the results.

(LS) Location of the seedling in relation to the cairn (see figs. 8.1, 8.2): Approximately 68% of the seedlings were situated on the cairn slope and about 25% on the lower part of the cairn. The least number of seedlings were found outside or at the top of the cairn.

(AGE) Age of seedlings during their first observation year (fig. 8.2): Relative quantity of seedlings decreases with age. Approximately 20% of seedlings were registered in their year of germination and a similar percentage recorded in their first year. Because, after the fourth year, we were unable to determine their specific age, the age-group of five years and over constitutes about 34% of the seedlings and includes a variety of ages. It should be noted that according to our impression, number of branches and height of seedlings in this group, their age was over five years.

(BS) Location of budding (fig. 8.2): Apical budding occurs in approximately 59% of the budding seedlings, about 21% from lateral buds and about 19% from basal buds. Of those seedlings which bud laterally or basally, most (80-84%) do not rebud a second time from the same type of bud; of those which bud apically approximately 33% rebud from the same type of bud, 22% rebud twice and about 45% rebudded basally, or died.

(BSB) Location of budding following damage or conflagration (fig. 8.2): Of those seedlings which budded during the same summer of autumn after fire or damage, most budded laterally or basally and only a small percentage (7%) budded apically.

(IB) Number of branches per seedling (fig. 8.2): Approximately 42% of the seedlings had only one branch and 13%, 2 branches. A small percentage of seedlings had a larger number of branches. About 21% of the seedlings had 15 or more branches. These are usually large, well-developed seedlings of an estimated greater age (see (AGE) above). They constitute a separate group which causes a gap in the distribution of the number of branches between this group and the group with 14 branches or less. In examination of correlation between age of seedlings and their number of branches no positive correlation was found between the two variables.

(IBB) Number of branches on seedling which had regenerated after conflagration or damage (fig. 8.2): 23% of the seedlings were damaged by fire. 20% of these did not regenerate in the same year and 33% rebudded during the summer or autumn following damage, usually producing a single branch.

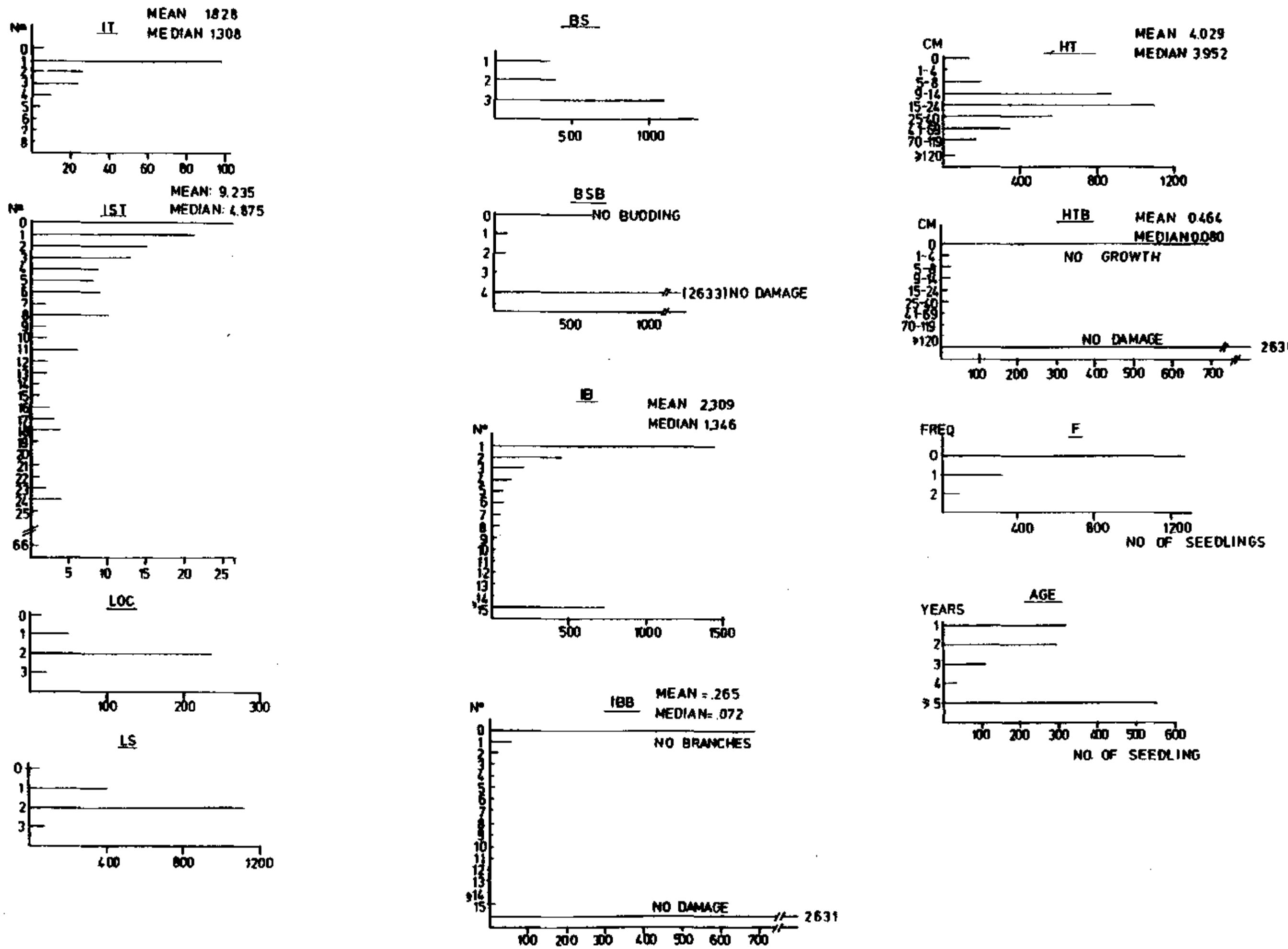
(HT) Height of seedlings (fig. 8.2): Most of the seedlings (approximately 57%) varied from 9 to 24 cms in height. Correlation between number of branches and height of seedling is described in fig. 8.3. It may be seen that over a relatively small range of heights there is a relatively large variability in the number of branches. Low linear correlation co-efficient (R=0.58) and extreme changes in the maximum height curve, indicate that there is no clearly unequivocal correlation between number of branches and height. In examination of correlation between age and number of branches or of height (fig. 8.4), we found that the two parameters follow a similar pattern to that of age, which showed a moderate increase until 4-5 years of age, followed by a steeper increase, with a tendency to stability, after the age of 7. The sensitivity of the curve after age of 7 years is less, because the age of the seedling, when first observed, can only be identified exactly up to the age of 4 years, (see 8.2.2.2); nevertheless, observation was continued. We were thus able to follow up seedlings until 7 years as well as a large group of 5 year old and over, seedlings during the first year of examination.

(DHT) Distribution in height differences in each seedling, calculated between each year and the previous year is given in fig. 8.5. From this figure we see that most of the seedlings remain at a more or less permanent height (± 10 cms), the minority grow taller or grow shorter at a greater rate (± 20 cms) and only single seedlings deviate from this in either a positive or a negative direction.

(HTB) Height of regenerated seedlings following conflagration or damage: (fig. 8.2): Most of the seedlings do not regenerate during the year of damage. The few which do regenerate do not reach any great height, usually by 20-60% lower than the original height.

We carried out several tests on the correlation between quantitative parameters describing the seedling (age, number of branches, height) and the location of budding which is a parameter of the physiological situation of the seedling and its growth potential.

FIG. 8.2: Frequency of measured parameters. See for explanation of parameters page 139.



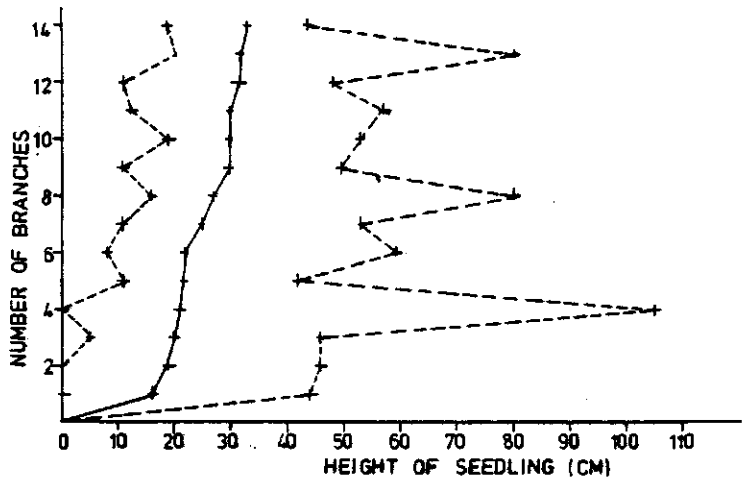


Figure 8.3: A scattergram of height of seedling against its number of branches. The full line represents the median values of height for each number of branches, in between the dotted lines representing minimum and maximum height values.

FIG: 8.4

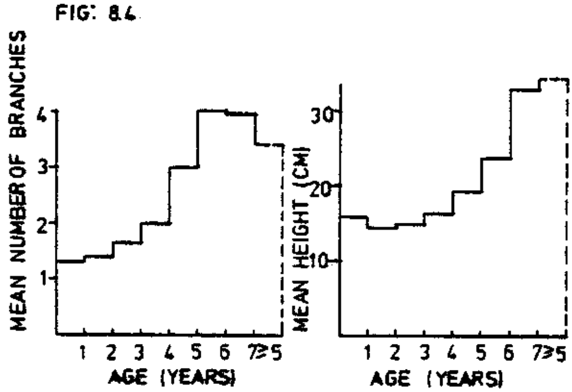


Figure 8.4: Change in mean number of branches and mean height of seedlings with age. Age $\geq$ 5 years refers to the first year of seedling observation.

FIG: 8.5

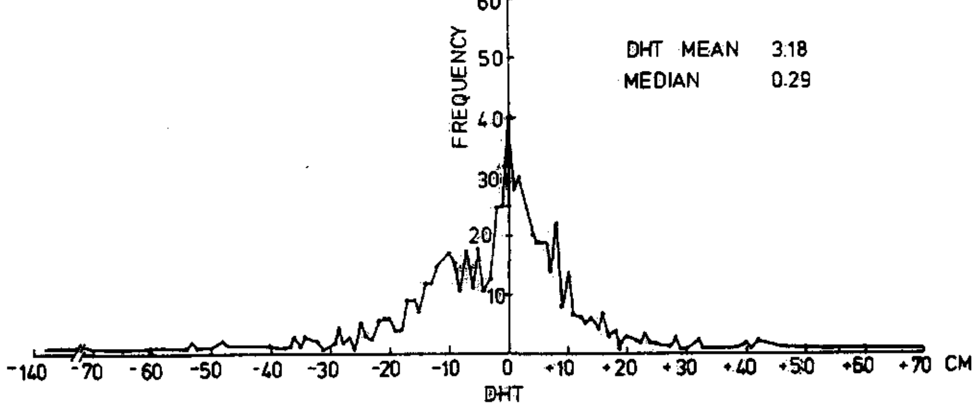


Figure 8.5: Distribution of change in length of seedlings in cms from one year to the preceding year. The graph describes median values of the 3 years of examination (1974-76).

Figure 8.2: Frequency of following measured parameters:

- IT - number of "parent trees" in group
- IST - number of seedlings round "parent tree" group
- LOC - location of trees in relation to cairn
- LS - location of seedlings in relation to cairn; (0 = open; 1 = bottom of cairn; 2 = slope of cairn; 3 = top of cairn)
- BS - location of bud of seedling
- BSB - location of bud after fire or damage (1 = basal bud; 2 = lateral bud; 3 = apical bud)
- IB - number of branches on seedling
- IBB - number of branches after fire or damage
- HT - height of seedling in cms
- HTB - height of seedling in cms after fire or damage
- F - frequency of fire expressed in number of times per seedling.
- AGE - age of seedlings in years.

FIG. 8.6

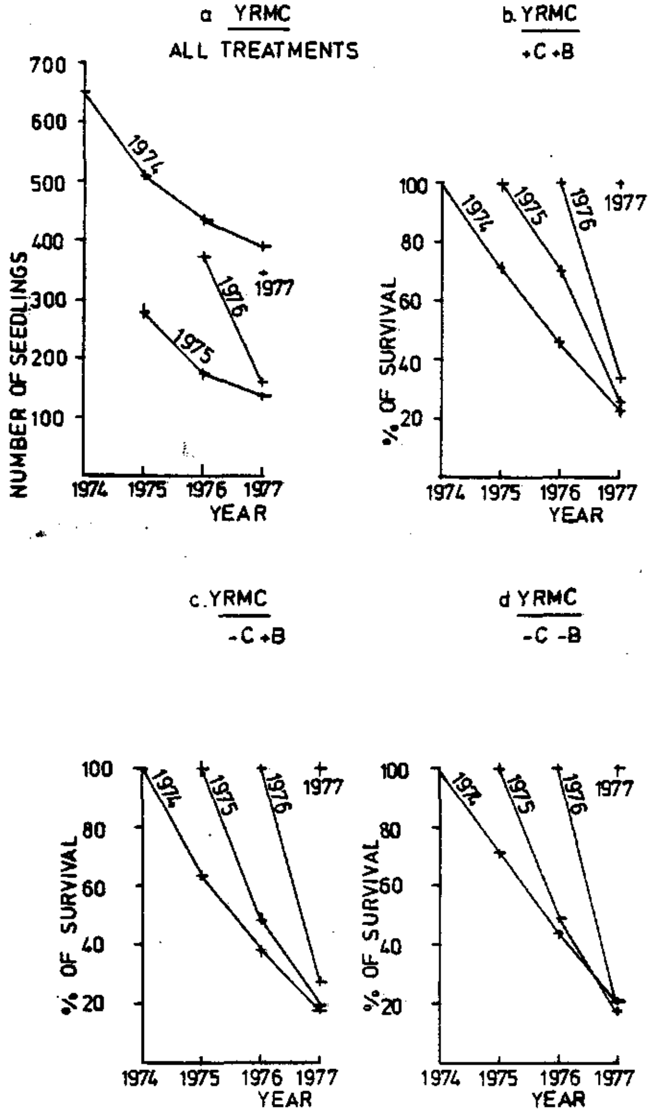


Figure 8.6: Survival of seedlings in 1974-1977 in a separate graph for each group of seedlings first observed in that year;
a : survival of all seedlings expressed in number of seedlings;
b-d : survival in percentages on the basis of the first observation year in grazing treatment;
+/-C = with/without cattle grazing;
+/-B = with/without boar foraging.

<u>(BS X AGE) Correlation between location of bud and age of seedling</u>: There is a most significant correlation (sig. $X^2 < 0.0001$) between the two variables, with greater frequency of younger seedlings when there is no budding. Those seedlings in which budding occurs, increase in quantity as they increase in age. However, there was no apparent correlation between location of bud and frequency of seedling at any age.

<u>(BS X IB) Correlation between location of bud and number of branches on seedling</u>: Significant correlation (sig. $X^2 < 0.0001$), was found between the two variables with frequency of apical budding increasing together with increase in number of branches. Lateral budding was found in great quantities in three-branch seedlings and basal budding found in two-branch seedlings. This correlation is shown in table 8.3. The table is limited to seedlings with no more than five branches, since there was not sufficient data for a greater number of branches.

Table 8.3: Distribution of number of seedling branches according to their place of budding. 0 - no budding; 1 - basal budding; 2 - lateral budding; 3 - apical budding. Each cell lists the number of seedlings and its column percentage (sig. $X^2 < 0.0001$).

count		number of branches					
col. pct.		0	1	2	3	4	5
BS	0	131 93.6	958 67.0	163 36.2	55 27.2	38 31.7	15 22.1
	1	2 1.4	189 13.2	64 14.2	27 13.4	8 6.7	6 8.8
	2	1 0.7	107 7.5	73 16.2	38 18.8	21 17.5	9 13.2
	3	6 4.3	176 12.3	150 33.3	82 40.6	53 44.2	38 55.9

BS = 0 signifies dead seedlings, but their number of branches was recorded. 0 branches signifies seedling found after damage at the bud break stage and prior to growth.

<u>(BS X HT) Correlation between place of budding and height of seedling</u>: Significant correlation was found (sig. $X^2 < 0.0001$) between the two variables. The greater the height the greater frequency of apical budding. High frequency of basal budding was found in groups of shorter height (15-40 cms).

<u>(F) Damage to seedlings by conflagration</u> (fig. 8.2): of all the seedlings recorded, 19.1% were totally damaged once by fire (no green leaves left after fire) and 4.4% twice damaged. Fire has a most significant effect (sig. $X^2 < 0.0001$) on rebudding which occurs in the summer or autumn following conflagration. Table 8.4 illustrates this correlation. Fire increases the rate of budding in these seasons from 4.7% to 22.9%.

Table 8.4: Frequency of budding seedlings (y=1) percentages thereof in case (F=1) or absence of (F=0) fire.

		Fire	
		0	1
count	y	1193	296
col. pct.	0	95.3	77.1
count	y	49	88
col. pct.	1	4.7	22.9

<u>(Z) Desiccation of seedlings</u>: 34.4% of the seedlings dried up during the course of observation, some rebudded the following year (see following). In 4.3% of the seedlings desiccation was recorded in the same seedling two years running and in one case a seedling became desiccated for three consecutive years.

<u>(X) Premature shedding</u>: Premature shedding which occurred in the summer or autumn was observed in 7.5% of the seedlings. Approximately one quarter of these continued to reshed their leaves prematurely for two or three years before the usual season in winter.

<u>(C) Trampling of seedlings by cattle</u>: This was recorded in only 1.4% of the seedlings.

<u>(V) Browsing of leaves by cattle</u>: This occurred in 6.8% of the seedlings. About half of these were browsed by cattle for one or two additional years.

(E) Uprooting by boar: Found in only 0.2% of the seedlings and constitutes only a marginal phenomenon in cases of seedlings after germination.

(O) Gnawing of leaves or stem of seedling by rodents: Phenomenon recorded in only 0.4% of the seedlings.

(T) Gnawing of root neck of seedlings by rodents: Recorded in 2.1% of seedlings.

(U) Gnawing of seedling apex by rodents: Exists in 3.7% of seedlings.

8.3.1.2 Factors influencing survival of seedlings:

As an indicator of seedling survival we examined the proportion of seedlings which had remained alive or which had died in the year following the recording of an event such as fire, desiccation, budding, etc. As a measure of seedling development, we chose a comparison of seedling lengths from one year to the previous year as expressed in centimetre or in terms of lengthened, shortened and unchanged (± 5 cms).

(YRMC) Survival of seedlings according to calendar year: Frequency of seedlings at each year's commencement of observation, for the duration of all observation years, indicated a survival rate of (in percentage approximately 60% as may be seen in table 8.5.

Table 8.5: Survival rate in % of seedlings, calculated each year on the basis of the first year (1974, 1975 or 1976) of seedling observation.

First observation year	1974	1975	1976	mean
% survival first year	78.3	63.3	41.3	61.0
% survival 2nd year	66.3	49.6		58.0
% survival 3rd year	60.0			60.0

From the time of the seedling's appearance, a change of 40-60% in their number occurred over a period of one year to three years, with the greatest annual decrease occurring in the first year (22-59%) and a smaller annual decrease (6-14% on the basis of the first year) in the following years. These trends may also be seen in graph form in fig. 8.6a by the graph's lessening slope with time.

1. Effect of location of budding on survival of seedlings (BS)

We see from table 8.6 that, of the budding seedlings most continue to live for the year following budding (approximately 90%) and lower in seedlings which bud basally (71-84%) while differences in survival potential among budding locations were found to be most significant during 1975, 1976.

Table 8.6: Survival of seedlings in the year following basal, lateral or apical budding during 1975, 1976. Order in each cell is as follows: no. of seedlings, row percentage and column percentage for each sub-table.

Life year after	Budding 1975			Budding 1976		
	basal	lateral	apical	basal	lateral	apical
dead	28 36.8 28.9	17 22.4 10.8	31 40.8 9.1	15 20.3 16.1	27 36.5 20.0	32 43.2 9.8
alive	69 13.3 71.1	140 27.0 89.2	309 59.7 90.9	78 16.3 83.9	108 22.5 80.0	293 61.2 90.2
sig χ^2		< 0.001			0.0100	

Of the remaining live seedlings we found that 33% had decreased in height in comparison with the previous year, about 5% remained unchanged and about 48% of the seedlings had grown taller although there was no significant difference between budding location and lengthening.

2. Effect of seedling desiccation on survival (Z)

In an examination of seedling survival in the year after desiccation had been recorded, we found significant correlation between the two factors. The death rate in seedlings had doubled as a result of desiccation as may be seen in table 8.7.

Desiccation had also usually caused greater frequency of shorter seedlings, as compared with seedlings which had been undamaged by desiccation, as shown in table 8.8, for 1975.

Table 8.7: Survival of seedlings in the year following desiccation (Z) or non-desiccation (0) for 1974-76. Order in each cell: number of seedlings, row percentage, column percentage for each sub-table.

Life year after	1974		1975		1976	
	0	Z	0	Z	0	Z
dead	133 94.3 21.0	8 5.7 44.4	100 55.6 17.2	80 44.4 38.6	140 46.8 21.8	159 53.2 46.5
alive	499 98.0 79.0	10 2.0 55.6	481 79.1 82.8	127 20.9 61.4	501 73.2 78.2	183 26.8 53.5
sig. χ^2	0.0371		< 0.0001		< 0.0001	

Table 8.8: Change in length of seedlings in year following desiccation (Z) or non-desiccation (0) as compared with previous year. Data are from 1975. Significance level χ^2 - 0.05. Order in each cell: number of seedlings, row percentage and column percentage.

	0	Z
shorter	164 74.5 34.1	56 25.5 44.1
no change	33 82.5 6.9	7 17.5 5.5
taller	28.4 81.6 59.1	64 18.4 50.4

3. Effect of conflagration on seedling survival (F)

No significant correlation was found between damage to seedlings by fire and their survival, or change in their length as compared with the year following conflagration. However, there was significant correlation between fire and desiccation (sig. $\chi^2 < 0.0001$) causing an increase in de desiccation from 11% to approximately 47% as seen in table 8.9.

Table 8.9: Number of desiccated seedlings (Z) or not-desiccated (0) from damage by fire (F). Order in cell is number of seedlings and column percentage (sig. $\chi^2 < 0.0001$).

	0	Z
0	955 89.0	297 52.8
F	118 11.0	266 47.2

Table 8.10: Survival of seedlings one year after premature shedding (X), summer or autumn budding (Y), cattle browsing (V), gnawing of root neck by rodents (T). Order in each cell: number of seedlings, row percentage and column percentage in each sub-table. Data are from 1975.

Life year	Fall of leaves		Budding		Cattle browsing		Root-neck nibbling	
after	0	X	0	Y	0	V	0	T
dead	177 98.3 24.3	3 1,7 4.9	179 99.4 24.2	1 0.6 2.1	179 99.4 25.0	1 0.6 1.4	167 92.8 21.6	13 7.2 92.9
alive	550 90.5 75.7	58 9.5 95.1	562 92.4 75.8	46 7.6 97.9	538 88.5 75.0	70 11.5 98.6	607 99.8 78.4	1 0.2 7.1
sig. χ^2	0.0009		0.0009		< 0.0001		< 0.0001	

4. Effect of premature shedding on survival of seedlings (X)
   Significant correlation was found between premature shedding and survival of seedlings in the following year (table 8.10). After premature shedding the percentage of live seedlings increases from about 75% to about 95%.

5. Effect of summer or autumn budding on survival of seedlings (Y)
   Significant correlation was found between rebudding occurring in summer or autumn and survival of seedlings in the following year (table 8.10). Following this budding the survival rate increased from about 75% to about 98%.

6. Effect of cattle browsing on seedling survival (V)
Significant correlation was found between browsing of seedlings by cattle and their survival (table 8.10) so that the percentage of those remaining alive in the year following browsing is greater than of those which were not browsed.

7. Effect of root neck gnawing by rodents on survival of seedlings (T)
Significant correlation was found between gnawing of root neck by rodents and survival of seedlings in the following year (table 8.10). Gnawing of root neck significantly reduces percentage of living seedlings from approximately 78% to approximately only 7%. We have provided data from 1975 in table 8.10 as sample data. 1976 data took the same trend and significance. 1974 data, based on 1973, were insufficient and not significant.
The minimal number of cases of other damage by animals did not enable us to make a reliable examination of their effect on seedling survival.

8. Effect of seedling age on survival (AGE)
Most significant correlation was found (sig. χ^2<0.001) between age of seedling and its survival. We see from table 8.11 that the greater the age of the seedling, the greater its likelihood of staying alive. Survival was examined at the end of the last year of seedling observation. If we compare distribution in age (column percentage) of those remaining alive and of those which had died, we find that in both groups there was a decrease in number of seedlings in each age-group until the age of 4, and an increase in the 5-years old and above age-group. As this latter group consists of a number of age-groups, it is possible that the tendency to decrease actually continues, although we were unable to measure this.

Table 8.11 shows that the proportion of age-groups 1-3 is smaller among the live seedlings (48.1%) than in the dead seedlings (66.3%). The four years age-group was of similar proportion among both the dead and the live seedlings. The proportion of 5 years and over age-group was greater among the live seedlings (49.5%) than the dead (31.3%). Thus, the four years age-group constitutes the meeting point of live and dead distribution.

Table 8.11: Survival of seedlings in last observation year according to age in years. Order in each cell: number of seedlings, row and column percentages.

Age	Dead	Alive
1	150 47.5 29.7	166 52.5 20.9
2	138 47.3 27.3	154 52.7 19.4
3	47 43.1 9.3	62 56.9 7.8
4	12 38.3 2.4	19 61.3 2.4
≥ 5	158 28.7 31.3	393 71.3 49.5

9. Effect on survival of seedlings position on cairn (LS)

An average of 77% of seedlings growing on the slope of the cairn survived. 70% of those at the top of the cairn survived. On the lower part of the cairn an average of about 62% and an average of 61% outside the cairn. Effect of seedling situation on their survival each year was significant. Table 8.12 gives 1975 as a sample year, when a significance level of 0.0001 was found in χ^2 test. There was no consistent correlation between change in length of seedlings from year to year and their situation in relation to the cairn.

Table 8.12: Survival of seedlings in various cairn habitats. Order in each cell: number of seedlings, row percentage, column percentage.

Life year after	Flat	Bottom	Slope	Top
Dead	9 5.0 39.1	65 36.1 33.2	98 54.1 18.5	8 4.4 21.1
Alive	14 2.3 60.9	131 21.5 66.8	433 71.2 81.5	30 4.9 78.9

Effect of cairn habitat on damage to seedlings by conflagration (F X LS)
Significant correlation was found (sig. $\chi^2 = 0.0131$) between position of seedling on the cairn and probability of damage by fire. Comparison of proportion of total damage by fire (no green leaves left) with partial damage by fire, showed that outside the cairn 100% total damage was caused, on the lower part of the cairn 94.4%, total damage, to those on slope of cairn 84.1% and top of cairn 86.7%. Therefore, the higher the seedling's position on the cairn, the less its likelihood of total damage by fire. The advantage of the cairn from the point of view of damage by fire is also apparent in table 8.13 which shows significant correlation for 1976, between position on cairn and likelihood of damage by fire. On the lower part and outside the cairn the likelihood of damage by fire is greater than on its slope and top.

Table 8.13: Damage to seedlings by fire (F) or non-damage (0) in various habitats connected with cairn. Order in each cell: number of seedlings, row percentage, column percentage.

Fire	Flat	Bottom	Slope	Top
	18	149	451	34
0	2.8	22.9	69.2	5.2
	78.3	76.0	84.9	89.5
	5	47	80	4
F	3,7	34.6	58.8	2.9
	21.7	24.0	15.1	10.5

Effect of cairn habitat on seedling desiccation (WZ X LS)
Frequency of seedling desiccation depends most significantly (sig. $\chi^2 < 0.0001$) on its position on the cairn. Desiccation rate lessens higher up the cairn.

Table 8.14: Damage to seedlings by desiccation (WZ) or non-damage (0) in various habitats connected with cairn. Order in each cell: number of seedlings, row percentage, column percentage.

Drying	Flat	Bottom	Slope	Top
	7	76	314	26
0	1.7	18.0	74.2	6.1
	30.4	38.8	59.1	68.4
	16	120	217	12
WZ	4.4	32.9	59.5	3.3
	69.6	61.2	40.9	31.6

10. Effect of grazing regimes on seedling survival (GRAZ)

For examination of table 8.15, we see that cattle grazing significantly affects greater survival potential of seedlings. Absence or presence of boar made no apparent difference to survival.

Comparison of *Quercus ithaburensis* forest with *Ziziphus spinachristii* type vegetation with +boar and -cattle grazing regime showed no consistent trend.

In examination of change in length of seedlings from year to year in various grazing regimes, we found that in 1976 lengthening of seedlings occurred in cattle grazing areas and in 1974-75 a lessening in height in presence of cattle and lengthening in absence of cattle.

Effect of grazing regimes on seedling desiccation (GRAZ X Z)

Frequency of seedling desiccation in various grazing regimes is described in table 8.16 which shows significant correlation between seedling desiccation and grazing regimes in which they are found. Percentage of damage from desiccation in cattle grazing is a good deal less than the percentage of damage in other grazing regimes. From these grazing regimes it would seem that with no grazing at all (-boar and -cattle), the percentage of desiccation is higher. With regard to the *Ziziphus spinachristii* there are no consistent results so that it was not possible to reach any conclusions.

Table 8.15: Seedling survival in 1975, 1976 in various grazing regimes in *Quercus ithaburensis* forest and *Ziziphus spinachristii* savanoid vegetation.
+/-C = with/without cattle grazing; +/-B = with/without boar foraging. Order in each cell: number of seedlings and column percentage in each sub-table.

Life year after	QUEITH			ZIZSPI
	+C +B	-C +B	-C-B	-C +B
dead 1975	23 10.0	117 29.7	12 19.7	28 26.9
alive 1975	206 90.0	277 70.3	49 80.3	76 73.1
sig. χ^2	< 0.0001			
dead 1976	43 15.4	131 32.9	19 30.6	106 43.4
alive 1976	236 84.6	267 67.1	43 69.4	138 56.6
sig. χ^2	< 0.0001			

Effect of grazing regimes on damage to seedlings by conflagration (GRAZ X F): No significant correlation was found between grazing regimes and damage by fire.

Effect of location of budding on survival in various grazing regimes (GRAZ X BS): In examination of the effect of budding location on survival potential in various grazing regimes (table 8.17) we found significant correlation between survival and location of bud in that the higher the place of budding, the higher the survival. We found differences in the range in survival potential in varying grazing regimes. In cattle grazing

Table 8.16: Desiccation of seedlings (Z) or non-desiccation (0) during 1975, 1976 in various grazing regimes in the *Quercus ithaburensis* park forest and in *Ziziphus spinachristii* savanoid vegetation. Order in each cell: number of seedlings, column percentage in each sub-table.

drying	QUEITH			ZIZSPI
out	+C-B	-C+B	-C-B	-C+B
0 1975	200 87.3	255 64.7	25 41.0	101 97.1
Z 1975	29 12.7	139 35.3	36 59.0	3 2.9
sig. χ^2		< 0.0001		
0 1976	226 81.0	281 70.6	44 71.0	90 36.9
Z 1976	53 19.0	117 29.4	18 29.0	154 63.1
sig. χ^2		< 0.0001		

regimes approximately 84% of those budding basally remain alive and about 93% of those budding apically. In -cattle and +boar grazing regimes about 44% of those budding basally remain alive and about 79% of those budding apically. Where no grazing exists only 25% of those budding basally remain alive, while about 86% of those budding apically remain alive. It may be concluded as most obvious, that the rate of those seedlings which bud basally and remain alive lessens, as the grazing regime "lessens" (+C+B > -C+B > -C-B).

Effect of premature shedding, summer or autumn budding and gnawing of root neck on survival of seedlings in various grazing regimes (GRAZ X Y, X, T): Significant correlation was found in all grazing regimes between survival and premature shedding, summer or autumn budding and gnawing of root-neck as found above with regard to all seedlings. In the case of gnawing of root neck by rodents we found that frequency of this phenomenon was greater in -cattle grazing and -boar foraging (5.6% of seedlings die from this type of damage). It was smaller where only +boar foraging (1.5%) and +boar foraging and +cattle grazing together (1.8%) existed.

Table 8.17: Survival of seedlings in various grazing regimes (GRAZ) classified according to location of budding in seedling (BS). Each cell contains number of seedlings and the column percentage. +/-C = with/without cattle grazing; +/-B = with/without boar foraging.

GRAZ	+C+B			-C+B			-C-B		
BS	basal	lateral	apical	basal	lateral	apical	basal	lateral	apical
dead	7 16.3	4 4.3	4 6.9	18 56.2	17 34.0	38 21.0	4 75.0	0 0	5 14.3
alive	36 83.7	90 95.7	54 93.1	14 43.8	33 66.0	143 79.0	1 25.0	3 100.0	30 85.7
sig χ^2		0.01			< 0.01			< 0.01	

Table 8.17 exemplifies data on survival and budding for 1975. A similar picture was obtained for 1974 and 1976.

Effect of grazing treatments on distribution in age of seedlings (GRAZ X AGE): With regard to young seedlings (1-4), we found that in the absence of boar there is a tendency towards greater seedling age than in treatments with boar, as may be seen in table 8.17 a.
In the case of 5 years and older seedlings, which, for our purpose, formed one unit, we found that frequency of seedlings in this group was significantly greater with cattle grazing than without it (in t test over the years at a level of 0.05).

Table 8.17 a: Summary of distribution in age of seedlings in various grazing regimes: +/-C = with/without cattle grazing; +/-B = with/without boar foraging.

	+C-B	-C+B	-C-B
mean age (years) for seedlings 1-4 years	1.9	1.8	2.4
median age (years) for seedlings 1-4 years	1.5	1.7	2.7
frequency (%) of seedlings of age $\geq$5 years	67.7	50.1	51.6

Effect of grazing regimes on height of seedlings (GRAZ X HT, DHT)
We found no differences worth noting in distribution of height in seedlings in various grazing regimes. However, in height distribution of seedlings regenerating after fire, we found a tendency to greater frequency of taller seedlings in cattle grazing regimes, as opposed to other treatments. Frequency of seedlings at a height of 5-8 cms. in cattle grazing areas was twice that in non-cattle grazing areas although most of the seedlings in all the treatments were up to a height of 4 cms.

We found no significant changes among grazing treatments when comparing height changes in seedlings from one year to the previous year. In all the treatments there was a mean change in height within a range of ± 4 cms. Median height was within the same range. It should be noted that in non-grazing treatments there was a positive median in the 3 years of examination (range: 0.50 - 4.17 cms). -Cattle and +boar treatments had one year of positive median (range: 12.66 - +0.84 cms), while in +cattle and +boar treatments there were two years of positive median (range: -3.63 - +3.64 cms).

11. Analysis of effects of conflagration, desiccation and location in cairn on survival, with the aid of stepwise logistic regression *)

In the first stage the stepwise logistic regression model was run through the computer with the following variables: difference in height of seedling in a particular year as against the previous year (DHT), damage or non-damage by fire (F) and by desiccation (Z), and location of seedling on the cairn (LS).

In 1974 it was found that DHT clearly explains survival, in 1975 survival was explained in order of importance, by DHT, Z, LS and F and in 1976 survival was explained by DHT, LS, Z and F individually and in order of importance as well as by interaction between them, DHT X Z and DHT X F.

In the second stage an experiment was made to examine the effect on seedling survival of F, Z and LS without DHT which was the dominant factor affecting survival in the first stage. There was no improvement in the explanation of survival and its rate without DHT was low.

---

*) This analysis was carried out by Mrs. Anat Halevi as a part of her degree for the M.Sc in statistics, at the Hebrew University of Jerusalem, and I wish to thank her very much for her assistance.

Tables 8.18 - 20: Number of replicate-plots at various germination percentage levels (PGERM). Table 8.18 - by habitats, 8.19 - by grazing treatments, 8.20 - by vegetation types. Figure sequence in each cell is: number of replicate-plots, row percentage and column percentage for each table. +/- C = with/without cattle grazing, +/- B = with/without boar foraging. QUEITH = Quercus ithaburensis. ZIZLOT = Ziziphus lotus, ZIZSPI = Ziziphus spina-christii.

	8.18			8.19			8.20					
count row - % column - %	Habitats			Grazing treatments			Grazing - vegetation treatments					
PGERM	flat	cairn	tree-cairn	-C-B	-C+B	+C+B	QUEITH -C-B	QUEITH -C+B	QUEITH +C+B	ZIZLOT -C+B	ZIZSPI -C+B	ZIZLOT +C+B
0	40 40.0 31.3	29 29.0 29.9	31 31.0 31.3	20 20.0 18.0	34 34.0 32.4	46 46.0 42.6	20 20.0 18.0	25 25.0 36.2	37 37.0 44.0	6 6.0 25.0	3 3.0 25.0	9 9.0 37.5
1-25	54 35.1 42.2	41 26.6 42.3	59 38.3 59.6	46 29.9 41.4	58 37.7 55.2	50 32.5 46.3	46 29.9 41.4	35 22.7 50.7	36 23.4 42.9	16 10.4 66.7	7 4.5 58.3	14 9.1 58.3
26-50	7 18.4 5.5	23 60.5 23.7	8 21.1 8.1	16 42.2 14.4	11 28.9 10.5	11 28.9 10.2	16 42.1 14.4	8 21.1 11.6	10 26.3 11.9	2 5.3 8.3	1 2.6 8.3	1 2.6 4.2
51-75	11 68.8 8.6	4 25.0 4.1	1 6.3 1.0	14 87.5 12.6	1.0 6.3 1.0	1.0 6.3 0.9	14 87.5 12.6	1 6.3 1.4	1 6.3 1.2	0 0 0	0 0 0	0 0 0
76-100	16 100.0 12.5	0 0 0	0 0 0	15 93.6 13.5	1 6.3 1.0	0 0 0	15 93.8 13.5	0 0 0	0 0 0	0 0 0	1 6.3 8.3	0 0 0
χ^2	< 0.0001			< 0.0001			< 0.0001					

In the third stage we attempted to operate the model without Stepwise by dictating the interactions which the model should examine. The interactions examine were between DHT and each of the variables Z, F and LS, after it was proven in the preceding stages that DHT is dominant in explanation of survival.

In 1974 it was found that DHT remains the dominant factor in explanation of survival, but interaction between DHT X LS and DHT X F took an important part in explanation of survival.

For 1975 the result was as in Stepwise: all of the main factors were effective in order of their importance: DHT, Z, F and LS, but without interaction between them.

In 1976 DHT was the dominant factor explaining survival followed by DHT X Z, DHT X F and Z, in that order.

In conclusion it may be stated that DHT is the factor which best explains survival, followed by Z, LS and F. DHT was also found to affect interaction with F (in 2 out of 3 years) and with Z and LS (each in one year out of the 3 years).

12. Summary of results of natural germination

We found that most of the seedlings in the Yahudia forest are concentrated in close proximity to mature trees with no preference for direction in regard to the compass. The major part of the seedlings and the trees grow in cairn habitats, mainly on the slope of the cairn. An insignificant number of seedlings grow on the flat, open ground. Damage by fire and desiccation is less and survival potential greater, on the cairn.

Phenological parameters such as number of branches and height of seedlings show a moderate increase until the age of 4-5 years, after which a steep increase occurs for 2-3 years, followed by a tendency to stability. The older the seedling the greater its survival potential. The proportion of age 4 among living and dead seedlings was similar whereas the proportion of younger seedlings was greater among the dead, and proportion of older seedlings was greater among living seedlings.

Apical budding indicates good condition of seedling with high survival potential. Basal budding indicates a worse condition with lower survival potential.

Desiccation and fire affect survival negatively, while premature shedding, summer or autumn rebudding and browsing of leaves by cattle, show a positive correlation to survival. Gnawing of root-neck by rodents was destructive.

In cattle grazing areas desiccation of leaves was lower than in other grazing treatments. Recovery of seedlings after conflagration was speedier in cattle grazing areas and survival rate greater with significant intensification of survival among seedlings which bud basally. As a result, age divergence in cattle grazing areas also showed a greater rate of seedlings in the 5 years and over age-group.

8.3.2 *Sowing and planting of Quercus ithaburensis in Yahudia Forest*

8.3.2.1 Germination of seeds and taking root of seedlings (PGERM)

Percentage of germination in seeds and percentage of seedlings which take root and their mean percentage in each replicate according to main plots, treatments and habitats for both transplanted and sown seedlings are listed in Appendix 8.1.II Vol. II.

1. Germination of seeds in various habitats

Table 8.18 shows germination of seeds which had been sown in various different habitats. This table shows significant correlation between percentage of germination and habitat. Percentage of plots in which 75-100% of the seeds succeed in germination is greater in open habitats (12.5%) than in cairn habitats (0%). Open habitats also retain their advantage over other habitats at a germination rate of 51-75% and the cairn is more advantageous than the tree cairn. The percentage of plots with low germination is greatest in tree cairns. Percentage of plots where seeds did not germinate at all was about 30% in all three habitats.

Table 8.21 shows mean percentage of germination in different habitats and different sowing years, and indicates a similar trend of highest germination percentage in open habitats and lowest in tree cairns. High variability from year to year is apparent. Germination percentage was low in 1973. Variability of data was high and all the differences in habitats were not significant.

Tables 8.21 - 8.23: Mean germination percentage (PGERM)(and - in parentheses - number of replicate plots from which means were calculated), by sowing years (B.year), by habitats and by grazing treatments. +/-C = with/without cattle grazing; +/-B = with/without boar foraging.

8.21

HAB	B. year		
	1973	1974	1975
Flat	0.7 (24)	20.5 (52)	29.5 (52)
Cairn	1.8 (16)	6.3 (37)	26.6 (44)
Tree-cairn	2.6 (16)	4.1 (29)	15.6 (36)

8.22

	GRAZ. TREATMENT		
B. year	+ C +B	-C +B	-C -B
1973	1.1 (32)	2.6 (15)	1.3 (9)
1974	1.0 (40)	1.9 (40)	28.5 (46)
1975	16.2 (36)	17.3 (48)	33.7 (56)

8.23

	B Year 1974			B Year 1975		
HAB	+C +B	-C +B	-C -B	+C +B	-C +B	-C -B
Flat	0.8 (16)	0.8 (16)	52.0 (16)	5.8 (12)	16.3 (16)	50.3 (24)
Cairn	1.3 (12)	4.5 (12)	12.8 (13)	27.2 (12)	20.8 (16)	32.0 (16)
Tree-cairn	1.3 (12)	0.8 (12)	8.0 (13)	21.3 (16)	15.0 (16)	10.5 (16)

In fig. 8.7 we see the relative advantage of the open habitat, from the high germination percentage.

2. Germination of seedlings in different grazing regimes

We learn about germination of seedlings in different grazing regimes from table 8.19, which shows significant correlation between grazing regimes and germination percentages. Percentage of plots in which germination was greater than 25% is higher in non-cattle grazing and non-boar foraging treatments than in the two other grazing treatments. Percentage of plots in which no germination occurred at all increases together with the intensity of grazing (highest in cattle grazing and boar foraging plots, reaching approximately 43%).

This trend also appears in table 8.22 which gives the mean germination percentages in various sowing years. Preference for non-grazing plots is apparent in the year 1975 and particularly 1974. Variability in germination percentages among the different plots was high and all differences in grazing regimes were not significant.

Fig. 8.8 presents the advantage in high germination percentages of non-grazing treatments as against a large percentage of plots in other treatments in which germination percentage is low.

It may thus be concluded that in boar foraging treatments the percentage of germination decreases significantly (in approximately 52% calculated on the basis of number of seedlings). In cattle grazing treatments there is a tendency to decrease in germination percentage (in about 14% of number of seedlings) compared with non-grazing treatments.

3. Germination of seeds in various vegetation units

Comparison of germination percentages among the three grazing regimes in *Quercus ithaburensis* forest (table 8.20) provides results similar to the general results which are mainly based upon the *Quercus ithaburensis* forest.

For the *Ziziphus lotus* type vegetation, table 8.20 compares two grazing regimes. In +boar foraging and -cattle grazing treatment the percentage of plots in which germination occurred was higher at all levels of germination than +cattle grazing and +boar foraging treatment. The percentage of plots in which germination occurred was also higher in -cattle grazing treatments. Altogether, the germination percentage in -cattle grazing treatments is approximately 12% higher, calculated on the basis of number of seedlings.

FIG: 8.7

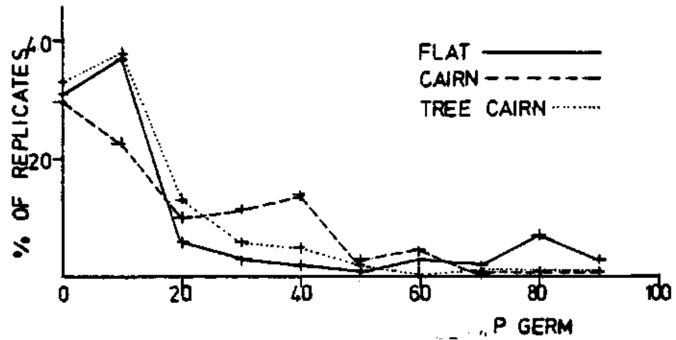


Figure 8.7: Percentage of seed germination (in tens) in various habitats: open area, cairn and tree cairn.

FIG: 8.8

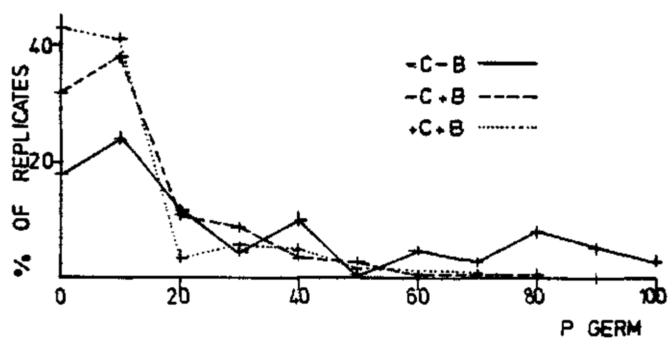


Figure 8.8: Percentage of seed germination (in tens) in various grazing regimes: with/without cattle grazing (+/-C), with/without boar foraging (+/-B).

In comparison of -cattle and +boar grazing regimes in the three types of vegetation we find that the germination percentage in the *Quercus ithaburensis* forest is lower than *Ziziphus* species by about 11% but no difference was apparent between *Ziziphus lotus* and *Ziziphus spinachristii*. In comparing +cattle and +boar grazing regimes between *Quercus ithaburensis* and *Ziziphus lotus* there was no definite trend.

4. Interrelations in influence of habitats and grazing regimes on germination

Table 8.24 shows the correlation between germination percentage and the habitat in various grazing regimes. It is seen that where there is no grazing at all, the advantage of an open habitat is significantly retained. However, the introduction of boar foraging lessens preference for this habitat and the correlation between habitat and germination percentage become non-significant. In the presence of cattle and boar the open habitat's germination percentage becomes inferior and the preference for the cairn becomes greater.

Table 8.23 shows that in sowing years 1974 as well as 1975 (1973 was excluded from the table since data was insufficient) the combination of total absence of grazing and open habitat provided the highest germination percentage. The combination of absence of grazing on the cairn was second in the level of germination. However, with grazing, the cairn becomes the habitat with highest germination percentage.

5. Taking root of seedlings transplanted from a nursery

Our data showed no significant correlation between root-taking percentage of seedlings following transplantation to an open area, neither between percentage of those which had taken root and habitats, nor between grazing regimes and vegetation units.

The only prominent, unequivocal fact was that in -cattle and -boar grazing regime there was 75-100% root-taking in all plots, while in other grazing treatments, taking of root was dispersed over the whole range from 0-100%.

6. Summary of results on seed germination and taking root of seedlings from a nursery

The topic of germination may be summarized thus. The open habitat takes preference for seed germination over the cairn, but the presence of boar which are more active in open ground, makes the cairn a preferable location.

Table 8.24: Number of replicate plots at various germination percentage levels (PGERM) under three grazing treatments with three habitats to each treatment. +/-C = with/without cattle grazing; +/-B = with/without boar foraging.

count row pct. col. pct.	- C - B			- C + B			+ C + B		
PGERM	flat	cairn	tree-cairn	flat	cairn	tree-cairn	flat	cairn	tree-cairn
0	3 15.0 6.3	8 40.0 22.9	9 45.0 25.7	12 34.3 20.0	11 31.4 22.9	12 34.3 24.0	26 54.2 44.8	10 20.8 22.7	12 25.0 27.3
1-25	12 26.1 25.0	12 26.1 34.3	22 47.8 62.9	24 41.4 40.0	14 24.1 29.2	20 34.5 40.0	19 36.5 32.8	15 28.8 34.1	18 34.6 40.9
26-50	4 25.0 8.3	10 62.5 28.6	2 12.5 5.7	2 14.3 9.3	9 64.3 18.8	3 21.4 6.0	2 14.3 3.4	7 50.0 15.9	5 35.7 11.4
51-75	11 78.6 22.9	3 21.4 8.6	0 0 0	7 50.0 11.7	3 21.4 6.3	4 28.6 8.0	4 30.8 6.9	4 30.8 9.1	5 38.5 11.4
76-100	18 81.8 37.5	2 9.1 5.7	2 9.1 5.7	15 40.5 25.0	11 29.7 22.9	11 29.7 22.0	7 36.8 12.1	8 42.1 18.2	4 21.1 9.1
Sig. χ^2	< 0.0001			< 0.0001			< 0.0001		

Germination with -boar and -cattle grazing is more intense than +boar both with regard to seedlings sown in the field and seedlings transplanted from a nursery.
Seed germination is better in *Ziziphus spinachristii* and *Ziziphus lotus* units than in *Quercus ithaburensis* forests.

8.3.2.2 Changes of measured parameters with calendar months, various habitats and grazing regimes and in major vegetation units

Tables 8.25 and 8.26 show observed parameters of seedlings. For each parameter the change of number of plots in which it was recorded, with calendar month, is shown.

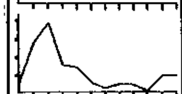
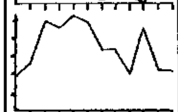
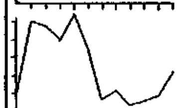
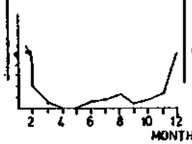
With regard to some specific months, numerical data is given on percentage of plots in which the parameter is recorded in the same month, and the percentage of plots in which the parameter was recorded in a month, out of the total number of plots in which it was recorded. The months chosen were peak months, or months which appeared significant as far as the results were concerned. In addition, the percentage of plots is shown in which the parameter is recorded all year round in various habitats and treatments for seedlings sown in the open ground ("SEED") and seedlings transplanted from a nursery ("SEEDLING" in table "SDING").

Table 8.25 gives several phenological parameters:

(NSEED) - Number of plots in which oak seedlings were observed: This value reaches a peak in spring and becomes stabilized in autumn. The highest percentage of seedlings was recorded in the cairn and the lowest in the open ground. With regard to transplanted seedlings the cairn was preferred. Among grazing treatments no great differences were noticeable among seedlings, and in the vegetation units there was a tendency to preference of the *Ziziphus spinachristii* unit. With regard to transplanted seedlings the low percentage of plots in which seedlings were observed was apparent in non-grazing treatments.

(NBUDS) - Number of plots in which budding seedlings were recorded: This value reaches its peak in the spring as may be expected from the characteristics of the *Quercus ithaburensis* (see chapter 6). Of particular interest is uncustomary autumn budding which shows two peaks at end of summer and end of autumn. Here too, there is a peak percentage of budding

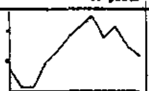
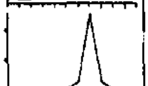
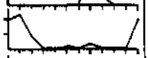
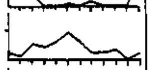
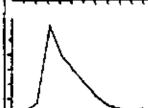
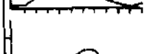
Table 8.25: Phenological parameters' frequency of Quercus ithaburensis seedlings and their changes over months, habitats, grazing treatments and main vegetation types

Description of parameter	Parameter	Scattergram no. of plots by months	Selected months: Month	Selected months: No. of plots	% of plots parameter was recorded: within month	% of plots parameter was recorded: out of all months	Habitat: flat Seed	Habitat: flat Sdling	Habitat: cairn Seed	Habitat: cairn Sdling	Habitat: tree-cairn Seed	Habitat: tree-cairn Sdling	Grazing: -C -B Seed	Grazing: -C -B Sdling	Grazing: -C +B Seed	Grazing: -C +B Sdling	Grazing: + C + B Seed	Grazing: + C + B Sdling	QUEITH -C + B Seed	QUEITH -C + B Sdling	QUEITH + C +B Seed	QUEITH + C +B Sdling	ZIZLOT -C + B Seed	ZIZLOT -C + B Sdling	ZIZSPI +C +B Seed	ZIZSPI +C +B Sdling	ZIZLOT + C + B Seed	ZIZLOT + C + B Sdling
		Total no. of plots	→ 6815				1744	264	2282	330	1886	339	2371	60	1751	569	1760	304	1131	341	1455	246	381	109	239	119	305	58
No. of plots with seedlings	NSEED		5 11	546 233	77.3 66.2	12.8 5.5	42.8	47.3	74.5	66.1	69.5	71.9	64.3	38.3	63.6	62.0	59.8	67.1	65.3	63.0	60.2	67.5	53.8	60.6	71.5	50.5	57.7	55.5
No. of plots with budding seedlings at checking time	NBUDS		3	377	52.5	29.4	13.6	22.3	22.7	23.6	17.9	21.9	20.2	20.0	18.0	20.0	15.8	27.1	17.8	19.4	15.7	25.6	16.0	82.9	22.6	19.3	35.4	34.5
No. of plots where leaves were recorded	MLVS		1 5	198 536	30.1 75.9	4.8 13.1	41.6	36.7	72.3	61.2	67.0	64.7	63.1	38.3	62.1	55.2	56.4	59.5	53.6	58.4	57.0	50.2	52.2	52.3	71.1	48.7	53.8	56.9
No. of plots seedlings with budding at basal-site	BS-1		2 8 12	50 9 20	7.4 1.7 3.1	5.6 31.3 14.1	4.8	0	5.0	2.4	4.2	1.4	6.5	1.7	3.8	0.9	2.8	2.0	3.9	1.5	2.7	2.4	2.6	0	5.0	0	3.3	0
No. of plots seedlings with budding at lateral site	BS-2		2	48	7.1	3.8	1.7	0.4	4.0	2.1	2.7	2.5	3.3	0	2.3	1.4	2.8	3.0	2.0	0.9	3.0	3.7	2.1	2.8	3.8	1.7	1.6	0
No. of plots seedlings with budding at apical site	BS-3		2	133	19.6	3.9	3.3	0.4	12.0	6.4	8.5	6.1	8.9	0	8.7	3.7	6.5	5.9	9.1	5.3	6.3	7.3	6.8	0.9	10.0	1.7	7.9	0
No. of plots-fall of leaves were recorded	X		1 8 6-10	99 11 32	15.0 2.0 1.3	45.6 5.1 14.8	0.4	0.8	5.4	3.3	4.1	0.7	3.2	0	3.3	2.3	4.0	0.7	4.0	1.8	4.1	0.8	2.9	1.8	0.4	4.2	3.3	0

Comments: 1) Number of plots in this table means number of replicate plots multiplied by number of visits in each.
2) The vertical axis of each graph is of different scale; origin is always zero; ╡- 100; ┤- 50; ┤- tens

Table 8.26: Remarks' frequency concerning drying out, burning and animal damages to Quercus ithaburensis seedlings, and their changes over month, habitats, grazing treatments and main vegetation types.

Percent of plots in which parameter was recorded

Description of remark	Remark	Scattergram no. of plots by months	Selected months: Month	Selected months: No. of plots	% of plots remark was recorded: within month	% of plots remark was recorded: out of all months	Habitat: flat Seed	Habitat: flat Sd-ing	Habitat: cairn Seed	Habitat: cairn Sd-ing	Habitat: tree-cairn Seed	Habitat: tree-cairn Sd-ing	Grazing: -C -B Seed	Grazing: -C -B Sd-ing	Grazing: -C +B Seed	Grazing: -C +B Sd-ing	+C +B Seeding	+C +B Sd-ing	Quercus -C +B Seed	Quercus -C +B Sd-ing	Quercus +C +B Seeding	Quercus +C +B Sd-ing	Ziziphus -C +B Seed	Ziziphus -C +B Sd-ing	Ziziphus -C +B Seeding	Ziziphus -C +B Sd-ing	Ziziphus +C +B Seeding	Ziziphus +C +B Sd-ing
		Total No. of plots →		6815			1744	264	2282	330	1886	339	2371	601	1751	569	1760	304	1131	341	1455	246	381	109	239	19	305	58
Dried out	Z		6 8 10	181 251 169	29.3 45.6 44.8	12.2 16.9 11.4	19.7	36.7	21.8	33.3	18.8	32.4	24.5	26.7	19.8	36.4	13.8	29.9	19.2	37.0	13.2	24.8	13.3	29.4	21.8	41.2	16.7	51.7
Totally burned	F		7	124	22.6	92.5	2.9	6.1	1.5	3.6	0.8	2.2	2.2	10.0	1.7	3.9	1.0	2.3	1.3	4.7	0.8	2.8	1.6	2.8	3.3	2.5	1.6	0
Partially burned	H		7	18	3.3	85.7	0.1	0.8	0.4	0.9	0.1	1.1	0.3	11.7	0.2	0.4	0.2	1.6	0.2	0.6	0.2	2.0	0.5	0	0	0	0	0
Trampling by cattle	C		2	23	3.4	31.5	3.0	0.8	0.1	0	0.1	0	0	0	0	0	4.0	0.7	0	0	2.7	0.4	0	0	0	0	10.5	1.7
Browsing by cattle	V		6	9	1.5	21.4	0.6	0.8	0.7	1.2	0.5	0.4	0	0	0	0	1.8	2.3	0.1	0	2.0	2.0	0	0	0	0	0.7	3.4
Rooting by boars	I		1	161	24.5	59.2	5.7	7.2	2.4	1.5	3.9	1.4	0	0	7.3	2.3	5.9	6.6	7.3	2.6	5.6	2.7	7.3	3.7	7.1	0	6.8	19.0
Eating by boars	Q		1	133	20.2	65.5	4.4	0.4	2.1	0.1	3.4	0	0	0	5.5	0	4.9	1.6	5.3	0	4.6	0.8	5.8	0	6.3	0	6.6	5.2
Nibbling by rodents	O		3	6	0.8	33.3	0.7	0	0	0	0.3	0	0.5	0	0.2	0	0.1	0	0.4	0	0.1	0	0	0	0	0	0	0
Nibbling of root neck by rodents	T		4 6	55 35	8.8 5.7	30.7 19.6	1.2	2.3	2.6	1.5	2.7	1.1	3.7	5.0	2.2	1.1	2.2	2.0	2.2	1.2	2.2	2.4	2.8	1.8	3.5	0	2.3	0
Nibbling of apical leaves by rodents	U		7	6	1.1	24.0	0.6	0	0.4	0.3	0.2	0	0.7	0	0.2	0.2	0.1	0.3	0.4	0	0.1	0.4	0	0.9	0	0	0.3	0
Seedling from partially nibbled acorn	M		3	6	0.8	50.0	0.3	0	0	0.9	0.1	0	0.3	0	0.1	0.2	0	0.7	0	0	0	0	0.3	0	0	0.8	0	3.4
Leaves eaten by insect larvae	N		7	12	2.2	92.3	0	0	0.3	0	0.4	0	0.5	0	0.1	0	0.1	0	0.1	0	0.1	0	0	0	0	0	0	0
Uprooting by animal	K		3	21	2.9	36.2	0.1	10.6	0.2	1.2	0.1	2.9	0	0	0.4	3.5	0.1	0.9	0.5	5.0	0.1	5.7	0	2.8	0.4	0	0	27.6

Comments: 1) Number of plots in this table means number of replicate-plots multiplied by number of visits in each.

2) The vertical axis of each graph is of different scale; origin is always zero; ⫣ = 100; ┤ = 50; ┤ = tens.

seedlings in the cairn and low percentage on the open ground, which can also be seen in fig. 8.9. This figure also shows, that in autumn budding, the percentage of budding seedlings is highest in the cairn.
Among grazing treatments, wild boar and cattle grazing have a tendency to a lesser degree of budding and in the vegetation units the *Ziziphus spinachristii* has the highest values. Transplanted seedlings have the highest degree of budding among +boar and +cattle grazing plots and in the *Ziziphus lotus* vegetation unit.

(MLVS) - Number of plots in which presence of leaves on seedlings was recorded: Absence of leaves can be a result of shedding, premature shedding, browsing, gnawing and desiccation. Percentage of seedling plots in which presence of leaves was recorded is greater in the cairn and smaller on open ground. Transplanted seedlings also had a slightly higher percentage in the cairn. With regard to grazing treatments there is a tendency in seedlings to a lower percentage with both cattle and boar grazing and with regard to vegetation units there is a higher percentage among the *Ziziphus spinachristii*. Transplanted seedlings have a higher percentage in +cattle and +boar grazing treatments, it is particularly low in non-grazing treatment.

BS1-3 - Number of plots in which recording was made of seedlings which bud basally, laterally or apically, respectively: In the three variables, the peak occurs in spring. This is caused by the phenological characteristics of the *Quercus ithaburensis* (see chapter 6). An additional peak in autumn represents autumn budding. Spring basal budding continues for a longer period of time than buds situated higher on the seedlings whose autumn budding values are the lowest. With regard to habitats, the cairn receives the highest values in all three parameters, and open ground usually receives the lowest. However, in comparison of BS1, BS2 and BS3, the advantage of the cairn in apical budding is prominent. This is shown in figure 8.10 where we also see that preference for the cairn over the tree cairn and preference for the latter over the open ground is also prominent in autumn wave of budding. These characteristics are seen both in sown and transplanted seedlings.
With regard to grazing treatments in sown seedling plots, +cattle and +boar treatment take the lowest values of all budding locations (BS1-3) and non-grazing treatments take the highest. Percentage of seedlings

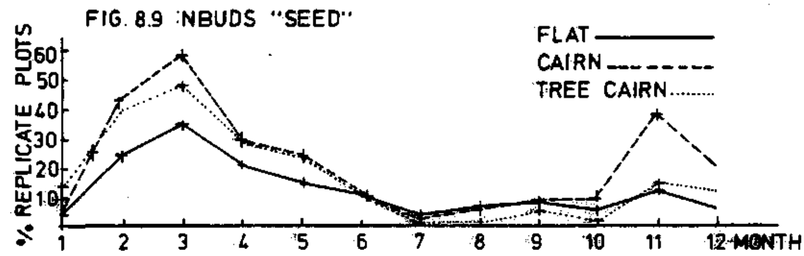


Figure 8.9: Frequency of budding in seedlings sown in the open ground, according to months and various habitats, expressed in percentage of plots in each month in each habitat in which budding was observed. General budding.

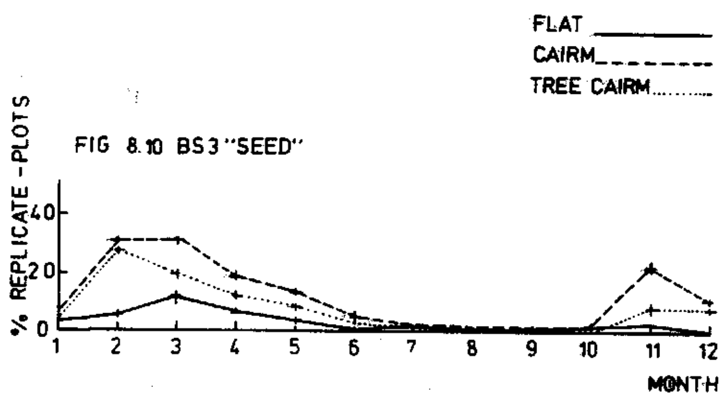


Figure 8.10: Frequency of budding in seedlings sown in the open ground, according to months and various habitats, expressed in percentage of plots in each month in each habitat in which budding was observed. Apical budding.

which bud apically is highest in all three treatments. In vegetation units the *Ziziphus spinachristii* is highest in all three parameters and *Ziziphus lotus* the lowest.

As opposed to sown seedlings, transplanted seedlings show preference for treatment with +boar and +cattle grazing and non-grazing treatments have the lowest budding percentage. In *Quercus ithaburensis* type vegetation budding is higher than in *Ziziphus spinachristii* and in the latter budding is higher than in the *Ziziphus lotus*.

X - Shedding or appearance of shedding colours: The characteristics of the *Quercus ithaburensis* usually cause winter shedding (see chapter 6). It is interesting to note premature shedding which sometimes occurs in summer and is typical of the seedling. On examination of variability of seedling shedding percentage throughout the year in various habitats, we found that premature shedding was more common in the cairn and tree cairn than on the open ground, but in no case was it higher than a rate of 5% of the seedlings. In table 8.25, we summarized the months of premature shedding (Jun-Oct) and it is apparent that during all these months the percentage of seedlings which shed their leaves prematurely is 14.8% of total shedding in seedlings, which constitutes a mean 1.3% per month of the seedlings. It is interesting to note here the low percentage of sown seedlings in the open habitat in which shedding was observed. With regard to transplanted seedlings this percentage is also very low in the tree cairn.

Table 8.26 illustrates a series of parameters concerned with damage to seedlings by desiccation, fire and animals.

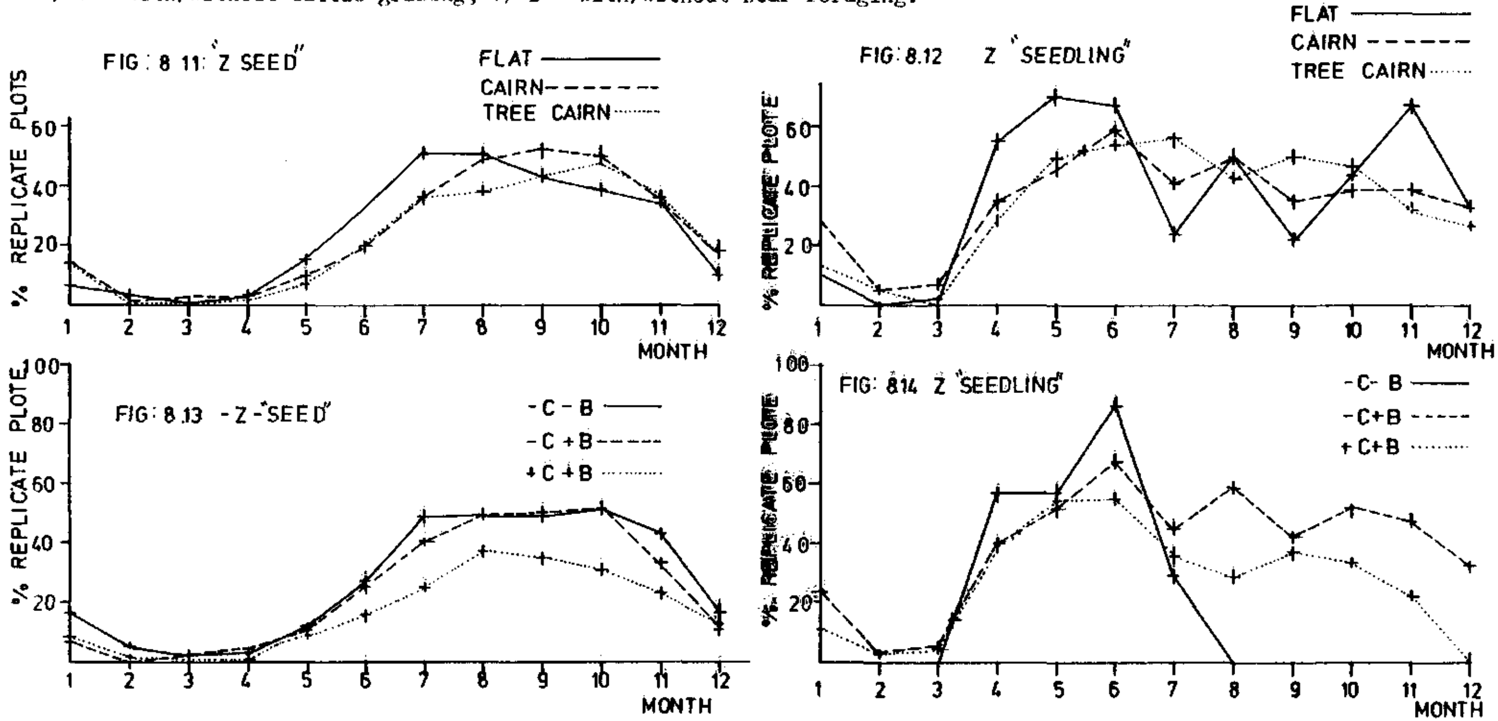
Z - Total desiccation of seedlings: Desiccation of seedlings reaches its peak in August. Percentage of sown seedling plots in which this phenomenon was recorded is slightly higher in the cairn, although in fig. 8.11 it may be seen that in comparing percentage of plots each month in the open habitat, the seedlings shedprematurely. This is also apparent in transplanted seedlings (fig. 8.12).

With regard to grazing regimes, the percentage of sown seedling plots where most desiccation had occurred, was in non-grazing plots and the least desiccation occurred where there was cattle and wild boar grazing.

Fig. 8.11: Seedlings from seeds, according to habitat. Fig. 8.12: Transplanted seedlings, according to habitat.

Fig. 8.13: Seedlings from seeds according to grazing regime. Fig. 8.14: Transplanted seedlings according to grazing regime.

+/-C = with/without cattle grazing; +/-B = with/without boar foraging.



Figures 8.11, 8-12, 8-13, 8-14: Frequency of desiccation in seedlings according to months and habitats or grazing regimes, expressed in percentage of plots in each month, in each habitat or treatment in which desiccation was observed.

This may be seen in figure 8.13 where we learn that desiccation occurs early where there is absence of grazing rather than where there is some grazing.
In the case of transplanted seedlings the highest desiccation percentage was in +boar foraging plots, but in non-grazing plots there was intense desiccation in the summer, which caused the death of most of the seedlings and thus low values for the rest of the year (fig. 8.14).
In vegetation units there was less desiccation in *Ziziphus lotus* plots, both among sown and transplanted seedlings. Parameter W, representing partial desiccation, is similar to Z (total desiccation). Because of the partial character of the phenomenon it represents, results were less significant and therefore not mentioned here.

F - All parts of seedling damaged by conflagration: Damage to seedlings by fire occurred only during Jun-Aug, with a peak in July, when 92.5% of the damage occurs. It is most common in the open habitat, less common in the cairn and minimal in the tree cairn.
The grazing regime in which percentage of plots damaged by fire is highest in the non-grazing regime, and the lowest is in the +cattle and +boar grazing regime.
Effect of conflagration in various habitats and treatments on sown seedlings and transplanted seedlings is similar, although the degree of damage is greater in transplanted seedlings.

H - Seedlings partially damaged by conflagration: The behaviour of this parameter is similar to that of total damage (F), although, due to its partial nature, to a lesser degree.
The subject of fire in a reserve and its effect on the *Quercus ithaburensis* will be dealt with in detail in chapter 9.

Damage to seedling by cattle

C - Trampling by cattle: Trampling occurs mostly during the winter months when the ground is muddy and effect is significant both in the underfoot and surrounding areas. The phenomenon is more common in open habitat than in cairn, to where the cattle usually cannot reach. Frequency of the phenomenon is quite low.

V - Browsing of seedlings by cattle: This occurs mainly in summer but is not common and no significant difference in frequency were found among the various habitats. We shall return to effect of cattle on *Quercus ithaburensis* in chapter 10.

Damage to seedlings by wild boar

E - Uprooting of seedlings by boar: This occurs only in spring and winter when the earth is soft and suitable for burrowing. During some of this period (Nov-Dec) this is accompanied by searching for acorns by boar in the vicinity of the trees. This is not frequent although more common in the open habitat and less common in the cairn. There was no significant difference in plots with cattle grazing or plots without cattle grazing.

Q - Consuming of seedlings by boar: This is a more frequent phenomenon, particularly in the season directly after sowing, when the boar burrow and eat either the acorn before germination, or as a young seedling. The highest percentage of damage to plots occurs in the open habitat and the lowest percentage in the non-tree cairn. The presence of cattle does not affect eating of seedlings.

Damage by rodents

O - Nibbling of foliage and stem by rodents: This is not common and occurs in winter and spring.

T - Gnawing of root-neck by rodents: This is a fairly common phenomenon and causes the collapse of the above-ground section. It is common mostly in spring and beginning of summer and there is no significant difference between the habitats. In -boar grazing treatment, however, the phenomenon is more common.

U - Nibbling of seedling apex by rodents: This is rare and occurs in summer, not damaging significantly the seedling.

M - Seedling germination from acorn gnawed by rodents: This sometimes occurs and was observed mainly in spring with commencement of germination, however, around growth is obtained.

Damage to seedlings by other animals

N - Eating of leaves by insect larvae: This is infrequent and occurs in summer, being relevant to the insect life-cycle.

K - Uprooting of seedlings by unidentified animals: Uprooting can be caused by porcupines, boar, spalax, etc., and is not frequent, occurring mainly in spring. It is significant mostly with regard to seedlings transplanted from a nursery to the open habitat.

8.3.2.3 Survival of seedlings (PLIVE)

1. Survival of seedlings in various habitats: Table 8.27 presents survival as a dichotomous variable taking the value 1 if seedlings survive in plot and 0 if they do not, as against the habitats. Correlation between survival and habitats was most significant (sig. $\chi^2 < 0.0001$). It may be seen from the table that seedlings survived in 31.8% of plots in the open habitat, in the cairn 85.3% remained, and in the tree-cairn live seedlings were found in 57.4% of the plots.
   With regard to seedlings transplanted from a nursery it appears that in the open habitat, seedlings remain alive in only 2.7% of the plots, 20% in the cairn and 25% in the tree-cairn. This is shown in table 8.28 where significant correlation was found between survival and habitats (sig. $\chi^2 = 0.0263$).

Table 8.27: Number of replicate plots in which seedlings in various habitats survived (PLIVES = 1) or did not survive (PLIVES = 0); sown seedlings.

Count Row % Col. %	HABITAT		
	FLAT	CAIRN	TREE CAIRN
PLIVES 0	60 60.6 68.2	10 10.1 14.7	29 29.3 42.6
1	28 22.4 31.8	58 46.4 85.3	39 31.2 57.4

Table 8.28. Number of replicate plots in which seedling, transplanted from nursery, in various habitats survived (PLIVES = 1) or did not survive (PLIVES = 0).

Count Row % Col. %	HABITAT		
	FLAT	CAIRN	TREE CAIRN
PLIVES 0	36 44.4 97.3	24 29.6 80.0	21 25.9 75.0
1	1 7.1 2.7	6 42.9 20.0	7 50.0 25.0

From examination of survival of sown seedlings each individual year, compared with the previous year ($PLIVE_i$) there is a similar trend with noticeably high survival in 1977, illustrated in fig. 8.15. Distribution of survival in 1977 (PLIVE 5) as in other years is characterized by 2 peaks: the first is 0% survival particularly noticeable outside the cairn in the open habitat, and a second peak in high survival percentage (96-100%), noticeable in the cairn, but also in the tree cairn.

FIG. 8.15

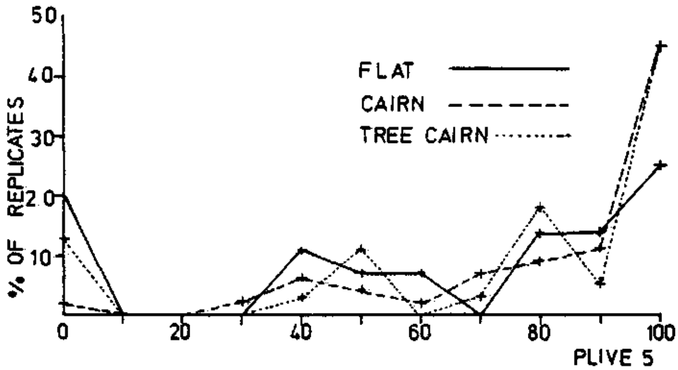


Figure 8.15. Survival of seedlings in 1977 (percentage in tens) which were sown in the field in various habitats: open ground, cairn and tree-cairn.

FIG. 8.16

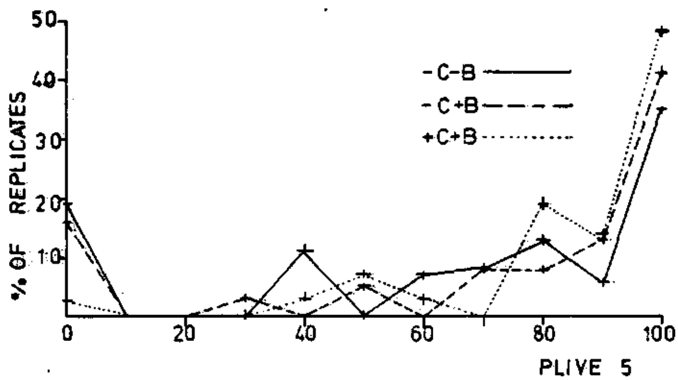


Figure 8.16. Survival of seedlings in 1977 (in percentage of tens) which were sown in the field in various grazing regimes: with/without cattle grazing (+/-C), and with/without boar foraging (+/-B).

Mean and median survival values in percentages for various habitats is given in table 8.29, where for each year most significant differences were found between habitats (median test sig. < 0.001). Here also, seedling survival is highest in the cairn habitat and lowest in the open habitat.

Table 8.29. Mean and median of sown seedling survival in three habitats: open ground, cairn, tree-cairn. Survival calculated each year in percentages from the previous year.

Mean Median	PLIVE 3 1975	PLIVE 4 1976	PLIVE 5 1977
HABITAT			
FLAT	6.8 0.0	13.8 0.1	60.2 74.8
CAIRN	59.2 80.1	59.8 62.0	86.7 92.9
TREE CAIRN	64.9 74.9	44.6 39.6	73.1 86.1
Median test sig.	< 0.001	< 0.001	< 0.001

1974 data were not given because of limited data from 1973.

In examination of survival each year (i) compared with the first year after sowing or planting ($T.PLIVE_i$), presented in table 8.30, it may be seen that each year consistently, mean survival is highest in the cairn habitat and lowest in the open habitat, (although no significant difference was found between habitats because of great variability of the data).

In table 8.30 the great difference in mean survival between sowing years in the open habitat is also emphasized. In sowing year 1975 survival is highest and in 1973 - lowest. This difference between years does not exist in the cairn and tree-cairn.

2. Survival of seedlings in various grazing regimes: We found no significant inter-relations in influence (χ^2 test) between grazing treatments and

Table 8.30: Mean survival percentages for the years 1975, 1976 and 1977 on the first year after sowing, in various habitats in each sowing year (in parentheses - number of replicate plots from which means were calculated).

	T.Plive 3 -1975		T.Plive 4 - 1976			T.Plive 5 - 1977		
B.YEAR	1973	1974	1973	1974	1975	1973	1974	1975
HAB								
FLAT		2.1 (32)	0 (10)	4.0 (32)	11.4 (45)	0 (10)	3.6 (32)	5.9 (46)
CAIRN	61.1 (8)	51.5 (22)	52.5 (8)	29.5 (22)	57.2 (38)	52.5 (8)	28.3 (22)	43.3 (38)
TREE-CAIRN	41.4 (10)	45.3 (18)	43.2 (10)	24.9 (18)	35.2 (40)	28.2 (10)	22.4 (18)	26.7 (40)

Table 8.32: Mean survival percentages for the years 1975, 1976 and 1977 calculated on the basis of number of seedlings in the first year after sowing in various grazing regimes and vegetation types in each sowing year (in parentheses - number of replicate plots from which means were calculated).

	TREAT.	QUEITH			ZIZLOT		ZIZSPI
	B.YEAR	+C +B	-C +B	-C -B	+C +B	-C +B	-C +B
T.Plive 3 1975	1973	34.9 (14)	31.8 (8)	26.7 (6)			
	1974	31.4 (13)	25.0 (13)	25.5 (34)	33.3 (5)	34.4 (8)	
T.Plive 4 1976	1973	34.2 (14)	21.5 (8)	33.3 (6)			
	1974	23.7 (13)	19.3 (13)	15.9 (33)	13.3 (5)	9.4 (8)	
	1975	48.4 (20)	33.0 (22)	25.0 (52)	28.1 (10)	51.6 (10)	31.2 (9)
T.Plive 5 1977	1973	34.2 (14)	21.5 (8)	8.3 (6)			
	1974	23.7 (13)	14.8 (13)	15.4 (33)	20.0 (5)	4.2 (8)	
	1975	37.0 (20)	21.3 (22)	18.7 (52)	21.5 (10)	29.1 (10)	29.6 (9)

survival, as a dichotomous variable neither in sown seedlings nor in seedlings transplanted from a nursery.
In examination of survival percentages in each year, based upon the previous year ($PLIVE_i$) it may be seen that there is a higher survival rate in +cattle and +boar grazing, and lowest in non-grazing regimes. Sample distribution of survival in 1977 is given in fig. 8.16, which shows a higher survival rate in +cattle and +boar grazing regimes and in only about 3% of plots in this regime no seedlings at all survived. However, in -cattle grazing treatments, with or without boar, no seedlings survived in about 16% or about 19% of the plots respectively.

It appears that this phenomenon is consistent, from examination of table 8.31, which gives mean and median values of survival percentages for various treatments, while differences in treatments are usually most significant (median test).

Table 8.31: Mean and median of survival percentages in sown seedlings over various years ($PLIVE_i$) with combinations of grazing treatments with and without cattle grazing (+/-C) and with and without boar foraging (+/-B).

Mean Median	PLIVE 3 1975	PLIVE 4 1976	PLIVE 5 1977
Grazing treatment			
-C -B	29.9 4.0	32.1 19.1	73.0 79.9
-C +B	33.3 6.7	40.9 25.0	70.9 87.0
+C +B	47.5 36.7	47.8 48.5	83.2 94.2
median test sig.	< 0.001	0.056	< 0.001

A similar examination of transplanted seedlings did not show a significant difference between grazing treatments and it is possible that this is due to lack of sufficient data and minimal surviving seedlings in the first year. In non-grazing treatments seedlings did not survive at all, and in +boar and -cattle grazing treatments survival percentage was 19.2%. In +boar and -cattle grazing treatments percentage was 11.1%.

In examination of survival percentage each year on the basis of the first year ($T.PLIVE_i$) it appears that +cattle and +boar grazing treatments are preferred to other treatments. In -cattle and +boar grazing, survival percentage is usually higher than non-grazing treatments, shown in table 8.32 which presents mean survival percentages for each year on the basis of each sowing year (B.YEAR) and for various grazing treatments. The advantage of +cattle and +boar grazing treatments is particularly apparent in *Quercus ithaburensis* vegetation treatments, for which data are complete, and plots numerous.
A similar trend was also seen in seedlings transplanted from a nursery, although this was based on too few surviving seedlings from the outset for us to be able to give the results here.
Complete data on T.PLIVE are given in appendix 8.1.II in Vol. II.

3. Survival of seedlings in various vegetation units: We found no significant interrelations in influence between main vegetation units, *Quercus ithaburensis* forest, *Ziziphus spinachristii* and *Ziziphus lotus*, and survival, neither in χ^2 test with survival as a dichotomous variable, nor in median test comparing survival distribution in various vegetation units and grazing treatments.
Table 8.32 presents mean survival percentages in various combinations of vegetation units and grazing regimes. The abovementioned trend of the *Quercus ithaburensis* forest in which the highest survival percentage is in +cattle and +boar grazing regimes and the lowest in non-grazing regimes, does not appear in the *Ziziphus lotus*. In comparison of the same grazing regime (+C and +B) between *Quercus ithaburensis* and *Ziziphus lotus* there is a tendency to higher survival in the *Quercus ithaburensis*, while in +boar and -cattle grazing regimes there is no definite trend when comparing *Quercus ithaburensis*, *Ziziphus lotus* and *Ziziphus spinachristii*.

4. Interrelations in influence of habitats and grazing regimes on seedling survival: A χ^2 test of habitat as opposed to survival as a dichotomous variable, was made on the following grazing treatments: non-grazing; +boar and -cattle and +boar and +cattle. Summary of these tests is given in table 8.33.

Table 8.33: Percentage of plots in which seedlings survive in combinations of habitat and grazing treatments with or without cattle grazing (+/−C) and with or without boar foraging (+/−B) and significance level in χ^2 tests as taken from original tables. (Parentheses: number of plots from which percentage was calculated.)

PLIVES = 1	HABITAT			
GRAZ	FLAT	CAIRN	TREE CAIRN	sig. χ^2
−C −B	40.0 (45)	81.5 (27)	38.5 (26)	0.0016
−C +B	10.4 (48)	56.8 (37)	57.9 (38)	0.0003
+C +B	18.8 (32)	61.8 (34)	43.8 (32)	0.0943

This table gives the percentage of plots and the number in which seedlings survived. Survival percentage in the open habitat is greater in the -boar grazing treatment than in the other grazing treatments and the -boar grazing treatment is equivalent to the tree-cairn habitat. Survival percentage in the non-grazing cairn habitat is also greater than this habitat in other grazing treatments.

Since the original table from which these data were taken and in which the correlation between grazing treatments and survival was examined, did not show significant correlation (see 8.3.2.2) one cannot reach any conclusions with regard to the difference in grazing regimes in each habitat.

In examination of survival percentage each year in proportion to the first year after germination ($T.PLIVE_i$) in combinations of habitats and grazing treatments, variability of the data was greater and we found no significant correlation between the combinations. Nevertheless, in the tree-cairn there was a tendency to the same order of treatments as above: highest survival in both +cattle and +boar grazing treatment and lowest in non-grazing treatment. In the cairn and the open habitat the highest survival rate was in +boar and +cattle grazing treatment. However, while there was no definite tendency in the cairn, towards other grazing treatments, there was consistent preference in the open habitat for -cattle and -boar treatment over +boar and -cattle treatment (see matrix

No. 2, App. 8.1.II).

5. <u>Correlation between survival of seedlings and change in their number of leaves</u>: We have seen above (table 8.25) the change in mean number of leaves per replicate plot over the months of the year and in various habitats and treatments.

We examined the difference in percentages between maximum number of leaves in two consecutive years ($DML_i = MNL_i - MNL_{i-1}$). This variable ranges theoretically from -100% to infinite, but in practice its value did not exceed 150%.

We divided the range of variability of DML into 5 categories:

-100%	seedling with leaves in the previous year now completely leafless. A seedling which was leafless in the previous year is not included in this category and is considered a missing value.
-99% - -21%	number of leaves on seedling significantly diminished.
-20% - +20%	no significant change in number of leaves.
-21% - +99%	significant increase in number of leaves.
≥ 100%	seedling at least doubles its number of leaves compared with previous year.

Fig. 8.17 shows the DML variable for 1977 against 1976 as a typical example. It may be seen that in most of the replicate plots there was no significant change in number of leaves, and a slight tendency to increase in number of leaves in the plots. In comparison of habitats in this figure we see that the percentage of plots in the open habitat, where no leaves remain or significantly diminish in number, is highest. Of the plots in which no significant change in number of leaves occurs, which is the largest group of plots, the percentage of plots is greatest in the cairn habitat. Among those whose number of leaves increased there was some preference for the open habitat. The smallest group was that in which the seedlings at least doubled their number of leaves and wihtin this group the tree-cairn habitat shows a higher percentage than the others.

In comparing DML in sown seedlings among the various habitats for 1975-1977, (1974 was excluded due to insufficient data), table 8.34 is obtained, which presents mean and median values of DML, with a significant difference in habitats for each DML in the median test.

FIG: 8.17

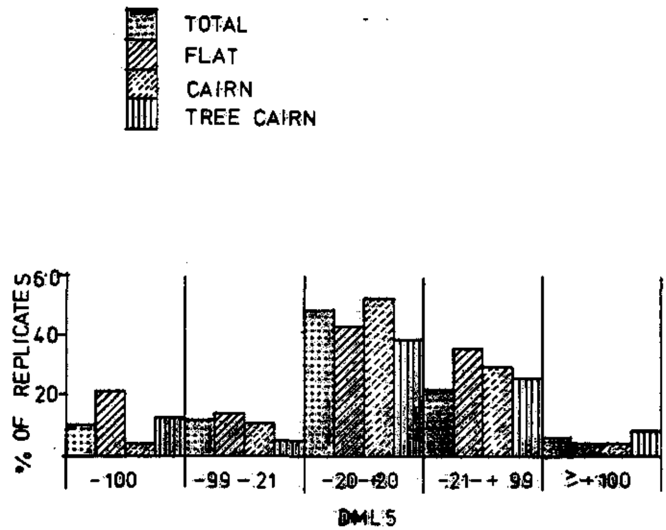


Figure 8.17: Percentage of plots calculated from the number of plots in each habitat, or of all the plots in which number of leaves in 1977 as compared with 1976 had at least doubled (100%), had increased considerably (-21% - +99%), had not increased considerably (-20% - +20%), had decreased considerably (-99% - -21%), or had been left left with no leaves whatever (-100%).

Table 8.34: Mean and median values of difference in number of leaves on seedlings in consecutive years 1975–1977 in various habitats.

mean median	DML 3 1975	DML 4 1976	DML 5 1977
HABITAT			
flat	-82.6 -99.7	-49.3 -57.1	-17.0 - 0.8
cairn	-20.1 - 8.3	12.9 9.7	12.4 14.7
tree cairn	-17.7 -11.1	-18.3 -19.3	4.3 0.0
median sig.	< 0.001	< 0.001	< 0.001

The table illustrates that the difference in number of leaves is very small in the open ground and usually very high in the cairn. Here, too, 1977 stands out as a year of comparatively greater development of seedlings compared with other years.
In seedlings transplanted from a nursery to the experimental area there is a tendency for preference of the cairn over open ground, where all the seedlings died. This tendency is not significant, probably because of insufficient data (see also App. 8.1 II).

Correlation between survival of seedlings and change in number of leaves according to habitats: χ^2 tests were carried out on seedling survival as opposed to change in number of leaves in two consecutive years ($PLIVE_i$ X DML_i) in various habitats. In every year (excepting 1974) and in every combination, most significant correlation was found between change of number of leaves and survival (χ^2 sig. < 0.0001, see App. 8.2. II).
After examining in these tables the three combinations of habitat in which the difference in number of leaves was greatest, the following was found:

In the open habitat: the three highest combinations ranged over 1%-100% survival, with the number of leaves either remaining unchanged or diminishing (DML -99% - +20%).

Cairn and tree-cairn: here we found that the three highest combinations ranged from 51% - 100% survival, usually within a positive DML range. Thus there is significant correlation between number of leaves and survival, with greater tendency to high DML values and survival in the cairn habitats.

Correlation between survival and change in number of leaves according to grazing regimes: tables 35 and 36 describe mean and median values of difference in number of leaves for consecutive years (DML) 1975-1977, against grazing treatments in all plots, in *Quercus ithaburensis* type vegetation and *Ziziphus lotus* type vegetation.

Tables 8.35, 8.36, 8.37: Mean and median values of difference in number of leaves from one year to the previous year for 1975-1977 in various grazing regimes: with/without cattle grazing (+/-C), with/without boar foraging (+/-B) in all plots (8.35), Queith forest (8.36), Zizlot unit (8.37).

mean median	DML 3 1975	DML 4 1976	DML 5 1977
TREATMENT			
-C -B	-46.8 -41.4	-24.8 -10.8	3.2 0.3
-C +B	-52.5 -98.6	-24.5 -23.1	- 5.3 0.1
+C +B	-35.4 -56.1	- 3.0 - 0.2	11.7 11.1
QUEITH			
-C -B	-46.8 -41.4	-24.8 -10.8	3.2 0.3
-C +B	-48.9 -97.6	-24.8 -23.1	- 4.7 1.2
+C +B	-43.8 -76.2	13.1 - 0.1	15.5 17.3
ZIZLOT			
-C +B	-61.1 -97.3	-25.1 -27.3	-32.9 -16.7
+C +B	17.2 -10.0	-46.1 -96.8	- 8.0 - 1.7

The difference in median values in each DML_i in the three sub-tables was most significant (median test sig. < 0.001). The tables show that the treatment in which difference in number of leave from one year to the preceding year is highest, is the +cattle and +boar grazing treatment, and the lowest in -cattle and +boar grazing, both in the *Quercus ithaburensis* forest and in the *Ziziphus lotus* unit.
Comparison of the 3 main vegetation units in -cattle and +boar treatments, show DML values in the *Ziziphus spinachristii* to be highest and in the *Ziziphus lotus* to be the lowest. Comparison of *Quercus ithaburensis* and *Ziziphus lotus* in +cattle and +boar treatments showed no definite trend.

There was no clear correlation in seedlings transplanted from a nursery, between the grazing treatment and difference in amount of foliage and this is possibly due to the great variability and small number of seedlings which survived after their first year.
In examining change in number of leaves in each of the years 1974-75 against survival in those same years (DML_i X $PLIVE_i$) for various grazing treatments, significant correlation was found (χ^2 sig. < 0.05) between difference in number of leaves in a year, as compared with the preceding year, as against survival in the same year (excluding one case in 1974). These data are given in App. 8.3. II of Vol. II. However, this correlation does not indicate an unequivocal trend in variability of combinations of DML_i and $PLIVE_i$ with treatments. In most of the treatments recurrence of high survival values occurs, accompanied by a more or less constant number of leaves (DML -20 - +20) with slight tendency to higher values of DML accompanied by high PLIVE in +cattle and +boar treatments. Any other difference in number of leaves (+20<DML<-20) was usually accompanied by lower survival values.

6. <u>Correlation between survival of seedlings and location of regeneration bud</u>: In examination of the correlation between seedling survival as a dichotomous variable (PLIVES) and each of the variables BS1, BS2, and BS3 which represent number of replicate plots in which seedling regeneration from a basal, lateral or apical bud respectively had occurred, significant correlation was found (χ^2 sig.< 0.0001) between survival and each of the regeneration sites. However, we did not find that the grazing treatments had any effect upon the rate of plots in which there was regeneration from a basal, lateral or apical bud. We have therefore not

shown the dependency of BS1-3 on PLIVE and in table 8.38 have shown the correlation between place of budding and survival for all the treatments together.

Table 8.38: Number of plots in which there was basal, lateral or apical budding (BS1, BS2, BS3 respectively) as against survival or non-survival (PLIVES 1, 0) of seedlings in all the treatments together. Order of numbers in each cell: count, row percentage, column percentage. Significance was found in each sub-table in χ^2 test < 0.0001.

	BS 1			BS 2			BS 3	
PLIVES	0	1	PLIVES	0	1	PLIVES	0	1
0	165 91.7 81.3	15 8.3 12.9	0	177 98.3 77.6	3 1,7 3.3	0	179 99.4 91.8	1 0.6 0.8
1	38 27.3 18.7	101 72.7 87.1	1	51 36.7 22.4	88 63.3 96.7	1	16 11.5 8.2	123 88.5 99.2

Of those remaining alive the percentage of plots in which apical regeneration occurred (BS3) was highest (range 80.5 - 95.8% in the three grazing treatments) as against those regenerating from lower buds (BS1, BS2, range 52.1 - 88.0% in the three grazing treatments).
Survival in the budding seedlings was sustained in 96.7 - 100% of plots with apical budding, 96.2 - 97.1% of plots with lateral budding and in 75.9 - 100% of plots with basal budding.
Analysis of numbers of replicate plots in which regeneration and survival occurred (lower right cell in each of the tables BS1-3 in each grazing treatment), showed us that there was no significant difference in grazing treatments. However, there was a significant difference in regeneration locations (a rate of 0.05 in F test), compared with the rate of those which survived and budded apically, which was the highest, and the rate of those which survived and budded laterally, which was the lowest.

We see, therefore, that apical budding has a very high rate, both among budding seedlings and surviving seedlings and this is illustrated in the table summarizing the three grazing regimes (table 8.38 above).

The BS variable behaves similarly with regard to PLIVES in habitats as well as in grazing treatments. Significant correlation was found in each habitat (χ^2 sig.< 0.0001) between PLIVES and each of the variables BS1, BS2, BS3. Among surviving seedlings a high percentage of regeneration from an apical bud was apparent (93.5 - 100%) as compared with lateral or basal rebudding (48.3 - 82.8%). Of the seedlings which rebudded, those which budded apically survived at a higher percentage (98.4 - 100%) than those which budded laterally or basally (70.6 - 100%).

Analysis of the number of replicate plots in which there was regeneration and survival (lower right cell in each BS table in each habitat) showed that variability of habitat is greater than variability of budding locations and that there was a significant difference between each two habitats (t test sig. = 0.05).

In the cairn, budding rate is highest. Of the budding locations, apical budding tended to have the highest rate, particularly in the cairn, and this is shown in table 8.39.

Table 8.39: Number of replicate plots in which seedlings survived and in which basal, lateral or apical budding occurred (BS1, BS2, BS3 respectively), in various habitats. Order of numbers in each cell is count, row percentage, column percentage.

count row % col.%	HABITAT		
BUDDING SITE	FLAT	CAIRN	TREE-CAIRN
BS 1	24 23.8 41.3	45 44.6 29.6	32 31.7 31.4
BS 2	14 15.9 24.1	47 53.4 30.9	27 30.7 26.5
BS 3	20 16.3 34.5	60 48.8 39.5	43 35.0 42.2
Total	58 18.6	152 48.7	102 32.7

7. Correlation between survival of seedlings and appearance of summer or autumn budding: Frequency of budding in seedlings is shown in table 8.25 above. The usual budding season is in spring (Feb.-April), while autumn and summer waves of budding are more rare (see also 6.3.1). Rebudding both summer and autumn is noteworthy. This appears in many cases, after conflagration or damage by animals.
Table 8.40 shows the number of replicate plots in which seedlings survived, compared with those in which budding was recorded in May-Dec., for the three grazing treatments.

Table 8.40: Survival of seedling against appearance of rebudding in May-Dec. in various grazing regimes with/without cattle grazing (+/-C) and with/without boar foraging(+/-B). Order of numbers in each cell: number of replicate plots, row percentage, column percentage in each sub-table.

GRAZ.	-C -B		-C +B		+C +B	
SN BUDS	0	1	0	1	0	1
PLIVES						
0	25 61.0 92.6	16 39.0 25.8	34 89.5 87.2	4 10.5 8.5	20 74.1 80.0	7 25.9 17.1
1	2 4.2 7.4	46 95.8 74.2	5 10.4 12.8	43 89.6 91.5	5 12.8 20.0	34 87.2 82.9
sig. χ^2	< 0.0001		< 0.0001		< 0.0001	

Percentage of surviving seedlings which bud, is over 85% with a very high percentage in non-grazing treatments (95.8%). However, comparison of surviving seedlings out of those which bud only, in a non-grazing treatment, shows that 74.2% survive, in contrast to 91.5% in +boar and -cattle grazing treatments, and 82.9% in +cattle and +boar grazing. (Difference between the first years, on the basis of the first three sowing years was significant at a rate of 0.01 in t test.)

Analysis of seedling survival against number of seedlings rebudding a second time in various habitats, showed significant correlation in the 3 habitats between survival and budding (see table 8.41). The highest percentage of surviving seedlings budded in the tree cairn, and the lowest in the flat, open habitat, although the difference was slight and non-significant.

Table 8.41: Survival of seedlings against appearance of rebudding in May-Dec. in various habitats. Order of numbers in each cell: number of replicate plots, row percentage and column percentage in each sub-table.

HABITAT	FLAT		CAIRN		TREE - CAIRN	
SN BUDS	0	1	0	1	0	1
PLIVES						
0	40 67.8 93.0	19 32.2 46.3	14 100.0 70.0	0 0 0	25 75.8 89.3	8 24.2 15.7
1	3 12.0 7.0	22 88.0 53.7	6 9.4 30.0	58 90.6 100.0	3 6.5 10.7	43 93.5 84.3
sig. χ^2	< 0.0001		< 0.0001		< 0.0001	

However, comparison of survival percentage of those which budded showed that in the open habitat only 53.7% survived and in the cairn and tree-cairn 100% and 84.3% survived respectively. The difference in the open habitat and the other habitats was found to be significant (in t test on the basis of three sowing years at a significance level of 0.01).

8. Effect of supplementary irrigation on seedling survival: Seedlings survived in 61.5% of the plots which received supplementary irrigation at the beginning of summer at a rate equivalent to 70 mm rain, compared with only 32.7% in those which did not. This difference was found to be significant at a rate of 0.03 in χ^2 test (see table 8.42).

Table 8.42: Seedling survival with and without supplementary irrigation of 70 mm. at the beginning of summer; order of numbers in each cell: number of replicate plots, row percentage, column percentage. Significance level in χ^2 test was 0.0306.

count row % col.%	IRRIGATION 0	 1
PLIVES		
0	33 76.7 67.3	10 23.3 38.5
	16 50.0 32.7	16 50.0 61.5

Comparison of tables similar to table 8.42, for each habitat individually, did not show significant correlation, possibly because of the small number of plots obtained when dividing irrigation treatment into three habitats. Nevertheless, the trend remained: irrigation increases survival. In the open habitat the increase rate was from 26.1% with no irrigation, to 36.4% with irrigation. However, in the cairn, irrigation increases survival percentage from 63.8% to 88.9% and in the tree cairn from 20.0% to 66.7%.

9. Effect of weeding on survival of seedlings: Examination of the dependency of survival on weeding round the seedlings, did not show significant dependence, neither in the various habitats, nor in all the plots together. However, we did see a tendency to greater survival in plots which had been weeded. In 55.3% out of 159 replicate plots, seedlings survived in weeded plots, compared with general survival percentage of 43.6%. It should be remembered that this difference is mainly due to weeding in the open habitat, since in the cairn very few weeds exist. Lack of sufficient untreated replicate plots in the year in which most of the weeding took place restricts the possibility of obtaining significant results.

10. Summary of results on seedling survival: From the above it may be concluded that seedling survival is greater in the cairn. Sown seedlings prefer the non-tree cairn and seedlings transplanted from a nursery tend to prefer the tree cairn. The more varied the grazing regime, the greater survival potential, so that the highest survival rate was recorded in +cattle and +boar grazing.

Correlation similar to the cairn and grazing regime was found in the difference in number of leaves from year to year. This was higher in the cairn and in +cattle and +boar grazing regimes.

Apical budding was accompanied by high survival mainly in the cairn. On open ground more seedlings budding basally survived.

Survival reacted positively to supplementary irrigation at the end of spring and also to weeding round the seedlings.

8.3.2.4 Summary of effect of habitats, grazing treatments and main vegetation types on germination and survival of seedlings sown in the open ground and seedlings transplanted from a nursery: The following is a summary in qualitative and schematic form, of the correlation between habitat, grazing regime and vegetation type, of variable concerned with germination and taking root of seedlings. We have only listed significant and main correlations.

The following symbols are used: > : greater than; < : smaller than; = : no significant difference; α : direct positive ratio.

habitats : flat, cairn, tree-cairn, as illustrated in fig. 8.1 (0, 2, 2 respectively);

grazing treatments : +/-C = with/without cattle grazing
+/-B = with/without boar foraging;

vegetation types : QUEITH = *Quercus ithaburensis* park forest
ZIZSPI = *Ziziphus spinachristii* savannoid formation
ZIZLOT = *Ziziphus lotus* bushy grassland;

propagation method : Sd - from seeds in the area; Sding- transplanted seedlings;

PGERM : Germination percentage;

Habitat : Sd : flat > cairn > tree-cairn

Grazing : Sd : -C-B > -C+B ≥ +C+B
Sding : -C-B > -C+B , +C+B

Vegetation : Sd : QUEITH : -C-B > -C+B ≥ +C+B
ZIZLOT : -C+B > +C+B
-C+B : ZIZLOT = ZIZSPI > QUEITH
Sowing year : Sd : 1975 > 1974 > 1973
Grazing X Habitat : Sd : -C-B flat > cairn > tree-cairn
-C+B cairn > flat, tree-cairn
+C+B cairn > flat, tree-cairn.

Remarks concerning drying out, fire, damage by animals

Z - drying out: -C-B > -C+B > +C+B
F - burning : flat > cairn > tree-cairn; -C-B > -C+B > +C+B
C - cattle trampling : flat > cairn, tree-cairn
E - boar uprooting : flat > tree-cairn > cairn
Q - boar eating : flat > tree-cairn > cairn
T - rodent root-neck nibbling : flat > tree-cairn, cairn; -C-B > -C+B, +C+B.

PLIVE - survival of seedlings

Habitat : Sd : cairn > tree-cairn > flat
Sding : tree-cairn ≥ cairn > flat
Sowing year : 1975 > 1974 > 1973; flat only
PLIVE : Sd : PLIVE 1977 > PLIVE 1976, PLIVE 1975
Grazing : Sd, Sding : +C+B > -C+B > -C-B
Habitat X Grazing : Sd : -C-B : cairn > tree-cairn = flat
(-C-B) (cairn) > (+C+B)(cairn) > (-C+B)(tree-cairn)
DML : $DML_i \propto PLIVE_i$ (i = 1975, 1976, 1977)
+C+B > -C-B > -C+B
-C+B : ZIZSPI > QUEITH > ZIZLOT
DML (1977) > DML (1976) > DML (1975)

DML X PLIVE : cairn, tree-cairn > flat
PLIVE (-20 < DML < +20) > PLIVE (+20 < DML < -20)
BS - budding site : PLIVES : BS3 > BS1 ≥ BS2
PLIVES X Grazing : -C-B = -C+B = +C+B
PLIVES X Habitat : flat : BS1 > BS3 > BS2

cairn : BS3 > BS2 > BS1
tree-cairn : BS3 > BS1 > BS2

SNBUDS - number of budding seedlings

SNBUDS α PLIVE
PLIVE (-C+B) > PLIVE (+C+B) > PLIVE (-C-B)
PLIVE (cairn) > PLIVE (tree-cairn) > PLIVE (flat)

IRRIGATION : PLIVE (IRR) > PLIVE (NO IRR)

WEEDING : PLIVE (WEEDING, flat) > PLIVE (NO WEEDING, flat).

8.4 Discussion

8.4.1 *Introduction*

In this chapter we have attempted to understand the factors affecting germination and establishment processes of *Quercus ithaburensis* seedlings in the Yahudia Forest. In order to isolate some of these factors, we devised an artificial system of selective grazing to learn what the effect of the most important animals would be. In order to learn about the mechanisms operating at the establishment stage only, we excluded the germination stage from part of the experiment and brought plants which had been nursery grown to the area. We simultaneously kept track of the existing seedlings which were at various stages of germination and establishment to learn of the conditions in which they grow naturally and their effect on major factors such as grazing and habitat, and on the survival potential of the seedlings.

8.4.2 *Germination of Quercus ithaburensis*

Examination of natural germination in fact began with a given situation of existing seedlings with a limited possibility of isolating factors affecting germination. During the second and third year we were able to keep track of seedlings added to those found in the first year and learn of the conditions in which they take root during their first summer. However, we collected much information on seedlings we had ourselves sown in various habitats and grazing regimes.

We have seen that of the habitats, the open ground outside the cairn is the best habitat for germination. The advantage of this habitat is retained for as long as there is no boar foraging. The presence of boar, which consume most of the acorns, decreases the comparative advantage of this habitat and increases the advantage of the cairn where acorns are less accessible to boar and are therefore better able to germinate. Behaviour similar to that of the boar exists in California, in the mule deer which consumes the greater part of the acorns (Bowyer and Black, 1979). We have thus seen that also in the case of natural germination, most of the new seedlings were found in the cairn.

Among the vegetation types, we found that in +boar and -cattle grazing, germination percentage was inferior in the *Quercus ithaburensis* forest compared with the *Ziziphus spinachristii* or *Ziziphus lotus*. The foraging habits of the boar are such that in the acorn season they "visit" the *Quercus ithaburensis* forests and forage most of the acorns in the plots which they reach. During the season in which there is an abundance of acorns in the oak forests, the boar are not attracted to the *Ziziphus lotus* areas and therefore the acorns which we had sown there were able to germinate in greater amounts. The difference in germination percentages between the various sowing years is not sufficiently explained. In 1975 germination was good, perhaps because most of the plots had been weeded, but the advantage of 1974 over 1973 is not explained and we were not able to draw any conclusions from comparison of precipitation between winter 73/74 and winter 74/75 (see fig. 3.2).

8.4.3 *Establishment and survival of seedlings*

8.4.3.1 Establishment and survival in various habitats: An unequivocal and outstanding finding is that the cairn habitat is preferred for establishment and survival of the *Quercus ithaburensis*. This can be learned from the frequency of mature trees connected with the cairn (over 90%) and also from the location of natural seedlings most of which established themselves in the cairn. Seedlings which had been sown in the cairn, or transplanted to the cairn were more successful. Within the cairn habitat, the cairn slope (see fig. 8.1), in which about ¾ of the natural seedlings are concentrated, was found to be preferred.

In the non-tree cairn survival was greater than in the tree-cairn. It seems that the shade which the tree provides the seedlings beneath is not significant, since success was not more marked to the north of the tree than to the south, despite the long hours of shade. It was also apparent that the tree's foliage (see 7.3.1.2 - 3) does not delay seed germination or growth. It is therefore, possible that competition over water between the seedling and the tree is already of consequence at this stage.

We have seen that natural germination is mostly concentrated in tree cairns. It should be remembered that long-range distributors of acorns in the Yahudia forest are rodents which can disperse the acorns to a distance of several tens of meters (see 4.1.2.3 - 2), far enough for them to reach nearby unoccupied cairns. However, such cases are most rare and the number of vacant sites within the forest is limited. Mellanby (1968) found that in the presence of birds such as the wood pigeon, oak seedlings were evenly dispersed to a distance of 400 meters from the tree.

It is interesting to note that seedlings which were transplanted from a nursery took root more successfully in the shade of the tree. We have already mentioned above (see 7.3.3.2) that nursery seedlings do not develop a long root due to the limitation caused by their container and their twisted root prevents them from reaching a moist layer of soil quickly. It is those seedlings with short roots which require shade in the first instance, until establishment of the root, to prevent drying out. In contrast to sown seedlings which grow deep roots in a short space of time (see 7.3.2) these seedlings do not have to compete for water with the tree at the outset, because they are divided vertically within the habitat.

8.4.3.2 Establishment and survival of seedlings in various grazing regimes

Survival of seedlings increases with the variability of the grazing regime, so that low survival is found in absence of boar and cattle, and slightly higher survival in presence of boar and highest in +cattle and +boar grazing. In California it has also been found that prevention of cattle grazing did not contribute to the increase in regeneration of oaks (Duncan and Clawson, 1979) and that grazing by black-tailed deer made germination and establishment of oaks possible (Griffin, 1979). However, we found that in the open habitat the survival percentages rises slightly in absence of boar but the cairn habitat is still preferred.

Survival potention of basally budding seedlings is greater in cattle grazing regimes than in others. These seedlings are more susceptible to fire and suffer more from competition with herbaceous plants. It is likely that these seedlings have a less developed root system, since, if it were more developed the physiological state of the seedling would be superior, enabling it to bud apically.

Cattle grazing provides weak seedlings with an advantage over other grazing regimes.

The increase in number of leaves from year to year, is also an indicator of more superior seedlings in cattle grazing regimes.

8.4.3.3 Difference in vegetation types with regard to germination and survival of seedlings: We saw no essential differences among vegetation types with regard to survival of seedlings and other parameters. However, there was a tendency of seedlings in the *Ziziphus spinachristii* type vegetation to develop more leaves from year to year comapred with seedlings in the *Quercus ithaburensis* forest, and of the latter to develop more seedlings than in the *Ziziphus lotus* type vegetation, but this can be attributed to topographical data of the three vegetation types.

The *Ziziphus spinachristii* belt is lower than that of the *Quercus ithaburensis*, which in turn is lower than the *Ziziphus lotus*.

The difference in height of the three units reaches about 300 meters (see map 5.1) and is expressed in temperature difference, particularly at the end of winter in the main budding season (February).

The temperature difference in this season can be significant for additional growth. It is important to note that we have seen that *Quercus ithaburensis* seedlings can establish themselves in all three types of vegetation more or less equally. We therefore extended our experiments to *Ziziphus* species types of vegetation. With regard to the *Ziziphus lotus* we have already noted (see 5.3.2) that it may be a secondary type of vegetation because of deforestation of the *Quercus ithaburensis* forest, and we have already seen that the *Quercus ithaburensis* can grow in existing *Ziziphus lotus* areas.

8.4.3.4 Change in phenological parameters relevant to survival of *Quercus ithaburensis* seedlings: Phenological parameters connected with budding show a peak in spring, such as number of seedlings, number of leaves and various budding rates. Basal budding also reaches a peak in May, partly because of damaged plants, which have a high frequency of basal budding and which rebudded in late spring. An additional, smaller peak in budding appears in autumn and indicates the autumn wave of budding whose frequency is mainly due to fire or damage. This peak partly overlaps the beginning of fall indicating lack of synchronisation between seedlings. This situation also stands out at the beginning of spring when there is overlapping between budding and shedding.

We found that the phenological parameters provide quantitative measures for evaluating establishment of seedlings and that there is close correlation between them and their survival.

We have seen that there is significant correlation between parameters indicating a good physiological state such as apical budding and sutumn budding, and survival. Correlation between survival and location of budding in the cairn, and between survival and grazing regimes is also seen in these parameters showing them to be high in those same habitats and treatments which have a good survival rate.

However, beyond survival or non-survival, these parameters also serve as a measure of development. We have seen that the physiological age of the seedlings is divided into a group of young seedlings from up to 4 years of age and a group of 5 years old and over seedlings. The steady rate of about 2/3 of the seedlings which belong to the 0-4 age group indicates that the majority does not pass this age. The remaining 1/3 is older and mostly takes up the 10-15 and even 20 years age group. This opinion is based upon the large number of branches and relative greater height of the mature group, compared with the young seedlings of 5 years of age.

In the two age groups the static situation stands out, of difference in number of leaves from year to year, of number of branches and of difference in height from year to year. These 3 parameters which indicate almost no annual differences, are individually measured on the same seedlings each year. This shows that the physiological age of most of the seedlings is static, despite increase in chronological age. Under these conditions it is difficult for trees to reach maturity, since this depends upon physiological age. Height, for instance, is a condition for acorn growth, irrespective of chronological age (Shmida, 1980).

We have seen that of those seedlings which survive, frequency of apical budding is greater. A plant which buds apically has a greater chance of growing taller from one year to the next, than a basally budding seedling. Basal budding, particularly the type which rebuds year after year on the same seedling, turns it into a kind of hemicryptophyte in which regeneration buds are at ground level. We shall deal with the reasons for this later on, but significance with regard to physiological development of the seedling is crucial. In the open habitat, where we have already seen that survival is low, frequency of basal budding is greatest. That is to say, in a habitat with many budding difficulties, those which survive are also in a state of delayed perennial growth, in contrast to the cairn, where both survival and frequency of apical budding is greater, i.e. the state of the plant is better.

8.4.3.5 Damage to seedlings by animals and effect of damage on their survival: In the group of parameters which represent various damage to seedlings, most prominent are the summer peak with regard to those related to desiccation (fire and desiccation), a considerable winter peak for damage by animals related to the wet seasons (trampling by cattle and uprooting by boar) and consuming of acorns which ripen in winter. Spring and summer damage is caused by animals which eat the seedlings. Rodents are possible active with seedlings in this season because of their still soft shell (see 6.3.2) and because in winter the acorns concern them as food, both in gathering and in eating. We thus found gnawed acorns in this season, which had germinated.

In California it has been found that rodents cause damage to valley oak seedlings, almost totally preventing survival of seedlings above the age of 4 (Griffin, 1979), which we too found to be a critical age for survival, although not necessarily through the fault of rodents.

Eating of seedlings by cattle and rodents is most common in summer. In this season, the *Quercus ithaburensis* is an important component of the cattle's food (see 10.3.2.2). The positive, significant correlation which we found between browsing of leaves by cattle and survival of eaten seedlings, is surprising. Possibly, autumn budding which is more common after browsing brings about survival of the seedlings, despite its being conditional to browsing, in the same fashion as autumn budding, which does not necessarily follow cattle browsing.

Damage by boar is greatest in the open ground, and smallest in the cairn, because of the facility of burrowing in the ground, especially in winter. In the tree cairn, there is more damage than in the non-tree cairn and this can be attributed to presence of boar under the tree, where they eat acorns and then attack the sown acorns and growing seedlings in the vicinity.

Gnawing of the seedlings root neck by rodents, which we have seen to be destructive to seedlings, is more common in -boar grazing treatments. We have mentioned above (see 4.2.2.3) that following the removal of boar from the plots the number of rodents increased particularly *Apodemus mystacinus* and *Acomys cahirinus*, and their activity increased accordingly. Although we have shown that this does not have any real effect on the germination potential of the acorns (see 4.2.2.3), there is greater activity and more damage to seedlings.

8.4.3.6 Conflagration, desiccation and water regime of seedlings and relevance of these to their survival: Correlation between desiccation of seedlings and their survival has been found significant. Damage by desiccation is most apparent in non-grazing treatments and least apparent in cattle and boar grazing. Greater frequency of seedling desiccation was found in the open habitat than in the cairn.

Fire: Similar correlation was found with regard to seedlings damaged by fire, in both the habitat and grazing regime. However, we did not find any direct, significant correlation between fire and survival, although it was obvious that fire significantly affects desiccation which in turn significantly affect survival. Circumstantial correlation which is also caused by relationship between the habitat and the grazing regime, shows that frequency of damage by fire in the cairn, was much lower and survival much higher.

Fire in +cattle grazing is also less intense (see 9.3.2) and survival in this grazing regime is higher.

In all, about 25% of seedlings were damaged by fire and of these only a small percentage rebudded in the same year. If seedlings do bud after fire, the majority issue a single branch from a basal bud, i.e. fire contributes one of the most significant factors in the creation of the "hemicryptophytic" stage of delay in the seedling in addition to its actual affect on survival itself.

We find that absence of direct significant correlation between fire and survival is due to fault in the parameter which we chose. Desiccation of the seedlings' leaves by fire was sufficient for it to be registered as damaged. It seems that damage to the stem is the decisive element in survival. Our records did not discriminate between damage to leaves only and damage to stem, and it is possible that separation of the two may have provided a more unambiguous picture.

Desiccation and water regime: Desiccation, which attacks nearly hald the seedlings destroys approximately half of them. The *Quercus ithaburensis* was found to be "wasteful" in its water regime. Its transpiration intensity is similar to that of deciduous trees with mesamorphic leaves, but is not typical of this group in the low level of water contained in its leaves

(Litvack, 1954). Oppenheimer (1950) also mentions this as well as a transpiration rate of 900 mg/g/h, which is 4 times greater than, for example, the *Quercus calliprinos*.

We have seen that, of the acorns sown in 1975, more seedlings survived than in 1974 and in this year more than in 1973. We believe that the advantage of 1975 came about partly as a result of weeding of herbaceous plants in the vicinity of the seedlings. We have seen that the reaction of seedlings to weeding has shown a positive tendency to survival, mainly in the open habitat.

With regard to survival years, we have seen that in 1977 survival was greater than in previous years, accompanied by a better condition in the seedling from a phenological point of view.

Examination of the conflagration map (see map 9.1) shows that in 1977 only one plot out of the experimental plots (5) was damaged by fire, while in 1975 and 1976 4 plots were damaged in each year, we have seen and shall also see in chapter 9 that effect of fire on seedling survival is negative, and it may be assumed that this was a decisive factor with regard to decrease in survival 1975-76.

Examination of the precipitation graph (see fig. 3.2) shows that in 1977 there was a high rate of precipitation (602 mm) with good distribution until April, a factor which could be of significance to the state of the seedlings in summer 1977. However, 1975 and 1976 had similar amounts of precipitation (458, 438 mm respectively) but the distribution of precipitation was better in 1976 and continued until mid-April. This may definitely be significant to greater survival in the summer of 1976 as against the summer of 1975.

We have seen that survival reacted positively to irrigation. Irrigation was, in fact, a better artificial method of distribution of precipitation and was similar, in this, to the natural precipitation of 1977.

It should be remembered that soil of the basalt type becomes extremely cracked with the onset of drying up (see 3.2.2) and this causes deep-down drying up and tearing of roots (see also 7.3.2). Supplementary irrigation at the onset of soil-cracking (MAY) postpones the process and permits longer root-length and improvement of the seedling.

The tendency to rise in seedling survival after weeding, especially in the open habitat where the amount of weeds is significant, is effective, similarly to irrigation, in preventing competition over water with herbaceous plants, and improving the water balance of the seedling in the same critical period and end of spring and beginning of summer, which is the major period for water consumption in herbaceous plants.

Premature shedding which showed significant correlation to survival, occurs more in the cairn than in open ground. Premature shedding is an important defensive mechanism in seedlings, to prevent drying up. Shedding of leaves in the difficult, end of summer and autumn season, 3-4 months before the usual time, saves water for the plant and prevents the destructive desiccation process. This mechanism acts less in the open ground where, due to presence of weeds, soil dries up more rapidly, both because of the exposed soil and deep cracking. Thus, in the open ground, the seedlings do not have sufficient time to develop absiccion tissue and to shed their leaves and become desiccated. We found proof of this in Litvack (1954), who discovered in the *Quercus ithaburensis* that a tree which is late in shedding also retains a high transpiration rate at the end of summer and a tree which sheds early decreases in transpiration rate at the end of summer.

We have seen that seedlings' survival is greatly influenced by their growth as compared with the previous year and that desiccation, fire and location of seedling in the cairn individually affected survival, especially in height interaction. Shorter seedlings are more susceptible to fire and their survival after conflagration is lower than in seedlings which had grown taller. Tall seedlings are also less susceptible to drying-out as their root system is deeper so that they have more tendency to survive. Similarly, seedlings growing on the slope of the cairn, which have been seen to have a high survival rate, survive more in a combination of greater seedling height, possibly also because of more superior water regime in the taller seedling.

8.4.4 *Theoretical model for describing stages of germination and establishment of the Quercus ithaburensis*

To summarize the main factors affecting germination, establishment and survival of the *Quercus ithaburensis*, it may be stated that the best theoretical habitat for germination is the open ground outside the cairn. However, in the reality of the Yahudia Forest, with boar impact, especially in mature *Quercus ithaburensis* areas which yield acorns, success is greater in the cairn. Effect of rodents on germination is usually positive, since their consumption rate is less than production of acorns and burying of acorns in the ground makes it possible for them to be "saved" from the teeth of boar, as well as germination of those buried seeds which are buried and not eaten.

To a certain extent, boars also make a positive contribution. Despite the fact that they eat most of the acorns, they also trample on them, thus burying part of the acorns in the damp soil and preventing their drying-up, which is destructive to acorns (see 7.3.1) and enabling them to germinate.

Establishment of seedlings and their survival is also good in the cairn with no boar grazing. Cattle grazing affects establishment and survival of seedlings most positively by decreasing the intensity of fire and lessening competition with herbaceous plants. Phenological parameters such as budding, location of bud and state of leaves indicate the preference for the cairn and cattle grazing.

The cental factor, therefore in the success rate of germination is boar, although a small percentage of germination is sufficient for perpetuation of the species, taking into consideration the production rate of the acorns (see 7.1).

The main factor in seedling survival is the water regime. The water regime is safeguarded by the cairn habitat which has the advantage of being able to retain humidity and an almost total absence of weeds. A second factor improving the water regime is cattle grazing which lessens the danger of desiccation from fire as well as lessening the amount of herbaceous vegetation at the end of spring which competes with seedlings for water.

Fig. 8.18 describes the theoretical course of growth in the *Quercus ithaburensis* in logarithmic axes of time as opposed to height, which in fact represents chronological age as opposed to physiological age (see above, height as condition of fertility). The figure describes a three-stage graph.

Stage I - "Hemicryptophytoid": This stage begins with germination which is greatly dependent upon boar and rapid growth in the first year. Next comes the stage of growth inhibition with basal budding which recurs each year and turns the plant into a type of hemicryptophyte. Typical of this stage is stiff competition with herbaceous plants over water and vulnerability to fire.

This stage continues until a chronological age of approximately 4 years, which is the point of balance in survival of seedlings at height range of 0 - ±30 cm. At this stage the percentage of survival is low.

Stage II - "Chamaephytoid": At this stage an increase in height occurs and a stage of long-term inhibition. At this stage, apical and lateral budding is more frequent, although from time to time there occurs a return to basal budding and in this the seedling resembles a chamaephyte in its behavior. Height range at this stage is about 20-150 cm.

The seedlings at this stage are usually over four years old, but the length of this period in time is unknown to us. In our estimation, this stage can even continue for tens of years. It is typical of these two stages of inhibition that their physiological age is static: minimal change in number of leaves, in number of branches and in height from year to year, in spite of increase in chronological age.

Inhibition factors in Stage II of inhibition are, without any doubt, complex. Competition over water increases from competition with herbaceous plants only in the first stage, to competition with the mature tree. The mature tree, which is extravagant in its use of water and has a shallow root regime and is the cause of outspread trees and formation of the park forest (Oppenheimer, 1950) does not usually develop roots deeper than one metre (Halfon-Meiri, 1958). There is also competition over water between the seedling and the tree, preventing seedlings in proximity to the mature tree from becoming trees themselves, thus giving preference to the treeless cairn habitat over the tree-cairn. These relationships form a self-inhibiting mechanism in the *Quercus ithaburensis* species.

Stage III - Phanerophyte: This is a life-form characteristic of the *Quercus ithaburensis* as a tree. The transition from second inhibition stage to tree is slow and does not occur during the course of one season as at the beginning of Stage I, nor during a small number of seasons as in transition from Stage I to Stage II. During transition to Stage III the tree reaches physiological maturity and reaching a height of 8-10 metres where it becomes stable.

Transition to Stage III is conditional to removal of inhibiting factors in Stage II.

We shall return to external inhibiting factors later on (chapters 9, 10, 11).

The self inhibiting mechanism described above brings us to the theory that "all sites are occupied" i.e., all the potential locations in the forest are taken up and there is no entry into new habitats. These locations are the cairns, most of which are occupied within the forest. According to this theory, there was supposedly one tree in the cairn, but mortality of the mature tree, which inhibits growth of seedlings in its vicinity enables growth of one or some of the seedlings at the second stage of inhibition. As already stated, there is survival potential for up to tens of seedlings in close proximity to most of the trees in the forest and which are in a "take-off" position at the second inhibition stage, until these inhibition factors are eliminated.

FIG: 818

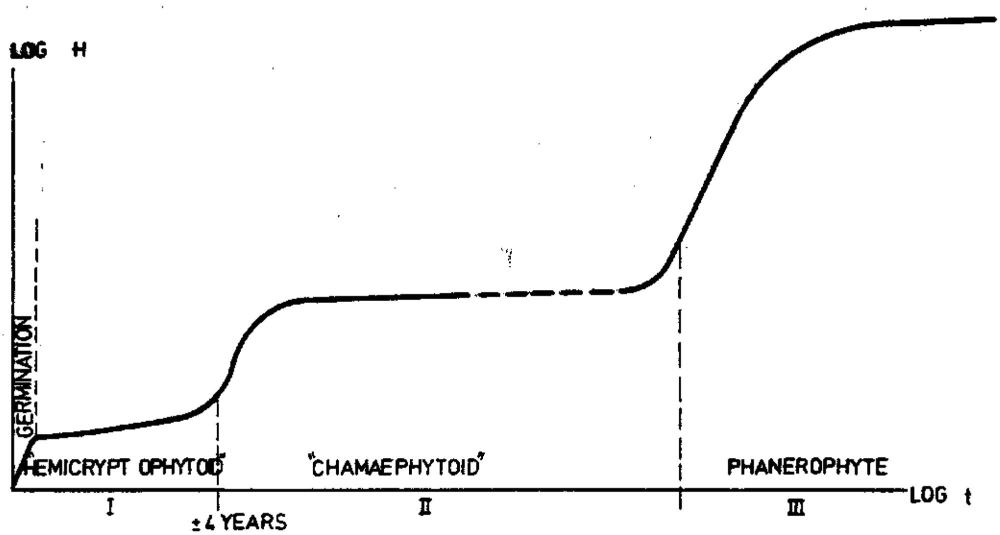


Fig. 8.18: Theoretical model of graph showing rise in physiological age against chronological age (expressed in logarithm of phenological parameter against logarithm of age in years).

9. FIRES: ANALYSIS OF INCIDENTS; EFFECTS ON THE ECOLOGICAL SYSTEM IN THE YAHUDIA FOREST

9.1 Introduction

Our aim in this chapter is to study the effect of fires on the vegetation of the Yahudia Forest in general, and on *Quercus ithaburensis* in particular; the frequency of fires, foci of fire outbreaks and ecological factors affecting them, and to outline management methods in which the fire factor is taken into account.

There are many researches which put forward a whole range of viewpoints regarding the effects of fires on the ecological system. This range of what often appear to be contradictory points of view is contingent in a great measure on the nature of vegetation and climate, and application of management methods is dictated by the researcher's point of departure - i.e. whether he is a nature conservationist, a forester, or a grazing expert, etc.

9.1.1 *Influence of fire on woody vegetation and vegetation structure*

The general opinion in the USA is that fire should be allowed to play its natural environmental rôle in fire-type ecosystems such as many of the world's mediterranean-type ecosystems. Failing this, prescribed vurning should be applied as a management tool for vegetation control. Otherwise, the accumulation of fuel material will cause outbreaks of wildfires with destructive effects (Parsons, 1977; Biswell, 1977). This procedure is applicable in the Sequoia and King Canyon National Parks in California, where at high elevations there is little fuel accumulation and fires are allowed to run their course, while at middle elevation (*Sequoia* trees) prescribed burning is used to reduce fuel accumulation and thus prevent disaster (Parsons, 1977; Van Wagtendonk, 1977).

Fire has a major influence on vegetation structure. The chaparral in California can be conserved only by prescribed burning (Menke & Villasenov, 1977), and the same applies to the scrub of Donana National Park in Spain (Novo, 1977).

After colonization of the USA by white man, density of *Quercus macrocarpa* and *Quercus alba* increased ten-fold, due to cessation of fire and oak opening with spaced mature trees is being maintained now by controlled burning (Cottam, 1949).

On the other hand, conservation of some woody formations can be achieved by fire prevention, and by enabling seeds to germinate and seedlings to strike root (Taber, 1960).

Trabaud (1977) found that frequency of fires in the *Quercus coccifera garrigues* was directly proportional to the below-50 cm vegetation-layer cover, but that the higher was the frequency of fires, the lower the scrub and tree-layer cover. A low frequency of fires stops succession and preserves the garrigue formation, whereas in a total absence of fires the garrigue will transform into a maquis of *Pinus halapensis, Quercus ilex* and others.

In the Rocky Mountains, USA, only 1/3 of the 8-12 months-old seedlings of Mesquite trees survive grass fires. Having been top-killed they later sprout from the base (Rocky Mountains, 1960). Of the Mesquite trees that are destroyed by fire, 52% are less than 0.5 inch in ground diameter, but some large trees can also be destroyed (Humphrey & Mehrhoff, 1958).

Fires result in age-grouping in Scotland's pine forests, with 20-50 year-old trees being fire-resistant, whereas younger, or older, trees with thin or eroded barks are not fire-resistant. Fire also builds certain shapes in adult trees by preventing regeneration of lateral growth and enabling thick-barked trees to regenerate (Carlisle & Brown, 1967).

In Spain, savannah-type vegetation, or open wood interspersed with herbaceous vegetation, may be maintained stable as an intermediate stage between forest and grassland, by prescribed fires. Propagated by seeding, this type of open oak wood is interspersed with patches of dense, non-propagating "forest fossil" (Novo, 1977).

Recurrent fires in mediterranean oak wood ecosystems cause conversion to maquis-engendered grassland, because most oak species will not produce acorns on branches that are less than 20 years old, and if fires are frequent branches will not reach this age and thus not produce any acorns, and hence germination will not occur. This can be seen in North Africa, where repetitive burning, together with cutting and grazing, is causing conversion to grassland or bare, eroded areas (Le Houerou, 1977).

9.1.2 *Influence of fire on vegetation composition and succession*

The promotion of herbaceous vegetation at the expense of woody formations in mediterranean ecosystems, has been commented upon by many researchers (Hallasey and Wood, 1976; Naveh, 1971; Vogl, 1977). Encouragement of grassy vegetation, too, has been mentioned in connection with *Quercus ithaburensis* associations in Israel (Katzenelson, 1956).

In other cases, fire encourages dwarf-shrub vegetation such as that in the phrygama in Greece (Papanastasis, 1977) or in the mediterranean maquis (Menke & Villosenov, 1977; Philpot, 1977).

In their early stages of succession, ecosystems are more sensitive to fire than in advanced succession stages when there is less fuel accumulation and hence less burning and trees attain higher ages and become more fire-resistant (Zivnuska, 1977).

Fires can keep vegetation diversity high mediterranean ecosystem mainly in tree-less shrublands (Kruger, 1977), but can also lessen species diversity and bring about a simple-structured, even-aged vegetation (Zivnuska, 1977).

Vogl (1977) claims that fire initially leads to an increase in species diversity, but if carried to extremes can create pure stands.

9.1.3 *Interrelations of fire and wild and domestic animals*

Fire is regarded in many cases as a silviculture tool for improving grazing pasture (Carlisle & Brown, 1967), and for converting maquis to grassland (Liacos, 1977). On the other hand, in *Quercus ilicifolia* scrub in Pennsylvania, browsing by deer was found to be more massive in recently-burned plots (Hallisey & Wood, 1976).

Grazing in woodlands renders fire rare, as shown in *Quercus ilex* and *Quercus suber* woodland in Spain (Parsons, 1962), but overgrazing coupled with fire, causes destruction of vegetation in mediterranean ecosystems (Papanostasis, 1977; Le Houerou, 1977).

Overbrowsing after fire, mainly of basal sprouts, resulted in trees in Arizona remaining small and finally disappearing altogether (Humphrey and Mehrhoff, 1958).

The influence of fire on small vertebrates has been studied in mediterranean ecosystem by Wirtz (1977), who proved that rodents can survive fire beneath soil or in rock outcroppings, and that their species-diversity was the same 1 or 17 years after a chaparral fire, but that the number of individuals had risen during that period. The number of species of breeding-birds was found to be greater in the first year after a fire rather than in the 17th year, but the number of individuals was smaller.

Howard *et al.* (1959) found in California no impact of fire on rodents, snakes, birds and game animals (the latter even benefit from the opening of the dense brush). "Fire breaks" created by trampling and foraging of small vertebrates, protect the trees from high-intensity fires.

9.1.4 *Influence of fire on soil and run-off water*

Lack of annual vegetation at the beginning of the rainy season in the mediterranean climate, due to fire, increases the run-off of water (Carlisle & Brown, 1967). Naveh (1975) claims that no erosion happens by low grass cover after the first winter following a fire.

According to Carlisle & Brown (1967), fire alters the physical structure of the upper 3-cm layer of soil, while Naveh (1975) claims no such effects, in the Middle East.

9.1.5 *Causes of fires*

Natural fires, caused by lightening, occur in 0.6-4% of the burned areas in the mediterranean region (Susmel, 1973). In the Yosemite National Park, USA, fires caused by lightening can cover 63% of the park area each year (Van Wagtendonk, 1977).

Intentional burning was practiced already in ancient times. Naveh (1975) claims that paleolithic hunters and food gatherers burned the dense forest and maquis to open them up for easier access. It can be assumed that intentional burning was stepped up steadily to enable grazing by semi-domestic ungulates, and used as a means for clearing land for cultivation. From the Bronze age until the Roman period burning was a common practice in clearing forests and shrublands for pastural use and cultivation (Naveh, 1975). Fire was used by Indians in the prairies of the United States, as a hunting technique in driving game (Cottan, 1949), as well as in other regions in the world.

Mediterranean ecosystems nowadays are burned also by shepherds to maintain grass pastures (Papanastasis, 1977). Recreationists and vehicles play a significant rôle in the occurrence of fires.

Man-made fires constitute a considerably greater danger than do natural ones, since they are more likely to occur in dry, windy weather, are of higher intensity, and can destroy even fire-adapted trees (Aschmann, 1977).

9.1.6 *Fire frequency and intensity*

Fire frequency is inversely proportional to fire intensity due to fuel accumulation (Vogl, 1977). Frequency and intensity of fire are related to vegetation type- and age. The age of chaparral in California was found to be inversely proportional to frequency, and proportional to the rate of spread and intensity of fire (Philpot, 1977). In southern France, *Quercus coccifera garrigue* fires are expected every 5-10 years due to accumulation of fuel (Trabaud, 1973).

The extent of area burned was found to be proportional to age of vegetation and speed of wind (Philpot, 1977).

The effect of fire on an ecosystem has more than one significance, and it depends to a large extent on the conditions obtaining in the area with regard to climate, vegetation, grazing, felling, and the human factor, past and present. In this paper, we shall endeavour to study the impact of fire under conditions obtaining in the Yahudia Forest Nature Reserve.

9.2 Methods and Results

9.2.1 *Introduction*

All the fires discussed in this paper were unintentional fires caused by human factors. No regular fire experiments were carried out for the following reasons:

a. Risks: Strong westerly winds prevail in the area during the fire season (May-October), and there is danger of fires spreading beyond the experimantal area and untold damage being caused to the reserve and its environments.
b. Control: In view of the increase of random fires, there is no guarantee of the control areas themselves not being burned down.
c. The increased incidence of random fires during the years has yielded us sufficient material for studying and analysing the problem.

9.2.2 *Mapping and Description of Fires*

All fires occurring in the reserve during the years 1972-80 were recorded on map 1:50000 (there are no full data for 1972). A separate map was drawn up for each fire season (May-October). The yearly maps appear in Map Collection 9.1. The classification of burned areas in the fire-frequency map (Map 9.2) is based on the frequency of fires occurring in them. This map was drawn up from 8 maps of annual fires during 1972-79, using an overlay technique.

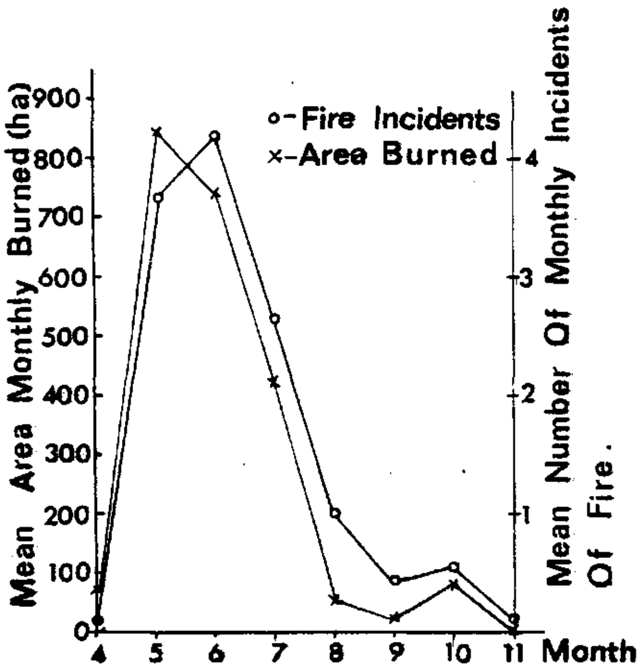
Each fire occurrence was annotated with date, size of burned area, cause of fire (if known), and method by which fire was extinguished.

Season-dependence of size of burned area and number of fires is expressed in Figure 9.1, showing monthly means of all the observation years.

In all, 115 fire incidents were recorded to have burned, during the observation years, 20285 ha of the reserve, amounting to a yearly mean of 12.8 fires, burning an annual mean of 2254 ha.

Fires occurring in the reserve area have been classified in accordance with the area's chief uses:

a. Grazing areas which include most of the hiking and holiday sites in the reserve;
b. Military fire-practice areas (free of grazing);



9-1

Figure 9.1: Dependence on season of mean size of area burned per month and mean number of fires per month in the Yahudia Forest Nature Reserve in 1972-80.

c. Other areas, including marginal areas, and hiking and holiday areas not covered by a. above.

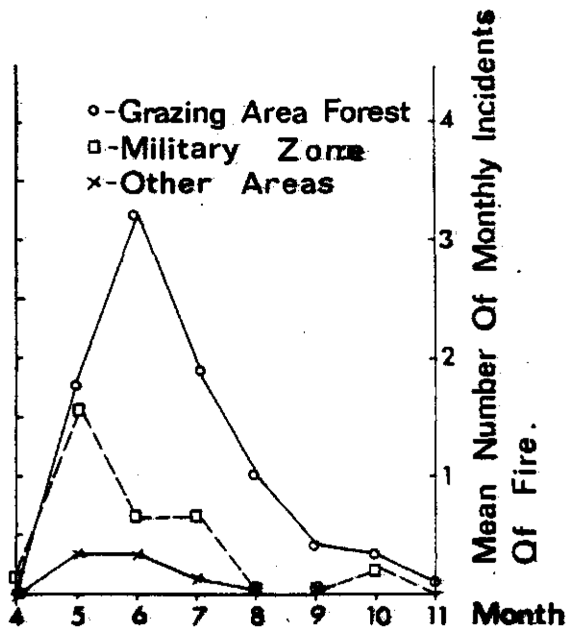
Table 9.1 sums up the relative parts played in fires by these three classification units as regards area affected as well as number of fire incidents.

Table 9.1: Fire incidents and areas burned in grazing sectors, fire-practice areas and other sectors, in the Yahudia Forest in 1972-1980.

Classification Unit	Grazing area	Fire-practice areas	Others
Total number of fire incidents	79	29	7
Percentage of fire incidents	68.7	25.2	6.0
Mean number of fire incidents per year	8.8	3.2	0.8
Total unit area in ha	3200	2800	600
Percentage of burned area calculated out of unit area	31.3	40.5	19.8
Unit percentage of reserve area	48.5	42.4	9.1
Percentage of burned area calculated out of total area burned in reserve	44.4	50.3	5.3

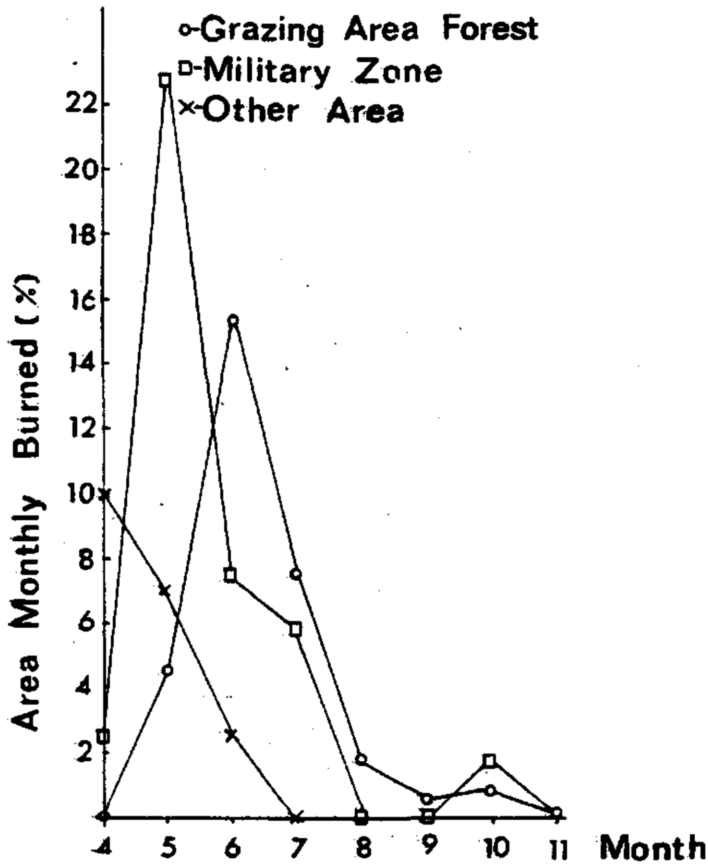
It follows from the table that the absolute as well as the relative number of fire incidents was highest in the grazing area, whereas with regard to the absolute as well as the relative surface burned this was bigger in the fire-practice areas.

Figures 9.2 and 9.3 express the dependence on season of the number of fires and percentage of area burned, in accordance with classification of the reserve areas into forest grazing areas, military fire-practice areas, and others.



9-2

Figure 9.2: Dependence on season of mean number of fire incidents per month in forest grazing areas, military fire-practice areas, and other areas in the Yahudia Forest Nature Reserve in 1972-80.



9-3

Figure 9.3: Dependence on season of mean percentage of forest grazing areas, military fire-practice areas and other areas burned per month in the Yahudia Forest Nature Reserve in 1972-80.

Table 9.2: Effects of fires and grazing regimes on height, deneness and cover of herbaceous vegetation in the Yahudia Forest Nature Reserve

Series		1			2					3				4				5	
Plot	Date	1-1	1-2	Date	2-1	2-2	2-3	2-4	Date	3-1	3-2	3-3	Date	4-1	4-2	4-3	Date	5-1	5-2
Fire Intensity		3	0		2	2	0	0		2	0	0		2	0	0		2	0
Grazing "		1	1		3	1	3	1		1	0	0		1	1	0		1	1
Date of Fire		7.76			7.75	7.75				6.74	6.74			10.74				7.74	
Max.height cm.	Nov.76	10	15	Dec.75	10	10	10	10	Feb.75	15	30	35	Jan.75	10	10	25	Jan.75	7	25
	Dec.76	7	8	Jan.76	20	15	15	30	Apr.75		190	180	Apr.75	170	170	160	Apr.75	170	170
	Jan.77	15	15	Feb.76	20	15	20	25											
	Feb.77	25	25	Mar.76	60	40	40	60											
	Mar.77	100	100	Apr.76	170	170	180	170											
Mean height cm	Nov.76	8	10	Dec.75	1	2	4	6	Feb.75	3	8	2	Jan.75	2	4	10	Jan.75	2	10
	Dec.76	5	4	Jan.76	5	5	8	8	Apr.75		70	70	Apr.75	45	70	70	Apr.75	65	65
	Jan.77	6	5	Feb.76	5	5	5	5											
	Feb.77	10	10	Mar.76	15	15	15	20											
	Mar.77	25	25	Apr.76	70	60	60	70											
Number of seedlings per sq.m.	Nov.76	180	200	Dec.75	150	110	300	800											
	Dec.76	480	1000	Jan.76	600	900	700	950											
	Jan.77	580	1000	Feb.76	800	800	800	900											
	Feb.77	900	1000	Mar.76															
	Mar.77			Apr.76															
Dry pasture vegetation cover %	Nov.76	+	60	Dec.75		+	6	50	Feb.75			5	Jan.75		10	15	Jan.75		10
	Dec.76	+	50	Jan.76			+	15	Apr.75				Apr.75				Apr.75		
	Jan.77		10	Feb.76				+											
	Feb.77		+	Mar.76															
	Mar.77			Apr.76															
Green vegetation cover %	Nov.76	+	+	Dec.75	+	2	2	20	Feb.75	75	60	85	Jan.75	60	60	75	Jan.75	70	80
	Dec.76	+	+	Jan.76	35	40	30	50	Apr.75		90	87	Apr.75	70	90	95	Apr.75	75	85
	Jan.77	20	20	Feb.76	60	70	80	90											
	Feb.77	70	70	Mar.76	85	90	95	95											
	Mar.77	85	90	Apr.76	95	95	95	95											
Graminae cover %	Nov.76	+	+	Dec.75	+	+	2	15	Feb.75	50	45	80	Jan.75	50	55	60	Jan.75	60	75
	Dec.76	+	+	Jan.76	25	20	25	30	Apr.75		45	80	Apr.75	55	55	70	Apr.75	60	75
	Jan.77	12	10	Feb.76	40	25	35	50											
	Feb.77	30	40	Mar.76	50	40	50	55											
	Mar.77	40	60	Apr.76	60	45	50	55											
Leguminosae cover %	Nov.76	+	+	Dec.75	+	+	+	5	Feb.75	2	5	5	Jan.75	8	3	10	Jan.75	5	2
	Dec.76	+	+	Jan.76	5	15	+	10	Apr.75		25	5	Apr.75	10	25	20	Apr.75	5	3
	Jan.77	4	2	Feb.76	5	35	25	30											
	Feb.77	35	15	Mar.76	15	35	25	30											
	Mar.77	40	15	Apr.76	15	35	25	30											
Other vegetation cover %	Nov.76	+	+	Dec.75	+	+	+		Feb.75	23	10	+	Jan.75	2	2	5	Jan.75	5	3
	Dec.76	+	+	Jan.76	5	5	5	10	Apr.75		20	2	Apr.75	5	10	5	Apr.75	10	7
	Jan.77	4	8	Feb.76	15	10	20	10											
	Feb.77	5	15	Mar.76	20	15	20	10											
	Mar.77	5	15	Apr.76	20	15	20	10											

Causes of fires were:

Military fire-practice	:	48.5% of fire incidents
Hikers and Passers-by	:	10.8% " " "
Unknown	:	39.8% " " "

Fires caused by 'Hikers and Passers-by' also include intentional ignitions by poachers, and fires occasioned by smoke bombs and flares, used in directing helicopters during rescue operations for extricating hikers in distress.

Extinction of fire occurred in 50.4% of the incidents without direct outside intervention, being the result of the fire line having reached a fire-break, or rocks, or of an increase in humidity and weakening of wind. In 49.6% of the cases, fires were extinguished by herdsmen whose herds were grazing in the reserve, and by Nature Reserves Authority wardens.

The fire-breaks are 6-20 m in width, and they are sprayed every year from the air by helicopter or from the ground, along the cattle fences and continuing down to the brooks. Spraying is carried out in December-January, with a view to preventing grasses germinating, and is effected with Atrazine (2-chloro-4-ethylamine-6-isopropylamine-1,3,3-triazine).

9.2.3 *Effect of fires on herbaceous vegetation*

In an endeavour to learn about the effects of fire on height, denseness and cover of herbaceous vegetation in the Yahudia Reserve, we selected within an open *Quercus ithaburensis* forest region grassy plots that were at least 50 m away from adult trees, with a 3-5% stone cover. Observations in these plots were carried out in 5 series, and in each plot we selected 2-4 neighbouring 2x2 m big sub-plots, representing diverse fire and grazing intensity conditions.

In each series 2-4 visits were made at 30-80 day intervals as detailed in Table 9.2.

The following parameters were recorded during the observation period:

- Fire intensity: classified as 'high', 'medium', 'low' or 'fire-free' (marked 3, 2, 1, 0 respectively).
- Grazing intensity: classified as 'high', 'medium', 'low' or 'no grazing' (marked 3, 2, 1, 0 respectively); classifications representing a relative degree of vegetation consumption by cattle.
- Date of Fire.
- Maximum height of herbaceous vegetation: being an estimate of mean height of the ten tallest specimens in the plot.

- Mean height of herbaceous vegetation: being an estimate of mean height of all herbaceous plants in the plot.
- Estimate of herbaceous plants seedlings per area unit.
  The estimate was made by counting the seedlings in five 20x20 cm squares, selected at random in each plot, basing our calculations of numbers of seedlings per square metre on countings made. No estimate was made of denseness exceeding 1000 seedlings per square metre.
- Percentage of absolute cover of dry pasture vegetation.
- Percentage of absolute cover of green vegetation.
- Percentage of absolute cover of principal vegetation components (*Gramineae*, *LegLeguminosae*, and other herbaceous plants).

In view of the many treatments and their combinations, the different dates of fire incidents and the small number of replicates, it is difficult to draw statistical conclusions from this table, although a repetition of clear tendencies can be found in the various observations:

Growth : in burned plots there is growth-delay at the beginning of the sprouting season, as opposed to plots in which no fires have occurred, and this is particularly noticeable in the absence of strong grazing effects. This disparity is recouped in early spring.

Denseness : germination-delay occurs in burned plots at the beginning of the sprouting season, and this, too, is particularly noticeable where there is little grazing. Denseness of herbaceous plants in burned and unburned plots evens out around February.

Cover of vegetation components :

Dry pasture vegetation	- hardly any dry pasture vegetation, or none at all, remains after a fire.
Green vegetation	- in plots where no fires have occurred there is a tendency towards a fairly large cover of green vegetation, chiefly at the beginning of the season - a disparity which is recouped in the month of March.
Gramineae	- there is a tendency towards a larger cover of *Gramineae* in unburned plots.
Leguminosae	- there is a slight tendency towards a lesser cover of *Leguminosae* in unburned plots.

Other herbaceous vegetation - there is no noticeable tendency towards cover-diversity as a result of fire.

It should be stressed that under conditions of high-intensity grazing the fire impact on herbaceous vegetation is less noticeable, and that the effect of high-intensity grazing is comparable to a certain extent to the effect of fire. The relationship between fire and grazing will be discussed in greater detail in chapter 10.

Chance observations made during our research in connection with fires, were also recorded. From these observations, too, it can be seen that after a fire there is a noticeable growth-delay at the beginning of the season. Belated flowering of *Gramineae* was observed in the burned area.

Regrowth of several perennials species, such as *Carlina hispanica, Cynodon dactylon* and *Prosopis farcta*, was observed in burned areas, whereas in unburned areas such species were found to have not yet regrown.

9.2.4 *Effect of fire on Quercus ithaburensis*

9.2.4.1 Effect of fire on *Quercus ithaburensis* seedlings and adult trees:

5 series of observations were carried out in burned plots. Each series covered 1-5 neighbouring plots of 1 ha each, burned on the same day and in the same fire, and representing different grazing regimes, or replicates under the same grazing regimes, as set out in Table 9.3. The number of trees contained in a plot varied between 35 and 134 (median 88), and the number of seedlings varied between 16 and 192 (median 47). The first observation was made within two weeks of the date on which the fire occurred, and repeat visits were made in several instances after 30 and/or 120 days. In each plot the following details were recorded.

- date of fire
- grazing intensity: relatively classified as High Intensity Grazing, Medium Intensity Grazing, Low Intensity Grazing, Very Scanty Grazing, and No Grazing (marked 3, 2, 1, +, 0 respectively)
- number of trees (or seedlings) unaffected by fire
- number of trees (or seedlings) partly harmed by fire, with at least part of foliage having remained green

Table 9.3: Fire damage to adult trees and seedlings, and extent of regrowth after fires under various cattle-grazing intensities in forest plots of the Yahudia Nature Reserve (blank spaces indicate absence of data).

Series	1	2				3					4	5
Plot	1-1	2-1	2-2	2-3	2-4	3-1	3-2	3-3	3-4	3-5	4-1	5-1
Date of Fire	6.77	6.74	6.74	6.74	6.74	7.75	7.75	7.75	7.75	7.75	6.76	7.76
Grazing intensity	0	0	+	+	+	0	+	1	2	3	2	3
Trees												
% unburned	0	33.3	18.3	7.5	2.2	6.7	18.8	33.3	71.2	85.7	33.0	40.0
% partially burned	0	33.3	38.3	44.1	25.4	46.7	52.1	40.7	25.0	14.3	65.9	60.0
% fully burned	100.0	33.3	43.3	48.4	72.4	46.7	29.2	25.9	3.8	0	1.1	0
% of burned trees sprouting 30 days after fire						50.0	92.3	13.0	93.3	100.0	22.0	21.0
% of burned trees sprouting 120 days after fire		43.5	40.8								88.1	66.7
% died out of total number of trees	8.0	1.1	3.3	0	0.7	0	0	1.2	0	0	1.1	0
Seedlings												
% unburned		67.1	14.9			27.1	48.0	62.1	56.3	93.3	32.3	29.2
% partially burned		17.7	0			7.8	12.0	6.9	18.8	3.4	9.7	60.4
% fully burned		15.2	85.1			65.1	40.0	31.0	25.0	3.4	58.1	10.4
% of burned seedlings sprouting 30 days after fire						15.7	23.1		42.7	40.0	47.6	29.4
% of burned seedlings sprouting 120 days after fire		21.2	0								81.0	55.9
% of budding seedlings sprouting from apical bud										25.0	41.2	63.2
% of budding seedlings sprouting from lateral bud									33.3	25.0	17.6	26.3
% of budding seedlings sprouting from basal bud						100.0	100.0		66.7	50.0	41.2	10.5
% died out of total number of seedlings		19.6	4.3			22.9	2.1	0	0	0.7	6.5	10.4

- number of trees (or seedlings) fully affected by the fire, with no green leaves remaining on tree.
  The number of trees (or seedlings) were calculated in percentages of total number of trees (or seedlings) in plot.
- number of trees (or seedlings) sprouting 30 and/or 120 days after date of fire, is calculated as percentage of total number of trees (or seedlings) affected by the fire.
- sprouting points in seedlings; 3 situations were diagnosed:
  - sprouting from apical bud;
  - sprouting from lateral bud;
  - sprouting from basal bud.

  Percentage of sprouting seedlings in each situation was calculated from total number of sprouting seedlings.

Results of these observations appear in Table 9.3. In analysing this table we generally ignored the fire incident of June 1977 (plot 1.1), which constituted an exception not only in the observation series recorded in the table but also in the fire incidents in the reserve in general as to prevailing weather conditions and the quantities of dry grass that combined together in producing a fire of singular intensity.

Effects of fire on trees

Some 85% of the trees were harmed in one way or another under grazing-free or very scant grazing conditions (grazing degrees 0, + respectively), as against some 47% in plots with low, medium or high grazing intensity (grazing degrees 1, 2, 3 respectively) - a quite significant difference (0.08 Wilcoxon rank test). Particularly striking is the percentage of fully burned trees, reaching 46% in plots free of grazing or under very scant grazing, as against a mere 6% in plots with low to high grazing intensity - an extremely significant difference (0.01 Wilcoxon rank test). In spite of this, no significant difference was found to exist between the various grazing regimes as to percentage of trees completely destroyed by fire, which is 0.7% of the total number of trees (if plot 1-1 is taken into consideration, the percentage reaches 1.3%).

The percentage of trees budding again in that season was some 57% in grazing-free or very scant grazing plots, and some 72% in plots with low to high grazing intensity, making for a significant difference (0.02 Wilcoxon rank test), with a tendency towards an increased rate of trees sprouting within the first 4 months following a fire.

Effects of fire on seedlings

Some 61% of *Quercus ithaburensis* seedlings are harmed by fire in one way or another under grazing-free or very scant grazing conditions (grazing degrees 0, 1), while in plots with low to high grazing regimes (grazing degrees 1, 2, 3) only 46% are harmed, which is regarded as a significant difference (0.01 Wilcoxon rank test). On the other hand, the percentage of seedlings that are totally harmed by fire reaches some 37% of all the seedlings almost irrespective of grazing regime. Equally, there is next to no difference between grazing regimes as to the percentage of seedlings perishing, reaching 7.4% of total number of seedlings in a plot.

There is a significant difference between grazing regimes with regard to the percentage of seedlings sprouting again in the same season (0.01 Wilcoxon rank test). which under non-grazing or very scant grazing conditions is about only 20%, and under low to high grazing intensity regimes about 55%. There is a noticeable trend towards an increase in the percentage of sprouting seedlings within the first few months after a fire.

In the non-grazing or very scant grazing plots where the subject was examined, the sprouting points were found to be at the base of the seedling, whereas in plots with low to high grazing intensity there was considerable sprouting also from lateral and apical buds.

Various chance observations connected with effects of fire on *Quercus ithaburensis* trees were recorded in the course of the research period. Some recurring phenomena that were observed are listed below.

Form of damage to tree: in most fires, damage was caused to lower half of tree, the upper half remaining green. In general, it was leaves, and not branches, that were harmed. The dry leaves remained on the tree until the following winter.

Sprouting after fire: sprouting after fire is a common occurrence in adult trees, but is less common in seedlings. In the event of an early fire (May-July) sprouting occurs shortly after (some 10 days), but after late fires (August-October), sprouting comes late, or not at all until normal sprouting in the following spring.

Effects of cairns: Trees or seedlings growing out of cairns are much less harmed by fires than trees and seedlings growing amidst herbaceous vegetation in open areas. A multitude of cairns makes for fewer fires, at least locally, and fewer trees and seedlings are exposed to fires there.

Effects of vegetation composition: Northerly declivities with dense growths of *Quercus ithaburensis, Styrax officinalis, Cercis siliquastrum* and sometimes *Quercus calliprinos* (vegetation types QS1-7, see 5.3.2), on which there exists a relatively lower cover of herbaceous vegetation, are less subject to conflagrations, and hence trees there are less harmed by fires.

9.2.4.2 Effects of fire on yield of *Quercus ithaburensis* trees

As already shown earlier on (see 7.1.2.3), harm is caused in the year of a fire to the lower acorns which were to have ripened in the following winter, whereas upper acorns are hardly affected. In the year after the fire there is a significant decrease in the acorn yield since acorns are more sensitive to fires in their first year than in their second.

Chance observations in the area showed that fires of low intensity due to weather conditions or intense grazing do not harm the adult acorns. Similarly, the actual impact of fire on trees growing out of cairns is weaker than the impact on trees growing in open areas.

9.3 Discussion

9.3.1 *Effect of fires on herbaceous vegetation*

As already shown above (9.2.3), retardation occurs in herbaceous plant growth in winter, in areas burned in the preceding summer, affecting the germination rate as well as the growth rate, and the consequences of this are also reflected in a belated flowering period. The absence of dry pasture vegetation at the beginning of the germination season no doubt makes for stronger radiation of warmth from the soil, a fact which can be of decisive influence on germination and growth rates during the germination season when relatively lower temperatures obtain. We have seen that the effect of high intensity grazing which also leaves the soil exposed at the beginning of winter, is similar to the effect of fire.

The cover of *Gramineae* in burned areas was found to be lower, while that of *Leguminosae* tended to rise; however, these differences in herbaceous plant composition are not significant. It is to be assumed that the fires which have been striking the region from time to time during a period of many years have produced a fire-type vegetation existing also in other mediterranean vegetation regions (Philpot, 1977; Naveh, 1975).

Natural pasture, sparse anyway at the beginning of winter, becomes even sparser after a fire due to growth retardation. On the other hand, regrowth of some perennials after a fire and before the onset of rain, somewhat compensates for this, chiefly because part of these are pasture plants, such as *Cynodon dactylon* and *Prosopis farcta*, that are eaten by cattle.

9.3.2 *The effect of fires on Quercus ithaburensis*

We have seen earlier on that the percentage of trees being harmed by fire in one way or another is high, but that of trees perishing through fire relatively low (some 0.7%) only. Damage to trees is generally in their lower parts whereas the crown remains unharmed. The parts most sensitive to fire are the leaves, which dry up on the tree, remaining on it also through the winter, not having had sufficient time to form absiccion tissues. Sensitive, too, are the acorns set in the spring preceding the fire; most of them get harmed, and this is expressed some one-and-a-half years later in a decreased acorn yield. Acorns due for ripening in the winter following a fire are less vulnerable, and in general only those growing on lower branches are affected. The branches on the other hand remain generally unharmed, and this is proved by the fact that most trees sprout again in the same summer.

The properties of *Quercus ithaburensis* - a tree with a usually single stemmed, fire-resistant trunk (Naveh, 1975), and with ramification starting high off the ground - endow the adult tree with a certain resistance to fires. *Quercus calliprinos*, too, was found to be fire-resistant, and thus trees having withstood a fire do not show a particular difference in lateral growth and ring-width in years in which fires have occurred (Lophshitz & Waisel, 1967). However, in high-intensity fires involving also the branches, the flames will spread to the trunk too, and the tree will perish. Hollow-trunked adult trees act as flues that fan the fire, and the tree will thus be destroyed before long with no possibility of extinguishing it.

The percentage of seedlings harmed by fire is very high, too, with about half of their number being fully harmed without, however, dying. The development of most of them is retarded by one year because in the majority of cases they will sprout anew from the base, while the entire aboveground growth will die since it consists of only one branch, or of a few thin branches, and is close to the fire and hence vulnerable.

The degree of fire damage to trees and seedlings greatly depends on the fire-intensity, which in turn depends on weather conditions, quantity of dry pasture vegetation, and location of tree or seedling. Most trees and seedlings are located within cairns (see Figure 8.1), which constitute insulation belts as no herbaceous vegetation grows on them. This phenomenon, at least in part, is the result of a higher survival rate after fires within cairns as opposed to open spaces. Also, steep and rocky declivities on which there grows not so much grassy vegetation are burned to a lesser degree, and this may be the explanation for the presence of typical types of vegetation which are outstanding for their dense growths and for the great variety of their tree species (see 5.3.2).

The effect of low to high intensity grazing is decisive for the extent of fire damage caused to trees and seedlings. Diminution of bulk of dry pasture vegetation, which constitutes the principal fuel material, will affect not only the number of trees or seedlings harmed, but also their revival and sprouting potential. Such grazing reduces to nearly half the number of trees suffering damage, and by about one third the number of seedlings affected by fire. All in all, however, seedlings are more vulnerable than trees, and the percentage of those sprouting again after a fire is much lower than that of trees, and this is the case under non-grazing (20%, against 57% trees) as well as under grazing conditions (55%, against 72% trees). Also, the percentage of seedlings perishing is about ten times higher than that of trees (7.4%, against 0.7% trees).

The phenomenon of quick sprouting after a fire occurring in early summer, and belated sprouting, or absence of sprouting, after a fire in late summer, (discussed above under 9.2.4.1) is inherent in the tree's physiological condition at the time of the fire. Fahn (1953) found that, in Israel, the cambium of *Quercus ithaburensis* is still active in early summer, while in mid-August it passes into a state of dormancy. The time-span from stimulation of cambium activity following a fire until bud-break, apparently covers several weeks, or, alternatively, no such activity takes place in that season at all.

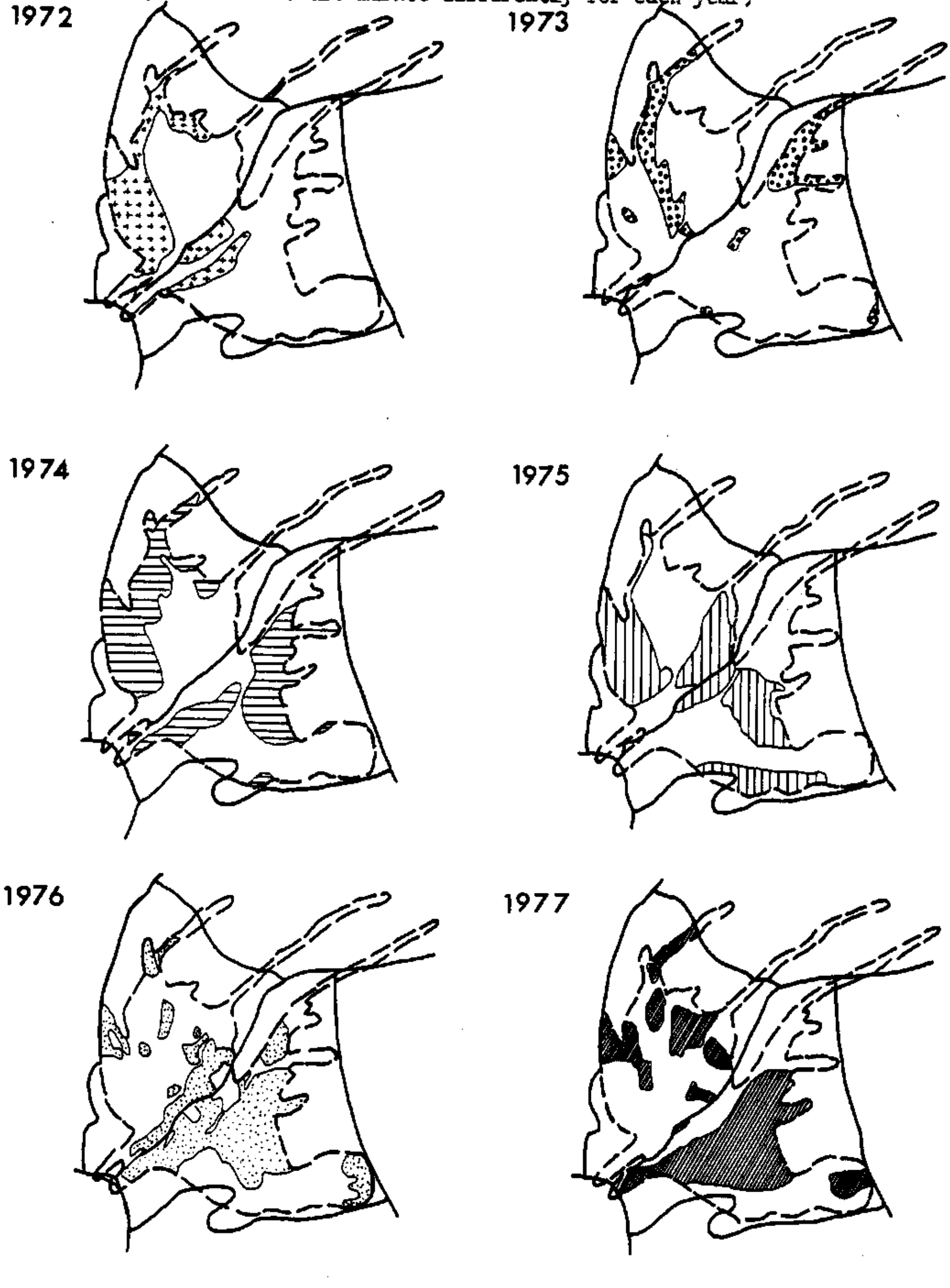
9.3.3 *Spreading of fires and fire-frequency*

Study of maps 9.1 and 9.2 will show that spreading of fires is discontinuous. This fact derives from natural obstructions which check the fire - such as streams, rocks, cairns, and also from fire breaks. The shape of a surface burned also depends on these factors, as well as on the wind prevailing during the conflagration. The area where fire-frequency is highest is the central part of the reserve's southern region, in which the chief conflagration factor is military fire-practice. Out of the 8 observation years recorded in map 9.2, 7-8 year fire frequencies appear in limited areas of the above region as well as in the northern and north-western corners of the reserve. Although under grazing, there are large stretches in the western part that were burned 3-5 times - a relatively high frequency as compared with the remainder of the area under grazing. This can be attributed to the combined factors of the proximity of the road passing throughout the length and to the west of the area, and the westerly winds prevailing in the fire season - factors which increase the likelihood of fires being caused by cigarette ends thrown from cars.

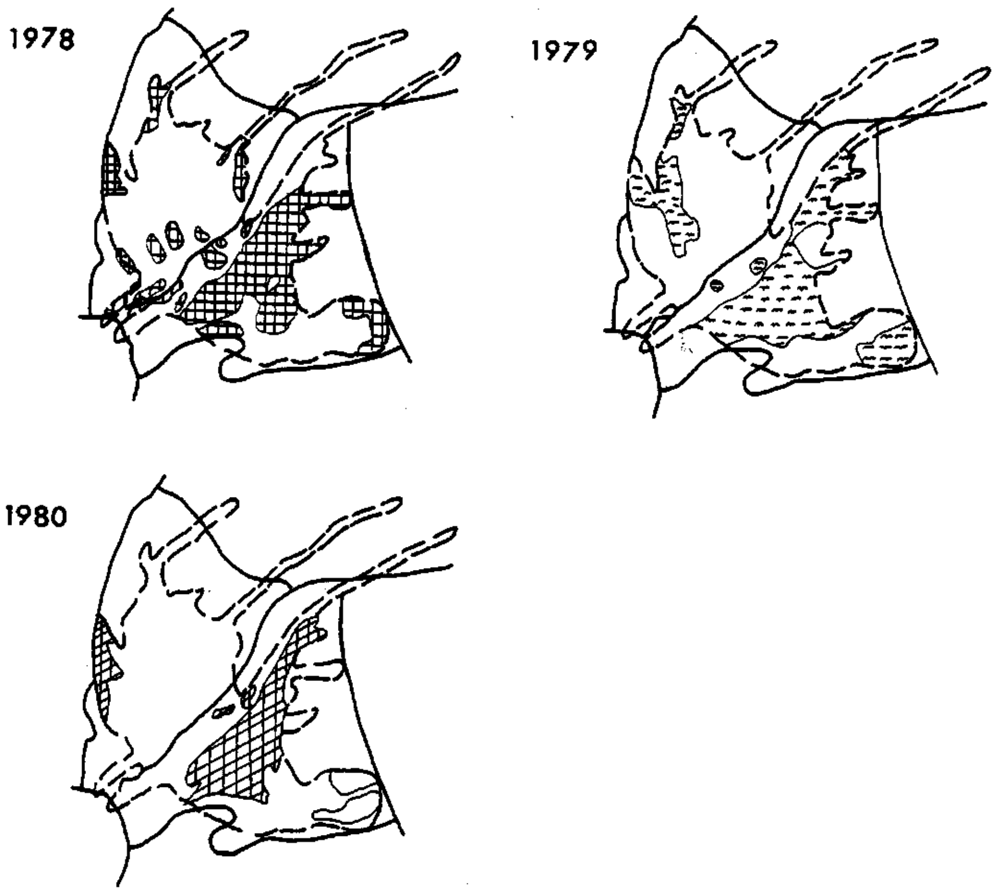
As against this, fire-frequency is lower in mid-forest, which forms the central area of the reserve's northern part, where even wide stretches were found to have remained untouched during all the observation years. Fire frequency is low also in the extreme southern sector which consists of the steep banks of the Daliot Stream and the stream itself, and large areas there have remained unburned.

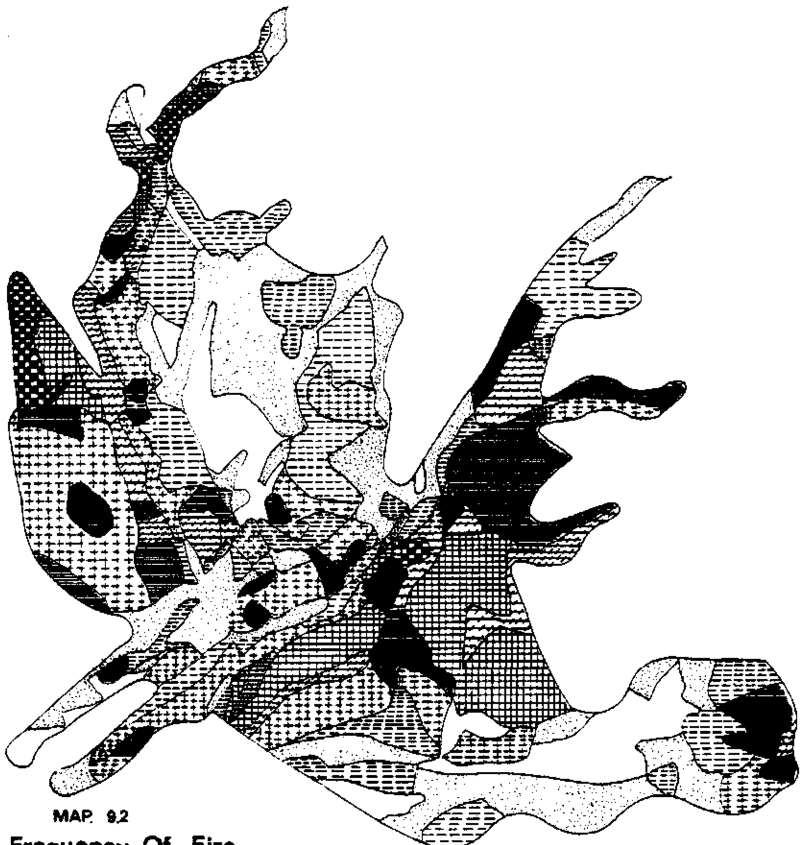
The majority of fires in the Yahudia Reserve as regards affected area (about 70%) and number of incidents (about 60%), occurred in May-June (Fig. 9.1).

Maps 9.1: Fires in Yahudia Nature Reserve during the summers of 1972-1980. (Burned areas are marked differently for each year)



Maps 9.1: continued.





MAP. 9.2

Frequency Of Fire

Years 1972-1979

1 Year 5 Years
2 Years 6 Years
3 Years 7 Years
4 Years 8 Years

The largest area in any one month was burned in May, the principal factor being conflagrations in military practice area (Fig. 9.3), but the major number of fire incidents occurred in June, the main factor being the fires in grazing areas (Fig. 9.2).

In military practice areas, large stretches are consumed by a small number of fires, whereas in grazing and forest area a greater number of fires cause smaller areas to be burned than appears to be the case from Figs. 9.2 and 9.3, and from Map 9.1. In pasture areas, measures are applied to quench fires and thus prevent them from spreading, while no preventive measures are taken in military practice areas. The relative as well as the actual surfaces burned are larger in military practice areas. The other areas are small and marginal, and the number of fire incidents occurring in them too insignificant for a meaningful analysis to be made.

Fire factors

In practice areas, the majority of fires are caused by military fire practice. In pasture areas, which are also forest and hiking areas, fire factors that can be enumerated are: hikers, cigarette ends thrown from vehicles, and premeditated incendiaries. Nevertheless, there are many fires the causes of which are unknown, but not a few of these may have their source in military fire practice too.

Information based on first-hand accounts of the period between the beginning of the century and the year 1967 (Toma Bakar and other local inhabitants, personal information), points to infrequency of conflagrations during that time. Fires in the area under review occurred once every 5 years and were not very extensive. At the outbreak of a fire villagers went out to smother the flames with wet sacking and branches.

Most of the prescribed fires being resorted to in mediterranean type vegetation areas in the world, are intended to prevent accumulation of combustible material which, if seized by flames once every few years, can cause big conflagrations (Parsons, 1977; Trabaud, 1973). With the type of vegetation growing in the Yahudia Forest however, there is in fact no accumulation of combustible material. For the most part, inflammable material consists of annual or perennial grasses which, unless grazed or burned, will decompose through rain in the winter, and the only combustible material to be found at the beginning of the dry period, in May, are plants grown in that season. This fact refutes the widespread opinion among many researchers (see 9.1.1) which is, however, also supported by Gutman (1979). Too few branches are shed by the *Quercus ithaburensis* trees themselves to constitute a factor in the accumulation of combustibel material, and most of the leaves shed either disintegrate during the winter period, or fall among the stones of the cairns on which most trees are growing (see Fig. 8.1). These factors, combined with the absence of bushes and shrubs in the Yahudia Forest (see 5.3), eliminate in fact the accumulative risk inherent in the absence of fires during a consecutive number of years.

Spontaneous fires resulting from lightening do occur to a certain extent in mediterranean regions (Van Wagtendonk, 1977; Susmel, 1973). In our estimation, the probability of such fires occurring in the Yahudia Forest region is extremely limited. From multi-annual averages of days on which thunderstorms occurred [*)], it appears that in one year there are about 15 thunderstorm-days in the Yahudia Forest region; of these 1.5 days on the average occur in May, 0.1 in June, 0.2 in September, 0.8 in October, while none were recorded in July-August. These thunderstorms occurred either after, or immediately prior to, or were accompanied by, rain. Thunderstorms in May occur in years in which the month of May is still rainy and herbaceous vegetation has not yet wilted and is therefore not combustible. Also in October thunderstorms occur under rainy conditions, with only little dry pasture vegetation remaining after the grazing season, with slicht probability of fires breaking out.

The thunderstorm data have been based on the number of thunder-peals heard near a local meteorological station and covering a radius of several kilometers; thus the already limited probability of lightenings occurring during June-October is even further reduced in view of the fact that they are spread over quite a large area. This fact, combined with the discontinuous pattern of fire expansion due to natural obstacles, accounts for the lightening-engendered fire element having, if any, a minimal effect in the Yahudia Forest Reserve. We therefore consider the conflagrations to be deriving from human factors, and particularly from man's modern life-style, finding expression in the frequency of fires which has been on the increase since 1967, when drastic changes occurred in the nature of activities in the area following the Six-Day War.

---

*) I am grateful to the Israel Meteorological Service for the collection and transmission of data.

9.3.4 *Conclusions, and recommendations for reserve management with respect to fires*

As we have seen, fires in the Yahudia Forest have no significant effects on herbaceous vegetation, and their influence on the establishment of *Quercus ithaburensis* is negative. Nor do they contribute to pasture improvement, as is usual in perennial and bush vegetation. Furthermore, small likelihood of spontaneous fires, low fire-frequency in the past as also the absence of year to year accumulations of combustible material, eliminate the risk of conflagrations of catastrophic proportions resulting from the accumulative effect of non-occurrence of fires. This situation dictates a policy of reserve management with a minimum of fires. Cattle, goat and sheep grazing as it existed in the past, and grazing regimes applied nowadays, no doubt constitute decisive factors in the diminution of the number of fires, areas burned, and fire intensity.

The northern region of the reserve which is the area of the *Quercus ithaburensis* forest and the main tourist and holiday area, is also the region which is under a cattle grazing regime today. It is important in this region to continue with preventive measures, such as spraying of fire breaks, and smothering by herdsmen and wardens of any fire breaking out. In California it is customary to sow the fire-breaks with perennial wheatgrasses (Pacific Southern Forest, 1961) and, indeed, it is easier to extinguish a fire in a strip of herbaceous vegetation. In the conditions obtaining in the Yahudia Forest it is not difficult to penetrate amongst the trees for the purpose of fire-extinguishing because there is no dense tree-growth; on the other hand, there are no local perennial grasses that are green throughout the year and will not burn.

Although remaining green for a longer period than other grasses, the *Cynodon dactylon* that spreads along the fire-breaks wilts in July-August, when it becomes a fire conductor. The introduction of non-indigenous plants for sowing along fire-breaks is not accepted by us as a management method in nature reserves. There would seem to be no solution therefore at present but to keep the fire-breaks clear of all vegetation. In addition, we recommend increased fire control and observations in the *Quercus ithaburensis* forest area, and having people on call in May-July, and especially in June, during which months fire-frequency in this area is at its highest. Particular attention should be given to the western part of the forest where fire frequency is higher, by exercising increased control and cutting of additional fire-breaks.

In our view, it is not necessary to adopt fire-extinguishing measures in the reserve's southern region, which is partly being used as a military practice area, and in any case less wooded. One plot of *Quercus ithaburensis* forest (plot T, see Map 3.2), - in which there is no grazing and fires are frequent - constitutes a control area for the remainder of the *Quercus ithaburensis* forest which is under grazing and in which fires are infrequent. Concentrations of *Quercus ithaburensis* appear on the declivities; a greater variety of tree species is to be found on the steep slopes facing north (see 5.3.2 and Map 5.1), and these trees are less vulnerable to fires because of the rocky slopes. The remaining parts in the southern region are areas of batha and springs. Fires in these parts to a certain extent take the place of grazing. Because, as we have seen earlier on, there is no change in the composition of herbaceous species in a burned area where the main sufferers from a fire are the trees, there is no objection to allowing batha areas partly to burn themselves out. Infrequent, as well as frequent burnings (Map 9.2) enhance the vegetation variety in the area. It is recommended therefore not to resort to any fire-extinguishing measures in the southern area and to discontinue the spraying of fire-breaks from the air being carried out there annually.

10 PASTURE MANAGEMENT IN THE YAHUDIA RESERVE AND ITS EFFECTS

10.1 Introduction

This chapter deals with the effects of cattle grazing on vegetation in the Yahudia Forest form the point of view of reserve management which employs cattle grazing as one of its methods.

10.1.1 *Pasture management, and reciprocal effects of pasture and vegetation*

Many researchers and nature conservationists consider grazing to be an efficient tool for the management of rangeland. It is accepted, however, that uncontrolled grazing may cause damage to plant composition and structure, to the soil, and to the ecosystem as a whole.

In principle, grazing - if distributed uniformly in space and time - is considered a good management system (Leloup, 1953) for maintaining plant composition, soil structure and equilibrium with other organisms.

The full potential of primary production is attained as long as the rate of biomass removed by grazing is less than the growth rate. Stability of the grazing system is maintained in this case (Noy-Meir, 1975).

Grazing regimes

Uniform distribution over a period of time is attained by utilization of grazing season and rotation of grazing, and uniform distribution in space through density of animals.

Rotation of grazing exerts less pressure on the range and affords advantages to the pasture as compared to continuous grazing (Tainton, 1974). The ground cover of species was not changed fundamentally by variation of grazing management, but changes in species composition were noticed, and these were most marked in treatments of extreme grazing regimes (Kydd, 1964; Gutman, 1979).

Deferred grazing allows seeds sufficient time to germinate and grow to a stage where the rate of grazing will remain lower than the growth rate and the system remains stable. It was shown that grazing in the dry summer increased primary production by 20% over grazing in the reproductive growth period (Tainton, 1974) and prevented soil compaction (Laycock & Conard, 1967). Grazing pressure in spring reduced production significantly (Frischknecht, 1968) and changed species composition (Blattman, 1966). In mediterranean vegetation it was shown that overgrazing starting too early in the season causes destruction of vegetation (Papanastasis, 1977).

Damage caused by trampling was found to be significant in wet soils and during growth stages of plants (Edmond, 1966).

Rotationally deferred grazing, or moderate grazing resulted in high species diversity and floristic stability in a *Quercus ithaburensis* park forest in Lower Galilee, Israel (Naveh & Kinski, 1975).

Uniform distribution of grazing in space is achieved by low grazing pressure. Increased trampling pressure initially stimulates but subsequently reduces primary production (Goldsmith, 1974) and number of species (Grime, 1973). Uniform grazing and utilization of range can be achieved by rotational use of watering places (Martin & Ward, 1969) and small paddocks.

Selectivity and species composition

Differences in palatability of species causes differences in preference and may have a strong influence on species composition and grazing intensities in different types of vegetation (Eygenraam & Pieters, 1966).

Grazing plays an important rôle in vegetation succession (Ellison, 1960; Westhoff, 1971; Knapp, 1971). Succession is influenced by change of cessation of grazing regime (Maarel, 1971; Wells, 1969; 1971).

Cattle grazing can be used to improve species composition in disturbed areas, restoring it to its natural condition (Katznelson, 1956). Katznelson showed how grazing of thorns in their flowering season suppressed them, and how grazing on dry pasture encouraged legumes. Letting the range rest during germination and early grass growth, led to an increase in the coverage of this group. It was found also (Naveh, 1971; Crompton & Walters, 1964) that cattle grazing favours geophytes and Orchidea.

Most conclusions concerning the influence of grazing on changes in plant species composition refer to heavy grazing, and little is known about the effects, if any, of light or moderate grazing (Ellison, 1960; Heady, 1964).

Selectivity of cattle depends on available forage and on season. Wangon *et al.* (1960) found that at the beginning of the growing season cattle are not particularly selective, mainly when plants are low, dense and evenly mixed. In spring, when forage becomes more abundant, the animal is able to consume more forage per unit time and begins to show increasing preferences for certain plant species. Preference of a certain plant species is related to the other plants with which it grows in association. For this reason, preference of the same species varies from pasture to pasture. Wangon (1963) showed that in Californian annual grassland dry forage, which is readily consumed in summer and early winter, is neglected by cattle in spring when green forage is available. Grasses were found to be 84% of the diet in the yearly average, while legumes composed 2% in the early season and 50% in late spring. Browse constituted 1-2% of diet only. Other researchers (Rocky Mountain, 1959) found that grassland was preferred by cattle over open timber, which in turn was preferred over dense timber.

The digestibility of leaves and shoots of some plants of the mediterranean maquis showed values of ca. 30-60% (Geri & Sottine, 1970). Higher values in herbaceous plants may be the reason for higher preference. In California during absence of green forage oak leaves are preferred (Wangon, 1963).

Preference of acorns

In examining aspects of grazing in a *Quercus ithaburensis* forest, special attention was paid to the rôle of acorns in the diet of cattle.
Acorns are quite palatable to cattle which, in California in years of plenty, spend considerable time (2 out of the 8 hours daily of feeding time) in foraging for acorns and consuming them (Wangon *et al.*, 1960). Wangon (1963) found that acorns of *Quercus douglasii* may constitute 15% of the diet in a season, and that in years of high acorn production the cattle ate acorns to the extent when they had to vomit them. In Spain, 1.6 million swine grazing in open oak wood during October-January feed chiefly on acorns the yield of which is 600-700 kg/ha (Parson, 1962).

In California the combination of green forage and acorns (up to 17.5 pound per day) was found to make the cattle gain weight while causing no negative symptoms, whereas consumption of acorns along with dry forage low in protein resulted in a marked decrease in liveweight (Wangon, 1960). This corresponds with our results, showing that acorns have high energetic value but are low in protein (see 7.2.2).

A comparable study in transitional mediterranean steppe

An interesting comparison can be drawn with the research being held in the Kare-Deshe Experiment Range. Kare-Deshe is located in Upper Galilee at +200 m altitude, about 10 km west of the Yahudia Nature Reserve. The climatic and edaphic conditions as well as herbaceous vegetation composition are quite similar to those obtaining in the Yahudia Nature Reserve (see Gutman & Seligman, 1979).

Basing ourselves on Seligman & Gutman (1976 a, 1976 b), Gutman & Seligman (1979) and Gutman (1979), we can draw the following picture of this grazing system.

A comparison of 4 cattle grazing regimes was made: continuous heavy (1.2 head/ha), continuous moderate (0.7 head/ha), and rotational moderate (0.8 head/ha) converted later into rotational heavy (1.3 head/ha). Grazing started in the green season when pasture had established itself (January-February) and continued into the dry season till the onset of the first rains, or until the dry herbage was completely grazed down.

Primary production was fundamentally the same in all treatments (ca 3000 kg/ha per year). This is attributed to the fact that less than 45% of plant biomass was consumed during the growing season, and 40% during the dry season. Dead standing vegetation was found to have little effect on biomass in the following season, although some delay in germination and cover development was recorded during heavy and continuous grazing.

Liveweight gain in cattle per unit area increased with grazing pressure, but liveweight gain per head was found to be somewhat higher at the moderate stocking rate, especially during the dry season when more dry forage remained in the field.

Heavy grazing - preferable in terms of liveweight gain per unit area - has a marked influence on plant species composition. High selectivity in heavy grazing reduces availability of seeds of some favoured species and may change the proportion of these species in the following season. Species propagating through windspread seeds reach the area where they succeed as a result of reduced competition. These are mainly *Compositae* species such as *Scolymus maculatus, Notobasis syriaca* and *Senecio vernalis* whose proportion in vegetation has been generally low.

The relative cover of grasses (60%) and of forbs (30%) suffers no change under moderate rotational grazing, but under heavy continuous grazing grasses decrease to 30% and forbs increase to 50%. Under moderate continuous grazing the relative grass cover decreases to 50%, with forb cover showing some increase. As regards legume cover differences between years are greater than differences between grazing units - a well-known phenomenon in these regions (Ofer & Seligman, 1969). No influence of grazing treatment on the perennials *Prosopis fracta, Psoralea bituminosa* and *Cynodon dactylon* was recorded.

10.1.2 *Pattern of behaviour and feeding habits of cattle on pasture*

Activities

Among the activities of cattle on the rangeland eating occupies most of the time. Time spent on grazing and browsing varies through the seasons and increases with growing herbage supply (Werk *et al.*, 1974), while Wangon *et al.* (1960) found that feeding takes up 12 hours of the 24 hours day on dry pasture, 14 hours on short new-plant growth in early spring, and 9-10 hours on high green forage in late spring.

Grazing time and rate depend not only on available forage but also on body condition. Grazing may be faster and more time consuming if body condition is poor, or during the lactation period (Arnold & Dudzinski, 1966).

The feeding tempo as measured by number of bites shows that in good pasture conditions cattle take 50-60 bites per minute and walk between bites without lifting their heads for 40 minutes (Wangon *et al.*, 1960). Generally speaking, most records of cattle movement show that daily distances covered are within a range of 0.68 - 6.4 miles, depending on forage conditions: the less forage is available, the more travel occurs. That is, in the early season and on a heavily-grazed range, more time is spent grazing mainly due to increased walking; supplemental food reduces travel by about one third (Wangon *et al.*, 1960).

Periodicity of grazing

The number of grazing cycles a day is 2-4, depending on conditions. Kilgour (1975) found 3 grazing cycles a day and Wangon *et al.* (1960) speaks of 2 major and 2 additional cycles a day. The first of the two major - and more or less constant - grazing cycles occurs from around sunrise and continues for 2-3 hours. The second cycle starts late in the afternoon and continues until after dark. Between these definite periods, there may be one or more distinct periods of variable lengths, depending on season, forage conditions and weather. These two cycles usually occur before noon and around midnight.

In winter, cattle graze during most of the daylight hours, whereas in summer they graze more at night. Nocturnal grazing takes up about one third of grazing time (Schlottler *et al.*, 1975) and is closely related to the high temperatures obtaining in summer, though it does not depend on the presence, or absence of moonlight (Wangon *et al.*, 1960). Kilgour (1975) found increased night-grazing time to be a sensitive indicator of heavy grazing pressure.

Other major activities apart from feeding and walking, are ruminating and resting. Ruminating takes up about 30% of time in continuous periods of 20-40 minutes with 15-40 minutes intervals. Resting occupies 10-15% of time, most of it lying down (Wangon *et al.*, 1960; Wangon, 1963).
Other activities such as sleeping, idling, lactating, watering, defacating and urinating are negligible from the point of view of time consumption.
Defecations occur about 12 times a day covering 8 sq.ft. a day (Wangon, 1963). These locations show changes in botanical composition within a radius of 2 ft, and are avoided by cattle during 13-18 months (Norman & Green, 1958). Except in favoured bedding areas, cattle scatter their droppings and urinations indiscriminately about the pasture (Wangon *et al.*, 1960).

Distribution pattern

Uniform grazing distribution in space, as mentioned above (10.1.1), depends on cattle density. Density depends not only on the number of animals in a given area paddock, but also on local conditions in the paddock, such as microclimate, topography, availability of forage, water, and supplemental food.

Goodall (1969) showed that the closer to water and fence an area is, the more densely it is used. During hot weather, more time is spent in the shade, with beneficial effects (Garrett *et al.*, 1967).

There was found to exist close correlation between forage production and cattle distribution, and thus in the early season southerly slopes with earlier forage growth were utilized to a higher degree (Wangon, 1968).

10.1.3 *Domestic grazing in relation to wildlife grazing*

The interaction of big herbivores and grazing cattle is frequently discussed in literature. Conclusions as to competition for food between these two groups cannot be drawn easily if stocking rate is low.

Competition for forage between cattle and elk populations exists due to similar food preferences (Nagle & Harris, 1966). Krueger & Winward (1974) found that cattle, mule deer and elk, grazing together in the same area, had an impact on the vegetation and that this was reduced when the area was being grazed by wild animals only.

On the other hand, forage quality can be improved by a combination of cattle - and big herbivore grazing (Anderson & Scherzinger, 1975), and the area put to better use by both producing beef and getting income from hunting fees (Passey, 1966).
Complementary use of range by cattle, buffalo and oryx was found in East Africa by Field (1975) and others.

Two big wild herbivores occur in the Yahudia Nature Reserve: the wild boar (*Sus scrofa*) and the gazelle (*Gazella gazella gazella*) (see above 4.1.1.3). The vegetarian part of the wild boar's diet, as recorded by Gnaani (1972) in Upper Galilee, Israel, includes grass spikes, roots and storage organs, leaves and acorns, fruits and mushrooms. Wild boars chew the grass, suck it and spit it out, as shown above (Table 4.1). While not being very selective with regard to species, wild boars are selective as to plant parts, showing a preference for roots, storage organs and fruits (Eisenberg & Lockhart, 1972).

Studies on the biomass and feeding habits of the gazelles were made by Baharav (1974; 1975) in a comparable area of the Yissakhar plains, 37 km south-south-west of Yahudia. In this area, whose primary production is 1800 kg D.M. per ha per year, gazelles were found to consume 500 gr D.M. a day per head. A population with a density of 30 head per sq. km, consumes 25% of primary production. According to Baharav, feeding during the growing season appears not to be selective and consists of 73% grasses, 23% forbs and 4% browse. During the drying-up and dry season, when browse is green, browse selectivity increases and the diet consists mainly of *Prosopis farcta, Zizyphus lotus, Zizyphus spinachristii, Alhagi maurorum, Cynodon dactylon* and *Aristida caerulescens*.

10.1.4 *Former grazing regimes in the Yahudia region*

The wild ox was first domesticated in about 8000 B.C., and modified eco-systems were created through intensification of animal husbandry (about 3000 B.C.) by grazing (Love, 1961). An intensely populated area for many centuries the Middle East was grazed continuously by domestic animals. Elan & Gutman (1977) state that nearly all existing range and forest plant species in Israel underwent a permanent selection process throughout the ages, and only those which withstood fire, over-grazing and cutting have survived.

Peters (1978) claimed that from the 2nd century onwards, Bedouin grazed their flocks of goat and sheep and their cattle and camel herds on the Golan chiefly in summer, after finishing winter pasture in Syria.

There is no evidence of over-grazing during the last centuries, since the Golan was not densely populated. Settlement there in the last century caused local phenomena of over-grazing around villages. During 13 centuries of Arab, Turkish, French and Syrian rule, pasture lands were considered public domains of the villages. Since everyone was free to take his flocks anywhere he chose, it was impossible to control grazing pressure, and naturally a gradient of overgrazing from the villages outward was created (Elan & Gutman, 1977).

No written information is available about pasture and grazing animals in the current century up to 1967. From aerial photographs of this period we have been able to discern cattle grazing, and our impression is that overgrazing took place around villages within a radius of about one km only.

A few members of the Bedouin tribe Arab-el-Talawiya, and several others who had connections in the area before 1967, have drawn the following picture: Sheikh Awad a Ga'aber and, from 1961, his son, had 300 head of cattle and 400 goats grazing in an area extending over 2600 ha, including most of the north-western part of the Yahudia Nature Reserve, i.e. the area between the Yahudia and Meshushim streams. To the north and east in the Asalia, Sewiya Garabe and Karane villages, there were living Bedouin of the Arab-el-Talawiya tribe who had some smaller herd on an area of about 1600 ha.

In the southern part of the reserve, between the Yahudia and Daliot streams, the Nimrod clan of the Arab-el-Talawiya tribe lived, with 300-400 heads of cattle and 500 goats on a range of 2500 ha. This creates a grazing pressure equivalent to about 5.9 ha per cattle head.

10.2 Methods

10.2.1 *Pasture Management in the Reserve*

Following the increase of fires in the reserve during 1967-69, a herd of beef cattle belonging to Kibbutz Neveh-Eytan was introduced for grazing in 1969. Main developments in pasture management took place during 1970-75.

10.2.1.1 Herd size and composition: Made up of beef cows deriving from Charolais, Brahma, Baladi (local), Dutch and Hereford strains, the herd comprises:

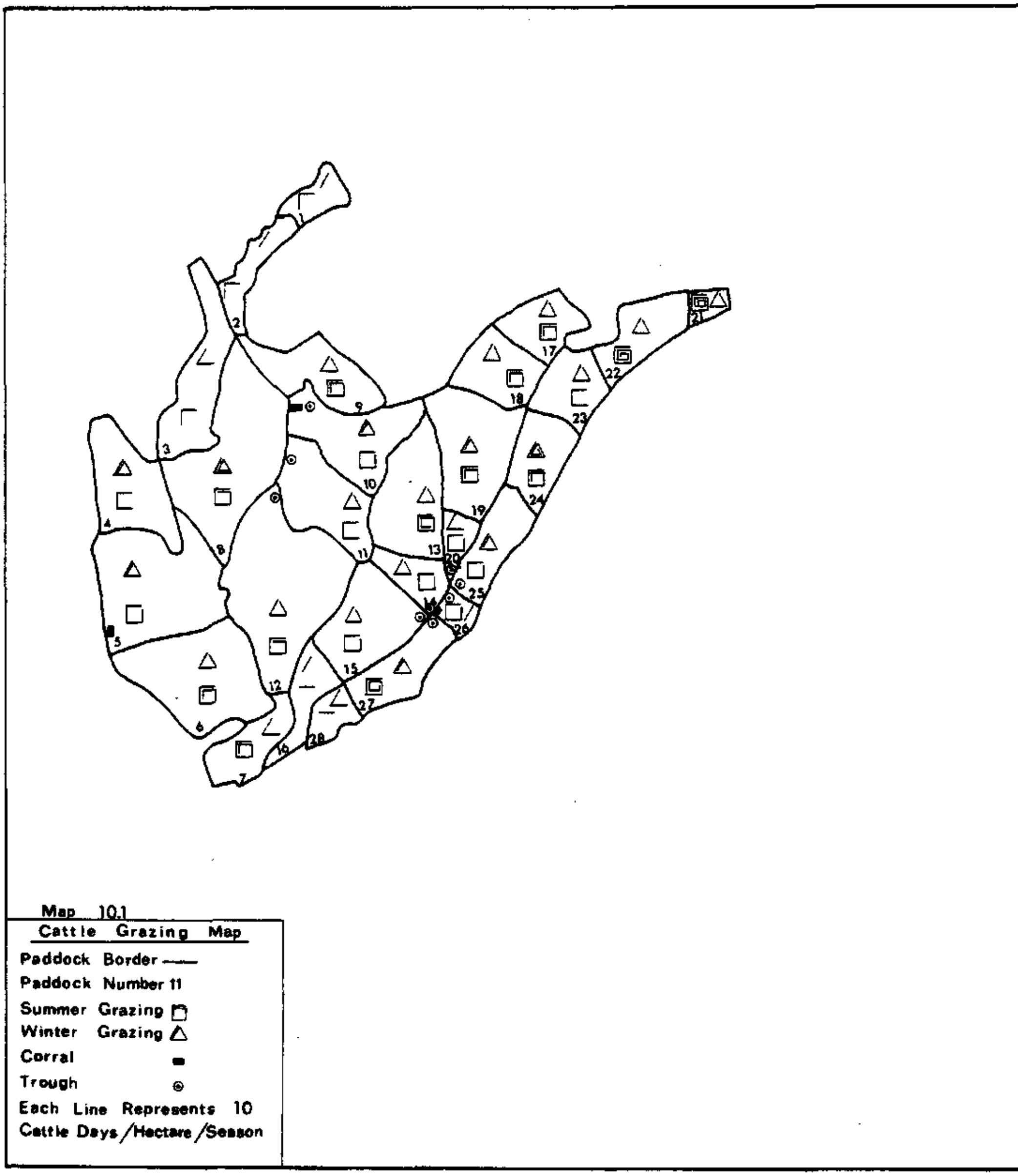
- about 800 mothers and offspring depending on seasons of year;
- about 40 breeding bulls;
- about 150 heifers.

10.2.1.2 Division of pasture area: The reserve area under grazing extends over 3300 ha brutto (including dissected plots not actually exploited for grazing purposes), representing 82% of pasture range of the entire herd.
The pasture area is divided into 28 paddocks, of which 20 are within the confines of the reserve (see Map 10.1). Mean size of paddocks is 173 ha (range: 50-400 ha). All paddocks are enclosed by a 1.20 m high cattle fence consisting of 4 barbed-wire strings. Most paddocks have natural water sources, and those where there are non have been equipped with troughs as detailed in Map 10.1. There are 3 corrals in the range (Map 10.1).

Each winter, fire breaks are sprayed on the cattle drives along the fences, continuing over the stream banks down to the water (see 9.2.2).

10.2.1.3 Pasture Management: The pasture management is concerned with the meat cattle remaining in the pasture area during all seasons of the year. The cow herd is split up into 4 basic groups of mother cows and heifers, a group of weaned calves, and a group of bulls.
The cattle breeding cycle is as follows:

- mating: November-January (bulls are kept in a separate group during February-October);
- calving: August-October;
- weaning: May-June (green pasture turns dry);
- sale of calves: July.


Map 10.1
Cattle Grazing Map
Paddock Border
Paddock Number 11
Summer Grazing
Winter Grazing
Corral
Trough
Each Line Represents 10
Cattle Days/Hectare/Season

Sales of calves and cows are made on a selective basis only, with emphasis still being on increase in number of mother cows.

supplemental food: supplemental food is given in the wilting season from the end of May till November. Chicken manure is given freely, and supplemental concentrated food is given in quantities of up to 1 kg per head depending on state of pasture and on growth stage;

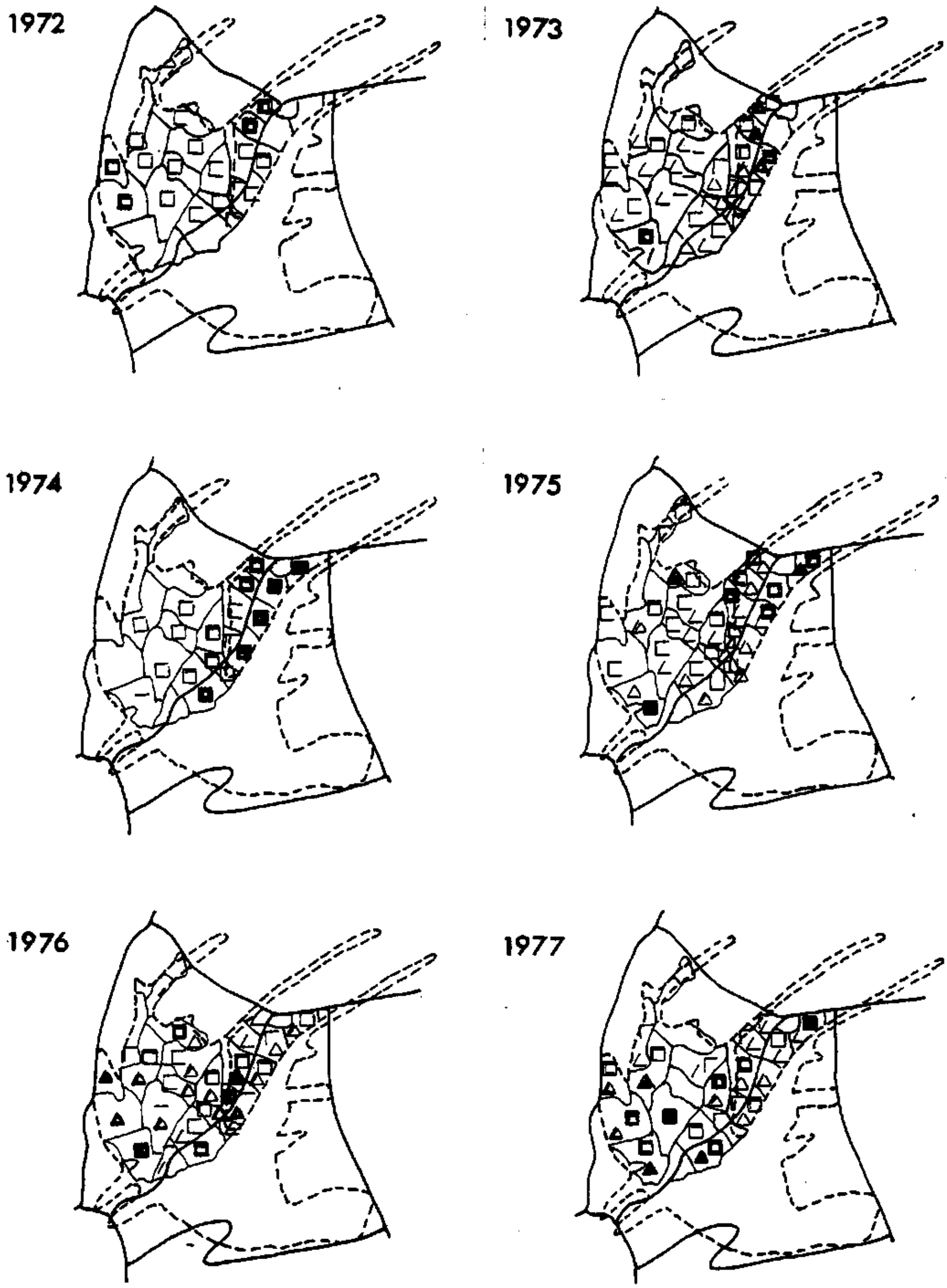
control: the Kibbutz keeps a pasture diary in which number of heads of cattle in each paddock, and supplemental food given, are recorded. Each autumn a grazing plan is drawn up for the following grazing year (December-November). This plan is subject to alterations arising from changed circumstances in the field such as fires, pasture yield, epidemics etc.

In each paddock, grazing days were summed up on the basis of the pasture diary. Separate summaries were made for the green-pasture season (December-April) - for this purpose entitled 'winter', and for the dry-pasture season (May-November), entitled 'summer'. For each season grazing pressure was calculated in units of grazing days per hectar. The number of grazing days in each season were summed up separately and divided into the number of seasons recorded. The total obtained was in fact the mean number of grazing days per hectar per paddock, severally for summer and winter season. This for the purpose of establishing a comparative scale for the various seasons and their total of all the years. However, the figures obtained should not be regarded as a representative mean, since there is great variability between years as regards paddocks.

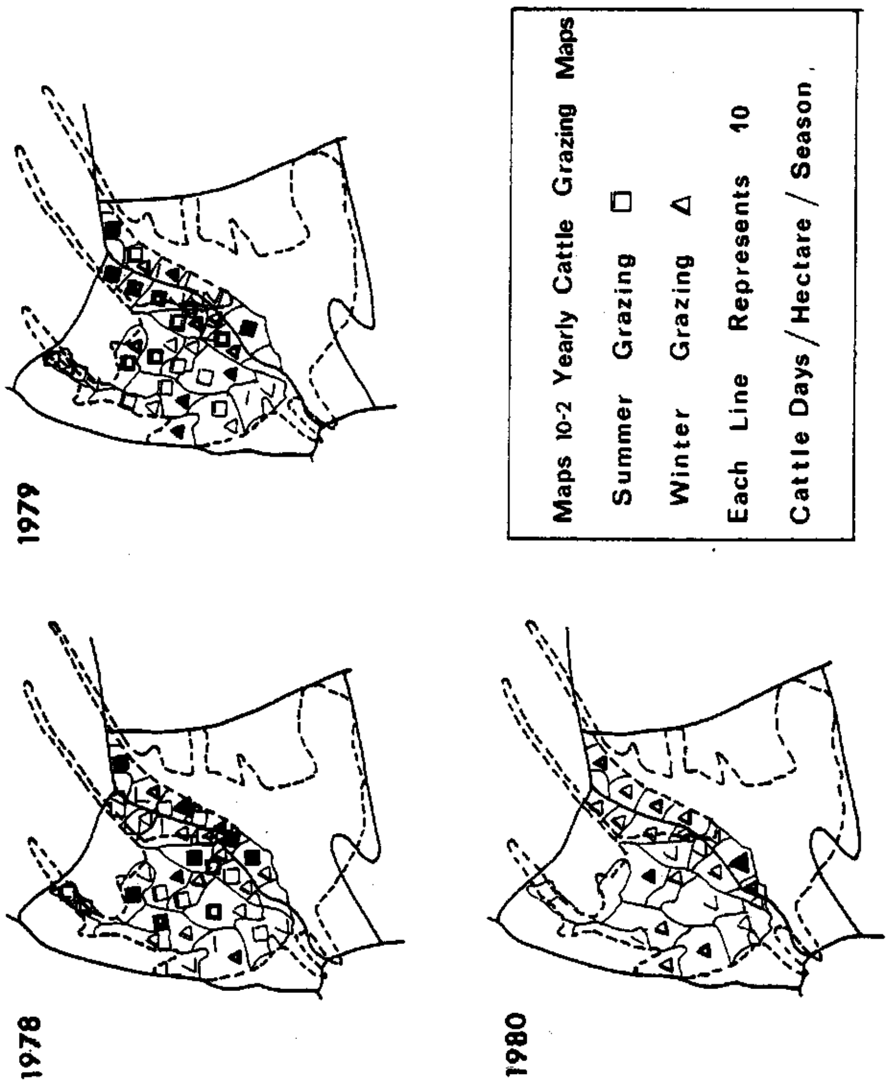
The number of seasonal grazing days per hectar were recorded in the map of grazing paddocks - a separate map for each year (Map 10.2), and also in a summarizing map of total number of grazing days per hectar per season divided by number of seasons (Map 10.1).

Since the wilting season (entitled 'summer') extends over 7 months, and the green-pasture season (entitled 'winter') over only 5 months, we have used the following method of graphic description: the summer season is represented by a square 'snail', and the winter season by a triangular 'snail', with each rib representing 10 grazing days per hectar per season. Thus, the comparative value of summer and winter is expressed by the number of

Map 10.2



Map 10.2 (continued)



convolutions and not by the number of ribs of the 'snail', and this in view of the following equations which are good approximations:

$$\frac{\text{number of ribs in triangular 'snail' convolution}}{\text{number of ribs in 'square' 'snail' convolution}} = \frac{3}{4} =$$

$$= 0.75 \; \frac{\text{'winter' months}}{\text{'summer' months}} = \frac{5}{7} = 0.71$$

We have therefore contented ourselves with a graphic method for describing pasture management in the reserve during the years 1972-80.

10.2.2 *Pattern of cattle behaviour and feeding in the reserve*

10.2.2.1 Mechanized survey of behaviour pattern: A time-recorder, model Kinzle T.F.W. 24/8 was used for measuring the behaviour pattern of cattle on the pasture range. The instrument is based on a revolving paper disk (see photo 10.1), divided into hours, with a recording pendulum gliding over its surface. The vibrations of the instrument cause lines to be traced on the paper disk in the direction of the radii whose density is proportional to rate of vibrations. Each month, the instrument was linked to one particular bull during 8 days on which the bull was on the pasture range. Because of his regular deeding habits a bull was chosen rather than a cow whose habits are subject to change as a result of pregnancy and suckling. In the years 1976-79 control was carried out with the aid of the time-recorder, and included 33 series of successful time-recorder operation.

Densities of lines on the paper disk were graded in three categories:

Grade 1 : much movement - if there is great density of vertical lines, and line-covered surface is larger than surface not covered by lines.

Grade 2 : little movement - if vertical lines are few and surface covered by them is smaller than surface not covered by lines.

Grade 3 : rest - if line is circular with no vertical lines being traced.

The fixing of borders between the 3 density grades is subjective to a certain extent, but the error margin is not great, and since the borders were fixed solely by the author - there is uniformity.

With the aid of a digitizer we transferred the data from the disks to coordinates within a vertical axes system graded them into categories of activity, and, with the aid of a computer, calculated the periods of time

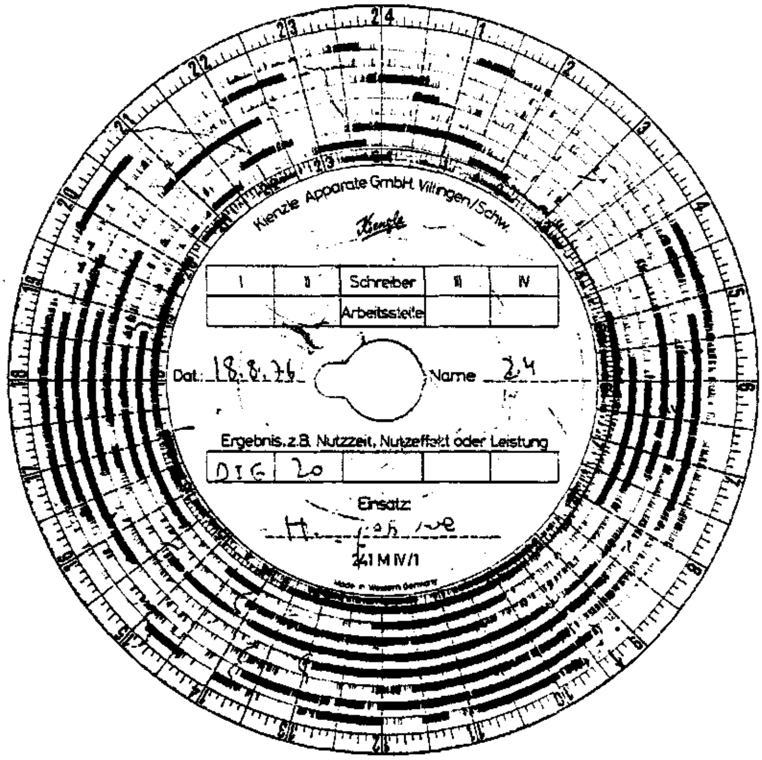


Photo 10.1: A paper disk of Kinzle T.W.F. 24/8 time recorder, used for a mechanical survey of cattle's behaviour pattern.

devoted to each category of activity. For this purpose, the day was divided into eight 3-hour periods, and the time devoted to each category of activity was calculated for each period - and this for each of the 8 monthly observation days.

10.2.2.2 Feeding habits of cattle on pasture range: During the years 1974-1979 (as also in January 1980), observation of feeding habits was carried out monthly in the following way. During the course of one day in the month we recorded the plant species consumed by a certain bull on the pasture range. Records were taken during a number of grazing hours. The length of the observation period depended on the feeding habits which showed considerable change during seasons, and was limited to day-light hours only. Observation was carried out from horseback at very close range (1-3 m) from the grazing bull, and the number of bites and the species consumed were tape-recorded. A separate record was made of species consumed, or of activity, during each full minute, as well as a continuous record for the periods "between minutes".

Distinction between species was generally clear, except in the case of *Gramineae* which are difficult to distinguish one from another during June-November and almost impossible to distinguish at the onset of the green season (November-January).

At the end of each observation day, we took 4 sample bites. The size of sample was determined by imitating a cattle bite on the basis of experience gained during that observation day. The samples were dried in an oven at 70 ^{o}C, and subsequently weighed. In case of *Quercus ithaburensis* leaves and acorns having been consumed, samples were also taken of these and treated similarly. This observation was carried out in the week the time-recorder was linked to the bull, and we were thus enabled to calibrate the results of the instrument with observations made in the field.

Simultaneously, a record was made of the vegetation composition in the region, on the basis of a representative quadrangle of 5x5 m for herbaceous vegetation, and of 100x100 m for arboreous vegetation. Composition was expressed in percentages of absolute coverage of the various species, and from these we later calculated the relative coverage percentages. A record was made of height of herbaceous vegetation.

Height was assessed on the basis of two parameters: estimated maximum height assessed by taking the mean of the ten tallest plants within the quadrangle, and mean height assessed on the basis of estimated average heights of all the plants in the quadrangle.

For the purpose of calculation of quantity and botanic composition of forage, we only took into account active grazing hours. For active grazing time, more or less continuous periods of grazing were taken into account, discounting time periods of 10 minutes and more during which continuous activities other than feeding took place.

In estimating botanic composition of forage on the basis of time, we calculated for each species (or group of species) the relative period of time devoted to its consumption, and for each activity the relative period of time devoted to it. Thus, the total proportional period of time for the different species gives us the proportion of the time period devoted to feeding. Total time devoted to all the activities, including feeding, gives us the full observation time.

For the purpose of assessing the botanic composition of the food on the basis of number of bites, we calculated the relative part of bites of each species (or group of species) out of the total number of bites on that observation day. Calculation was made on the basis of one observation day (one day per month), and we also made a general assessment of the total percentage of bites for each species out of the total of bites recorded during all the observation years.

A description of the species preferred by cattle in forage is given by two graphic methods:

1. The consumption by cattle of botanic species is calculated as percentage of bites of species in their diet as a function of the relative cover of the species in the area. All dots above the diagonal between the axes of the square represent preference, while all dots below it represent avoidance.
2. The electivity index for fish food, as defined by Ivlev (1961) is as follows:

$$E = \frac{ri - pi}{ri + pi}$$

which, adapted to pasture forage composition, would read:

ri = the relative proportion of ingredient i in the diet;

pi = the relative cover of the same ingredient in the food complex.

Elective index values vary from -1 to +1. Where the E values are positive the species is consumed in greater proportions than are to be found in the area - i.e. it is a preferred species. Value E=1 represents maximal selection. Where E=0, species consumption is in proportion to what exists in the area, and where the E values are negative, the species is consumed by cattle in lesser quantities than are to be found in the area. Where E=-1, the species is being avoided altogether. The remainder of the negative E values indicate that although the species are eaten by cattle they are being consumed in lesser quantities than are to be found in the field. These aspects we shall call "species avoidance", and their rate will decrease in keeping with value's approach to zero.

Apart from the regular observations, we also recorded and summarized chance observations of cattle behaviour and feeding.

10.3 Results

10.3.1 *Pasture Management*

Table 10.1 represents a typical model of annual grazing planning in the Yahudia Reserve. Planned grazing pressure in all the paddocks was 130 grazing days per hectar per year. This figure is based on experience in similar areas and on estimation of carrying capacity of this area, effected with the help of Dr. M. Gutman to whom I wish to express my thanks here. In view of this area being a nature reserve, the estimated carrying capacity was multiplied by 2/3, to be on the safe side. The herd was divided into a number of groups, with several paddocks being allotted to each group for rotational grazing throughout the year.

The table records grazing days that were actually utilized in each paddock and their relative part in the desired grazing pressure planned for 130 grazing days per hectar per annum.

Maps 10.2 show pasture utilization inside and outside the reserve during 1972-80, and Map 10.1 is a summary of pasture utilization in that period.

Table 10.1: Annual grazing planning in the Yahudia Reserve (December 1978-November 1979), and utilization of actual grazing days and their relative part in the desired grazing pressure of 130 grazing days per hectar per annum (numbers of paddocks are those appearing in Map 10.1).

Herd composition	Number of cattle heads	Paddock No.	Grazing days per ha per year	Utilization %	Remarks
Mothers	150	1	69	53	
		2	69	53	
		3	72	55	
		8	31	24	
		9	4	3	
Mothers	150	4	65	50	
		5	65	50	
Mothers	150	10	94	72	
		11	62	48	
		12	148	114	
Mothers	150	6	33	25	
		7	33	25	
Bulls	40	15	126	97	15.3 - 15.11
Calves	200	19	105	81)	from weaning
		13	112	86)	(May) to
		14	59	45	weaning
Heifers	200	21	142	109	
		22	142	109	
		23	75	58	
		17	153	118	
		18	118	91	
Treatments and spare areas		24	70	54	
		25	29	22	
		20	20	15	
		27	153	118	
		16	0	0	
		28	153	118	
Horses		26	146	112	

10.3.2 *Behaviour and feeding pattern of cattle on pasture*

10.3.2.1 Mechanical measuring of cattle behaviour on pasture: The statistics, named for the purpose of this analysis "RAD" and "SLOPE" (see Appendix 10.1.I), show that the 8 monthly days do in fact represent replicates which are representative of that month. "RAD" measures the deviations from the mean during time intervals - deviations which were found to be slight -, while "SLOPE" measures the direction taken by the change during transition from one interval to the next, and this, too, was found to be slight.

From the "RUN TEST" we made it was found that there was no dependence between one observation day and another in the same month; that is, the days in that month were autonomous replicates representative of that month, and in accordance with this we examined the daily observations. We chose to present the median value of activities during each time interval of the 8 observations days, this being placed between the second biggest and seventh biggest values, rather than presenting the minimum and maximum values (first and eighth day), in order to avoid the effects of days of extreme activity.

Apart from the impression gained from the graphs, some of which appear in Appendix 1.I, we also made a separate analysis of variance for each season. We found that there was no significant effect of any one month of activity within the season, which means that the months represent replicates that are representative of the season. On the other hand, we found that there were significant differences between time intervals and years as well as interaction of month and interval (with the exception of spring and autumn), month and year, and interval and year. Information interpreted by analysis of variance was meagre (20-32%) in most seasons, and middling (some 55%) in winter. There was no great difference between years. In view of the significance of the interaction components and the existence of mutual effects of the divergencies, it has been difficult to distinguish between the effects of single variables, and hence all the effects of time intervals on activities, and of seasons on activities, represent tendencies only.

The mean of activities in all the seasons of the year was around 1.5 hrs per interval of 3 hours, so that activity totals are similar in all the seasons. Thus, the differences between seasons can be attributed chiefly not to the duration of activities but to the pattern of their distribution over the 24-hour day.

In general, it can be said that the sum of day activities exceeded that of night activities, and seasonal changes were as follows.

Winter (Nov.-Jan.): 2-3 daily activity cycles are apparent: at dusk, in the late morning, and at dawn. Where there were 3 cycles, peak activity took place between 06.00 and 09.00 hrs, with activity going on during most of this 3-hour time interval. When there were two activity peaks the principal one occurred during 15.00 and 18.00 hrs, with generally over 2.5 hours out of 3 being utilized for activity.

The secondary activity peak took place before dawn between 03.00 and 06.00 hrs (sometimes between 00.00 and 03.00 hrs), with about 2 out of 3 hours of this time interval being utilized for activity.

During the remaining hours, certain activity took place in most time intervals and almost no absolute rest was recorded.

Spring (Feb.-Apr.): This season is conspicuous for the absence of uniformity in the various months. Principal peak of activity usually occurs between 15.00 and 18.00 hrs, and the number of secondary peaks varies between 0 and 3 peaks recorded at different hours of night and dawn. Although no characteristic tendency is apparent, it can be said that what is characteristic is the time at which principal paek activity takes place; that the level of activity is generally more than 1 out of 3 hours (usually between 1 and 2 hours), and that almost no rest whatsoever is recorded.

Summer (May-Aug.): Two main forms of activity were observed during the summer months:

a) a single daily peak, occurring between 12.00 and 18.00 hrs, with level of activity being over 2.5 out of every 3 hours.
b) 2 daily peaks is the more characteristic summer activity pattern, when the principal peak occurs generally between 15.00 and 18.00 hrs, with activity level being more than 2 out of 3 hours, and a secondary peak mostly between 03.00 and 06.00 hrs, with an activity level of 1 out of 3 hours.

There are almost no periods of rest in summer, though between peaks, the level of activity is almost always less than 1 out of 3 hours.

Autumn (Sep.-Oct.): Scarcity of full data for the autumn months renders observation of general tendency difficult, but it appears that a single peak of activity occurs between 15.00 and 18.00 hrs, with a high activity level (3 out of 3 hours), and a low activity level during 00.00 and 03.00 hrs, with activity occurring during about 1 out of 3 hours.

Calibration of observations made with the aid of a tape recorder with data obtained from the time-recorder, has shown that what has been recorded as "high activity" by the time recorder identified with over 90% of grazing time. In winter and spring, more than 98% of the time was devoted to feeding, with almost no "walking for walking's sake", whereas in summer and autumn these values varied between 90 and 95%. In view of this accord, we have considered "full activity" to be grazing, because in our estimation there was ±10% accuracy in the interpretation of the time recorder data, too.

10.3.2.2 Cattle feeding habits and forage composition on pasture

1. Bite and food gathering rate: Number of bites of cattle on pasture per hour as counted during active grazing hours, are shown in Figure 10.1. Here, the high rate of winter feeding is conspicuous, especially in December-January. A relatively low rate of feeding is discernible in late spring (April-May). The feeding rate tends to rise in June-July. In late summer and autumn there is lack of correlation between minimum, maximum and median values, indicating an inconsistent tendency in this period.
   Figure 10.2 records weight changes in bites of cattle on pasture. Relatively small bite-weight (less than 1 gr dry matter per bite) was recorded in the winter months, with a steep rise in spring, reaching its peak in April, with about 3 gr dry matter per bite. Bite-weight diminishes with the onset of summer, attaining an additional peak in autumn (Sept.). Multiplication of the values of number of bites by mean bite-weight gives the weight of forage per active grazing hour, hereinafter called "Food Consumption Rate", the change pattern of which during the months of the year is recorded in Figure 10.3. Two peak forage collection rates are discernible. The first one in spring (March-April), and the second, less characteristic one, in summer (August). In winter, hourly values tend to be low, but there is a conspicuous absence of a clear tendency in this period due to the high maximum values.
   Figure 10.4 shows height of vegetation in the paddocks in which control of grazing rate and forage composition was carried out.
   The relatively low growth of herbaceous vegetation in winter reaches its peak height in April. Beginning in May and continuing until the autumn, herbaceous vegetation height shows a decline which can be attributed to grazing. In order to keep the figure legible, we abstained from giving maximum and minimum values for each curve, but there was considerable

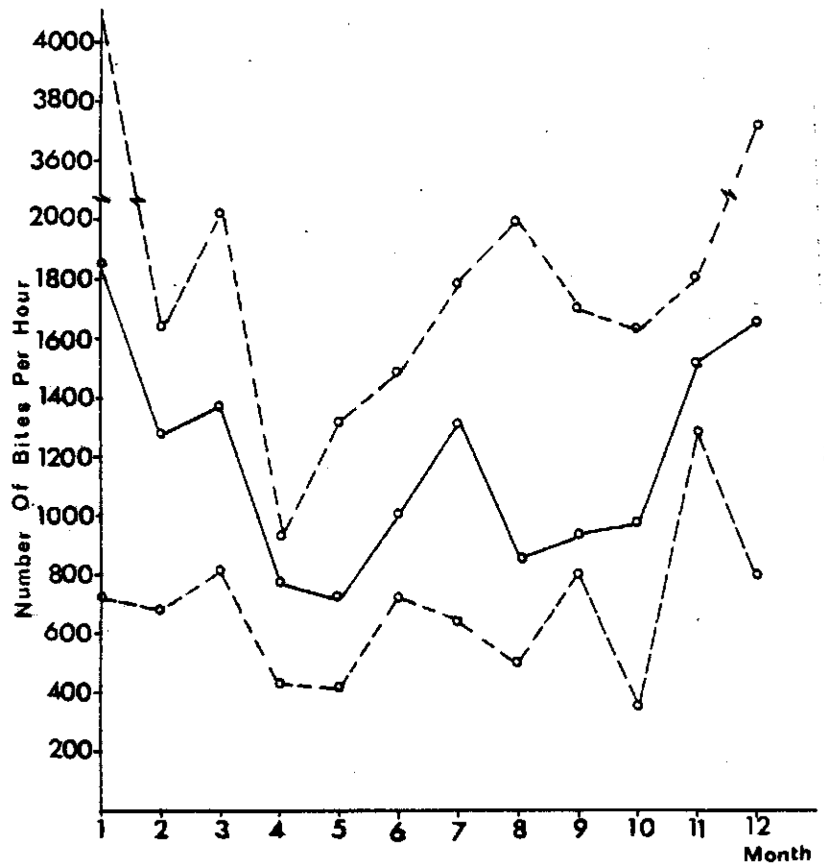


Figure 10.1: Median values of number of bites per active grazing hour of cattle on pasture during 1975–1980 (broken lines indicate maximum and minimum values).

Fig 10.2

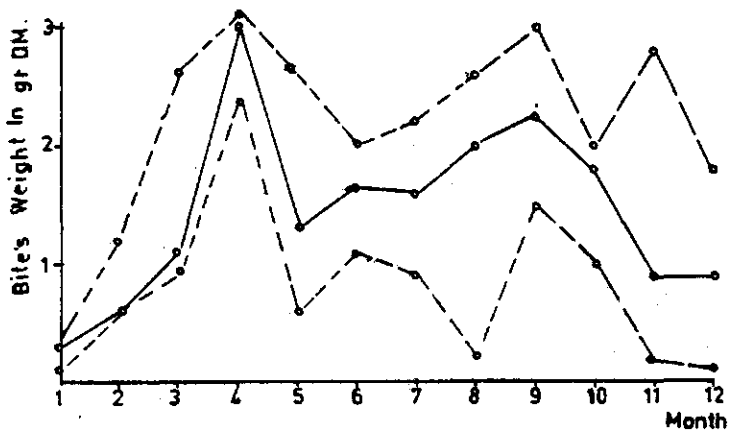


Fig. 10.2: Median values of grassy cattle bite weights during 1976-1980, expressed in grams of dry matter (broken lines indicate maximum and minimum values).

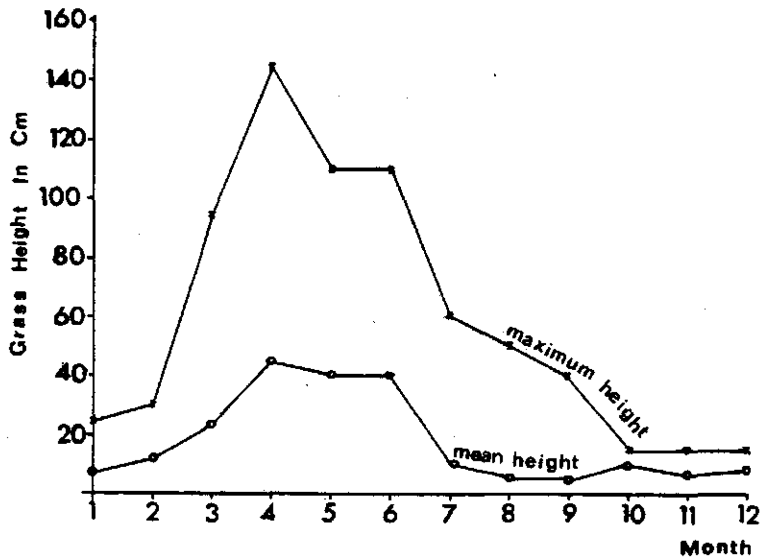


Fig. 10.4: Maximum and mean heights of herbaceous vegetation in paddocks. Median values for 1975-1980.

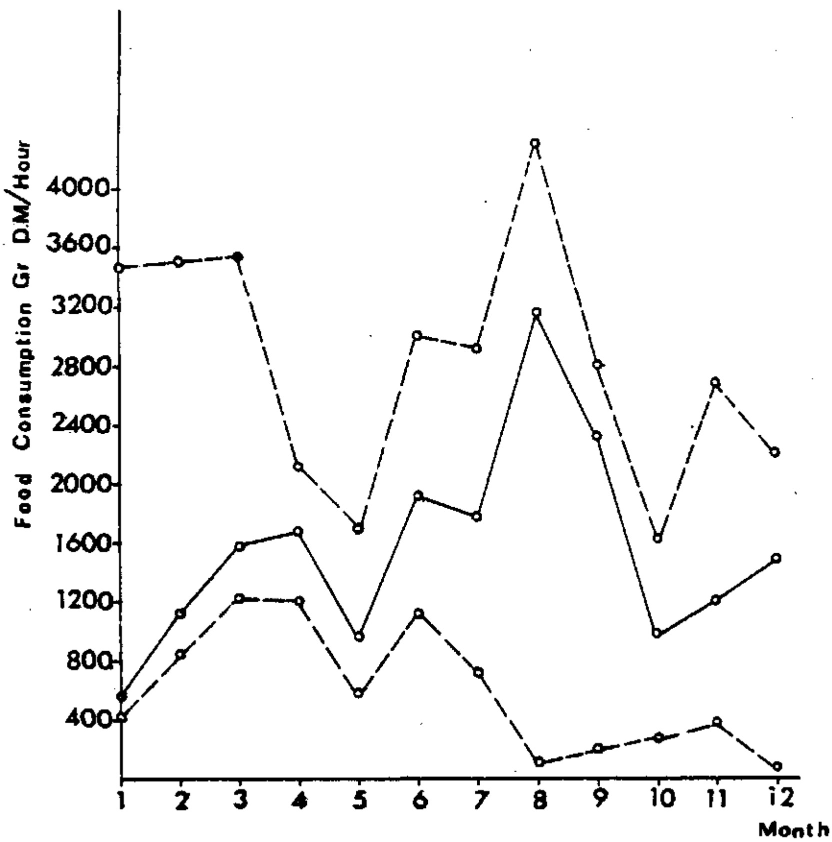


Fig. 10.3: Median values of food collection rate per hour during 1976-1980, expressed in grams of dry matter.
Broken lines represent maximum and minimum values.

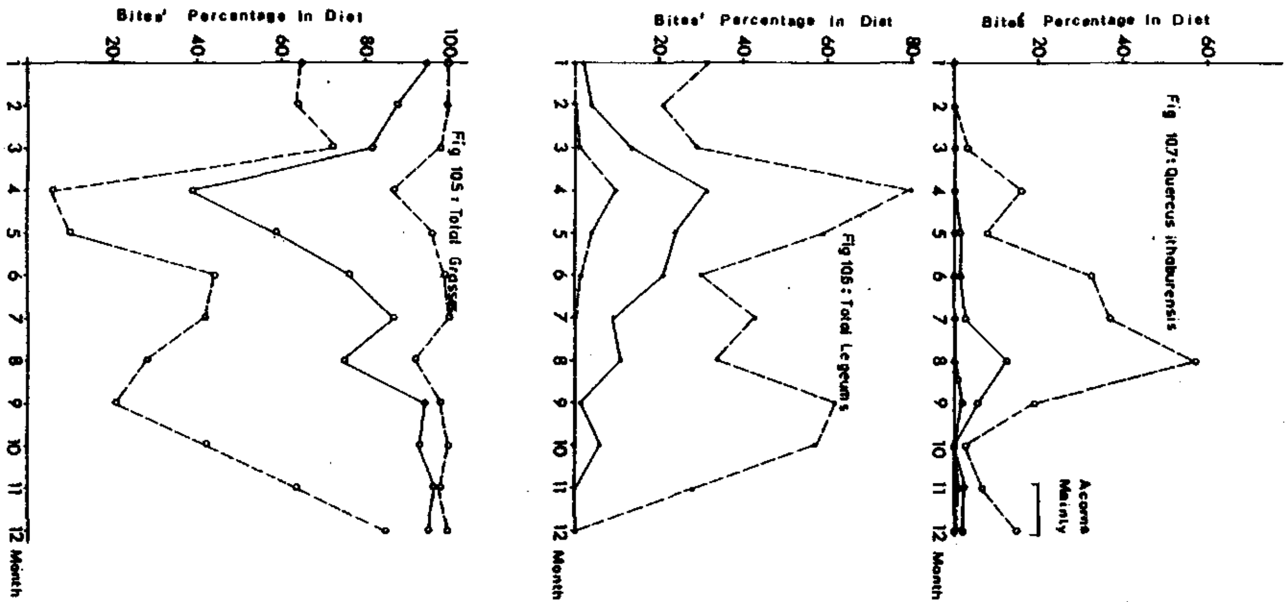
uniformity between years in most months except for the spring months in which the dispersion of dots is greater. As regards relative retardation in the vegetation growth rate, 1975 was conspicuous among the years.

2. Forage supply and composition in cattle's diet: Forage composition expressed in bites: Figures 10.5, 10.6 and 10.7 demonstrate the pattern of change in the consumption of grasses, legumes and *Quercus ithaburensis* leaves and acorns by cattle on pasture. Consumption is expressed in percentage of total number of bites observed. Grasses represent the chief component of forage, constituting over 80% of the diet during most months of the year. The grass component decreases from March onwards, but especially in April and May, and there is a simultaneous increase in the legume component during this period. *Quercus ithaburensis* leaves constitute a significant component in the forage in late summer, whereas during ripening of acorns in winter the latter make up an important part of the forage. From figure 10.7, which is based on number of bites, it is difficult to learn something about the significance of acorns in forage composition. Weight of herbaceous vegetation bites varies between 0.1 and 3.0 gr of dry matter, whereas the bite weight of *Quercus ithaburensis* leaves comes to 1.0 - 3.2 gr of dry matter, and that of acorns to 8.2 - 11.8 gr of dry matter. We therefore decided to demonstrate the changes in weight of *Quercus ithaburensis* components consumed per active grazing hour.

   Figure 10.8 shows changes in weight of *Quercus ithaburensis* components consumed during the months of the year, with separate records for leaves and for acorns. This figure draws a comparison with figure 10.3, which represents hourly weight of all the forage components taken together.

   At this point, we consider it worth bringing a number of additional observations collected by us with regard to consumption of *Quercus ithaburensis* components by cattle; observations that have not found expression in the above figures.

   In January, when most *Quercus ithaburensis* trees are shedding their leaves, we repeatedly observed cattle browsing on twigs. In February and March, during the budbreak period, the trees show many signs of browsing, and there is "pruning" up to a height of about 1.5 which is being kept up in fact during the entire year. Considerable browsing of leaves can be noticed in sparse *Quercus ithaburensis* forest (where no regular observations were carried out), as also in areas where there is little



Figures 10.5, 10.6, 10.7: Median values of bite-percentages of species in diet of cattle on pasture for 1974-1980. (Broken lines represent maximum and minimum values.)

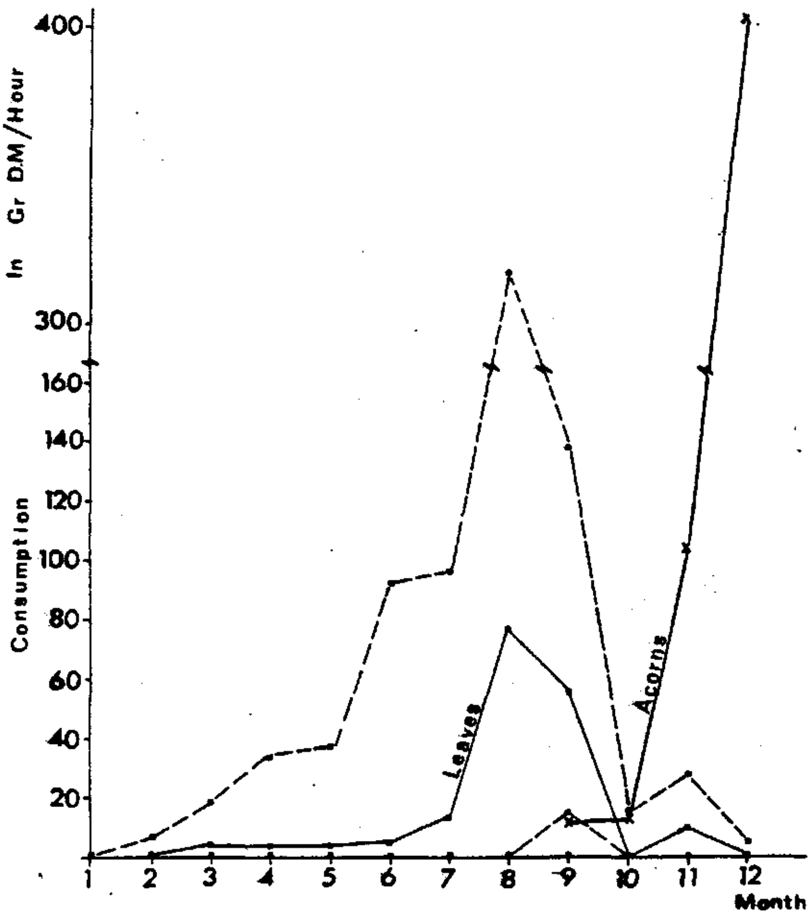


Figure 10.8: Median values of weight of *Quercus ithaburensis* leaves and acorns consumed by cattle on pasture during active grazing hours in 1974-80, expressed in grams of dry matter (broken lines indicate maximum and minimum values).

herbaceous vegetation due to intensive grazing or fires. As against this, there is hardly any consumption of *Quercus ithaburensis* components in wet grasslands with green vegetation where we noticed, however, considerable consumption of swamp plants: *Prosopis farcta* and even *Salix acmophylla* trees were seen to have been browsed up to a height of about 1.5 m and to have developed a single trunk. In summer, we saw in pasture paddocks *Quercus ithaburensis* trees budding up to the browse-line, but at the same time we noticed an absence of budding in paddocks free of grazing.

In the acorn ripening season, the cattle search vigorously for acorns on the trees as well as on the ground, and will even move stones to find them. Much time is devoted to looking for acorns and to scrabbling among the fallen leaves to find them, particularly at the end of the acorn season when they are getting scarcer. Acorn consumption is conspicuous in easily accessible places, while consumption is smaller in places that are less easy of access, such as cairns. In the majority of cases, the glands are eaten without the cupules, and we even observed cattle separating the glands from the cupules by rolling the acorns on the ground with their tongue and lips; however, in the absence of glands cattle will also eat the cupules. In extreme cases, some 30% of the time was devoted to foraging and looking for acorns, and up to 600 gr of dry acorn matter were consumed per hour. The stomach contents of a cow slaughtered in November showed a very high percentage of glands with shells, but without cupules.

The proportion of each species in the cattle's diet (as estimated on the basis of its proportion in the number of bites), is shown in Table 10.2. The first column gives the percentage of bites devoted to each species in each month of the year as the mean of that month of the years 1974-1980. Column No. 2 of Table 10.2 gives the percentage of the species in the general forage composition, calculated as percentage of the bites eaten of that species out of the total bites observed during the whole period. During the single months as well as during the whole period, we summarized the percentage of bites according to principal groups: Grasses, Legumes, Other Forbs, and *Quercus ithaburensis*.

So far, we have expressed the composition of cattle diet in bite percentages. As said before (10.2.2.2), diet composition was measured by us also

Table 10.2: Composition of species in cattle's diet calculated on number of bites basis, for the period April 1974 - January 1980

Group	Species	1	2	3	4	5	6	7	8	9	10	11	12	2. % in diet	3. number of months a species was abundant in cattle's diet in the following month during the period Apr.1974 - Jan. 1980* (1–12)	4. total abundance (months/species)	5. mean selectivity index
		1. mean percentage of species in cattle's diet in the following months															
Grasses																	
	Avena sterilis	0.2		30.3	18.9	42.3	62.4	63.1	39.4	36.7	23.6			22.400		37	+ .06
	Hordeum bulbosum	2.5	1.9	6.9	12.8	6.2	2.2	3.0	2.2	7.4	0.7	1.7	0.1	3.687		32	- .39
	Lolium rigidum		0.0	0.1	1.7	2.0	0.1	0.0	0.1	3.5				.243		15	- .17
	Cynodon dactylon						7.7	1.2	2.3	5.5	3.0			1.299		7	+ .38
	Alopecurus utriculatus			0.5		0.1								.036		4	- .26
	Bromus sp.			0.0	0.1	0.0					0.0			.013		4	- .70
	Phalaris brachystachys				0.1	0.0								.010		2	- .61
	Poa bulbosa	0.1											0.3	.038		2	- .81
	Triticum dicoccoides				0.1									.006		1	- .61
	Piptatherum miliacea							0.1						.002		1	- .30
	Dactylis glomerata								0.3					.012		1	+ .09
	Hordeum spontaneum			0.3										.045		1	+ .24
	dry pasture grasses	0.7	0.3	0.0			0.1	11.0	23.9	23.9	53.7	60.4	25.3	13.947		26	- .08
	Unidentified grasses	88.0	80.6	57.1							1.2	35.5	69.4	42.062		10	+ .14
Legumes																	
	Trifolium purpureum			0.4	15.0	7.8	5.8	2.2	1.2	1.4	0.4			1.358		27	- .12
	T. pilulare		4.1	3.6	4.6	3.0	0.2		0.4	0.4				1.037		17	- .30
	Medicago rotata		3.5	5.2	6.5	0.6								1.306		11	- .07
	Hymenocarpos circinnatus	1.5	0.6	0.2	0.8	1.2	0.2							.475		10	- .30
	Trifolium sp.	3.5	0.4	1.5		0.0								.931		8	- .08
	T. argutum				17.9	0.0	0.1							.775		5	+ .24
	Lathyrus ochrus			0.0			0.1		0.2					.011		5	- .30
	Prosopis farcta							0.2	1.3	0.3				.321		3	+ .09
	Medicago sp.			0.4										.029		2	- .57
	Psoralea bituminosa					0.6								.418		2	+ .19
	Astragalus hamosus		0.1											.001		1	- .68
	Lathyrus blepharicarpus		0.1											.004		1	- .54
	Pisum fulvum											0.0		.001		1	
	Scorpiurus muricatus			0.0										.002		1	
	Unidentified legumes	0.8				10.8	13.0	10.6	8.8	13.9	16.8		0.1	5.368		24	- .46
Quercus ithaburensis																	
	leaves	0.2	0.1	0.5	2.6	2.0	7.2	8.0	16.1	6.3	0.2	0.8	0.2	1.253		31	
	glands								0.0	0.1	0.1	1.2	2.7	.262		12	
	cupules									0.1	0.0	0.1	0.4	.030		7	
Other forbs																	
	Cichorium pumilum		0.2	0.6	4.8	0.6	0.4	0.1	0.1	0.2	0.0		0.2	.381		18	- .14
	Scabiosa prolifera	0.0	0.1	0.2	0.4	0.5	0.0							.073		15	- .67
	Daucus bicolor			0.0	4.0	2.6	0.0							.143		10	- .22
	Anthemis bornmuelleri			0.9	0.5	1.0		0.0	0.0	0.1				.237		10	- .47
	Dianthus polycladus	0.0				1.0	0.1		0.0					.034		7	- .41
	Crepis sp.		0.4	0.0	0.1		0.1	0.1						.022		7	- .50
	Carlina hispanica	0.2	0.1							0.0		0.0		.096		6	- .83
	Synelcosciadium carmeli		0.1	0.0	5.1	4.7								.397		5	+ .22
	Isatis lusitanica			0.0	0.4	0.2								.007		5	-.84
	Silybum marianum	0.0		0.4							0.1			.032		5	-.41
	Senecio vernalis		0.1	0.1										.013		5	-.68
	Aredia squamata				0.6	0.8								.036		4	-.15
	Tragopogon coelesyriacus			0.0	0.2	0.0								.006		4	-.67
	Scolymus maculatus		0.1	0.0	0.7	0.4								.110		4	-.57
	Ochthodium aegyptiacum		0.0	0.0		0.1				0.1				.012		4	-.84
	Malva nicaeensis	0.3		0.0	0.0									.019		4	-.80
	Bellevalia flexuosa			0.1					0.0					.007		3	-.78
	Eryngium creticum	0.0	0.0			0.0								.010		3	-.80
	Thrincia tuberosa	0.0	1.3	0.0										.069		3	-.27
	Lagoecia cuminoides					0.1			0.0	0.0				.006		3	-.76
	Gundelia tournefortii	0.0	0.1							0.4				.041		3	-.70
	Tolpis virgata		0.2								0.1			.028		3	-.46
	Pallenis spinosa		0.0								0.1	0.0		.007		3	-.73
	Pistacia atlantica					0.2	0.1							.005		2	-.44
	Galium judaicum					0.4							0.3	.047		2	+.21
	Erodium gruinum			0.0	0.0									.005		2	-.84
	Ranunculus marginatus		0.0		0.1									.012		2	-.59
	Mentha longifolia								2.2		0.1			.215		2	-.40
	Echium judaeum	0.0				0.0								.006		2	-.78
	Ricotia lunaria							0.1						.006		1	
	Salvia hierosolymitana							0.0						.002		1	
	Daucus carota				2.9									.092		1	+.86
	Rapistrum rugosum									0.1				.002		1	-.43
	Cyclamen persicum		0.0											.001		1	-.85
	Notobasis syriaca				0.2									.009		1	-.12
	Scirpus holoschoenus								0.3					.034		1	+.21
	Torilis sp.									0.0				.001		1	-.93
	Euphorbia oxyodonta				0.0									.001		1	-.85
	Apium nodiflorum								0.8					.077		1	+.64
	Cuscuta sp.					0.2								.001		1	-.23
	Hirschfeldia incana								0.3					.024		1	+1.8
	Picris galilaea					0.0								.004		1	-.69
	Calendula arvensis			0.0										.002		1	-.67
	Carthamus glaucus				0.0									.001		1	-.82
	Echinops viscosus	0.0												.002		1	-.87
	Scabiosa palaestina					0.2								.001		1	-.23
	Plantago afra		0.0											.001		1	-.82
	Raphanus rostratus			0.0										.004		1	-.69
	Urospermum picroides				0.1									.002		1	-.45
	Scandix iberica		0.1											.010		1	-.33
	Ainsworthia trachycarpa			0.0										.001		1	-.83
	Linum pubescens			0.1										.007		1	-.56
	Polygonum equisetiforme									0.2				.010		1	-.39
	Centaurea iberica									0.0				.001		1	-.93
	Lavatera punctata					0.0								.001		1	-.83
	Verbascum orientale	0.1												.013		1	-.56
	Unidentified other forbs	1.5	5.1	0.4									0.1	1.043			
mean number of species per month																	
	grasses	91.5	83.8	65.2	33.7	50.8	73.5	78.4	68.2	76.8	82.2	97.6	95.1		1.8 2.0 2.6 3.0 3.4 2.8 2.0 2.0 2.5 3.0 2.2 2.4		+.08
	legumes	5.8	6.8	11.3	44.6	32.2	18.4	13.2	11.8	14.0	17.2	0.0	0.1		0.7 2.8 4.2 3.0 4.2 2.6 1.6 1.8 1.3 1.0 0.2 0.2		-.28
	Quercus ithaburensis	0.2	0.1	0.5	2.6	2.0	7.2	8.0	16.1	6.5	0.3	1.8	4.3		0.2 0.5 0.6 0.4 0.6 0.4 0.3 1.0 1.5 0.8 2.2 1.0		-.68
	other forbs	2.5	8.1	2.8	20.1	13.2	0.7	0.3	3.7	1.1	0.4	0.0	0.6		3.0 5.5 7.4 6.6 6.2 1.6 1.0 1.5 2.0 1.0 0.4 0.4		-.55
	all species														5.7 10.4 15.0 13.0 14.4 7.4 6.2 7.1 6.1 6.0 5.0 4.0		

* ▬ 1,2,3,4,5 months respectively

according to the percentage of time devoted to the consumption of each species. After summarizing these data, we found that discernment is less accurate in this method, and many species consumed "between minutes" do not figure.

Although the relative proportion importance of these species in the diet is minimal, their appearence, or non-appearance, contributes to the picture of the range of diet in the various seasons. As against this, so far as the main components of diet were concerned, we found no significant difference in the relative diet composition which is expressed in bite-percentage or time-percentage, and we therefore decided to omit from this paper the data of diet composition on the basis of time percentage. At the same time, we should point out that for the purpose of field-recording, this method is easier and costs less effort, and it also reflects the time devoted to other activities, because each activity, including foraging taking place during a full minute, is recorded. Hence, we do not reject the time-percentage measuring method but prefer, in this case, to demonstrate diet composition in terms of bite percentages.

Diet composition expressed in terms of frequency of species consumption

Columns 3 and 4 in Table 10.2 show the frequency of consumption of species in the various months and in all the years together. Species consumption frequency represent the number of times a species appears in the cattle's diet during a certain calendar month over the years 1974-80, without having regard to quantity consumed of that species, but referring only to the fact of its appearance, or non-appearance, in the diet. This presentation also for species forming a minimal diet component, but the fact of whose consumption at the period at which they get eaten is in itself of interest.

In summarizing the columns, it can be learned that the largest species variety in the diet appears in spring, mainly in the month of March, when a mean of 15 different species are consumed during each observation. Species variety in the diet declines in summer and autumn to about 6-8 species, and in winter to about 4-6 species on the average per observation. The species variety has been summarized separately also with regard to main plant groups. As far as the range of grasses is concerned, not many changes can be discerned over the seasons of the year, and the number of species usually averages around 3 grass species per observation. The low figures in winter are due mainly to difficulty in distinguishing between grass species in this season, as already pointed out above (10.2.2.2).

In the legume range we have relatively high values, averaging 3-4 species per observation in spring, with a considerable decrease in winter (0.2-0.7 species on the average per observation).

The main contributors to the range of species in spring are the other forbs, many species of which are consumed between the beginning and end of spring (February-May).

In Table 10.2 *Quercus ithaburensis* appears as a group made up of three components: leaves, acorn glands and cupules; and the total figures of comsumption frequency express in fact the mean of components consumed during each observation. Hence, these figures are lower than 1.0 during the greater part of the year, but show an increase in the acorn ripening season.

Selection as a function of forage supply in the field

Figures 10.9 - 10.14 show the percentage of consumption by cattle on pasture of several species and groups of species, as a function of the relative cover of these species in the field. The diagonal line represents equality where there is no food preference and cattle eat in accordance with the forage supply extant in the field. Dots above this line indicate selection - i.e. relative consumption is higher than relative supply -, and dots below the line indicate rejection - that is, consumption is lower than existing supply.

There is a conspicuous preference for the whole range of grasses (Figure 10.9). Grass consumption tends to rise more steeply than does grass supply, especially where high cover percentages are concerned. Consumption and preference of dry grasses, too, (Figure 10.12[1]) increases with rise in cover, so that under low cover conditions there is rejection (up to 10%), under medium cover conditions (10-15%) there is no selection, whereas under high-cover conditions (50-80%) there is a clear preference for dry vegetation, consumption of which varies between 82% and 97% of total forage consumed.

As opposed to grasses, legumes are not preferred by cattle (Figure 10.10), and conspicuous rejection is apparent in the low cover percentages. Consumption tends to rise with increase in cover.

Compared with their cover in the area (Figure 10.11) other forbs are not generally selected by the cattle, excepting a few cases of selection in conditions of relative cover of 10-20%. Consumption does not appear to be

Fig 10.9: Total grasses

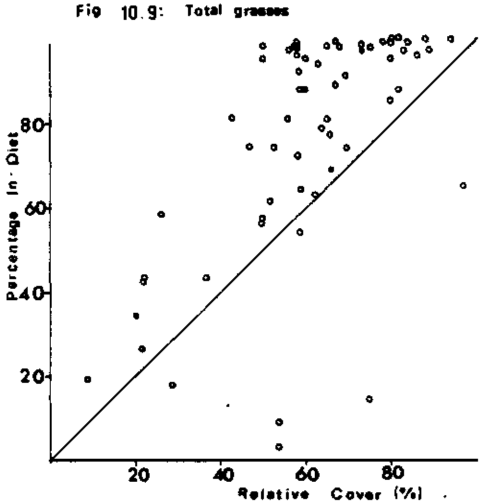


Fig 10.10: Total legeums

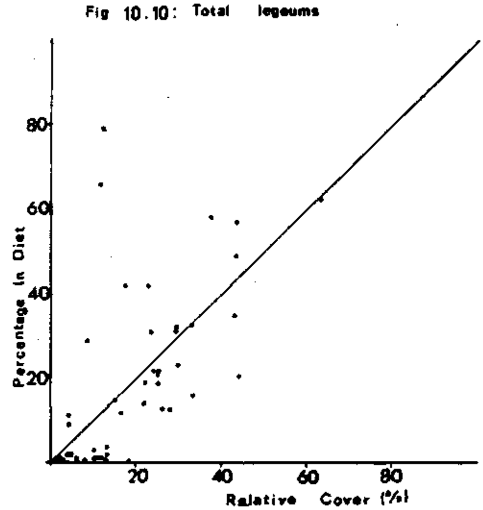


Fig 10.11: Other forbs

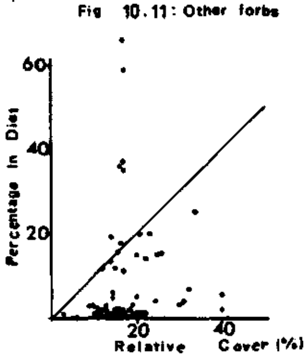
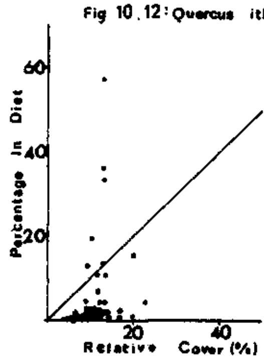


Fig 10.12: Quercus ithaburensis



Figures 10.9 - 10.14: Percentage of species in cattle forage composition as a function of relative species cover in field. (Diagonal line represents equality line of the two parameters; full dot equals 5 dots.)

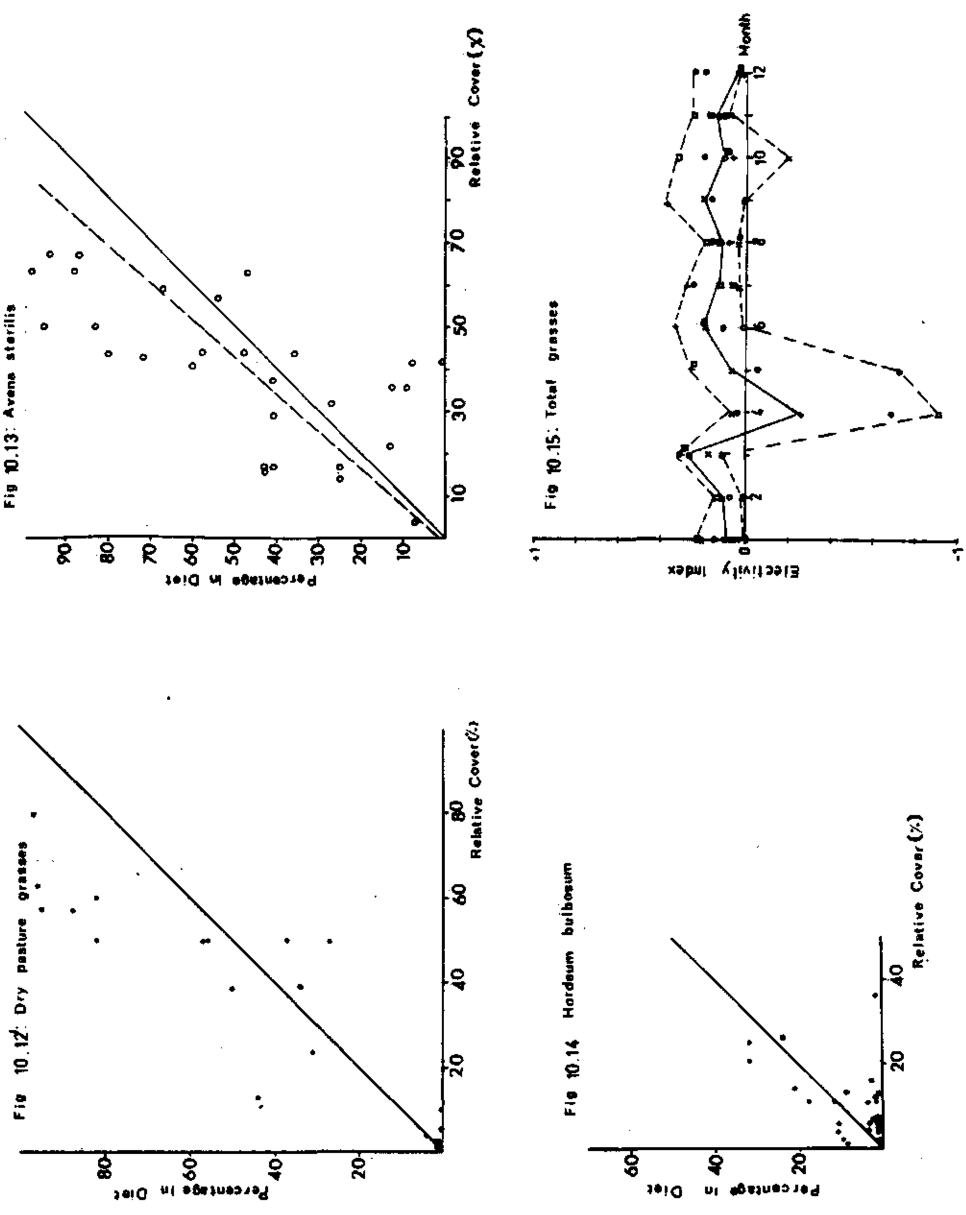


Fig. 10.15: Median values of electivity index for cattle on pasture during 1974-1980, covering several species and species groups. Broken lines represent maximum and minimum values.

contingent on the cover of species in the field.
The consumption cover of other forbs is similar to that of *Quercus ithaburensis* consumption (Figure 10.12) which is limited to a more or less constant cover of these trees in control paddocks, and to changes in consumption. Figure 10.13 shows that consumption of *Avena sterilis* rises steeply with increased cover of this species in the field, so that under low cover conditions there is only slight preference, and under high cover conditions preference is considerable. Cattle do not show preference for *Hordeum bulbosum* in the relatively low cover percentages (up to 15%), evincing slight preference in the higher cover percentages (Figure 10.14); all the same a rise in consumption is apparent where there is an increase in relative cover.

With regard to other species and species groups consumed by the cattle, we have considered unnecessary bringing a graphic description of their consumption as compared with their cover in the field, either because of sparsity of dots in the graphs or because of very low cover and consumption (less than 5%) in which the relative percentage of measurement error is high. Of these species and groups we shall mention only a few: unidentified grasses showed a distribution similar to that of *Avena sterilis*, and they in fact turned out to be *Avena sterilis* which had not been identified as such with certainty in the winter period. *Lolium rigidum*, whose cover in the field is low, shows also low consumption by cattle, with a tendency towards selection independent of cover percentage. *Trifolium purpureum*, normally having a lower cover than 10%, shows normally also low consumption. In a number of cases, consumption relative to cover was high (15-28%) without there appearing to be a clear dependence on cover percentage.

In other observations we saw that in spring leaves and stalks of *Avena sterilis* and *Lolium rigidum* get eaten, whereas of *Hordeum bulbosum* mainly the leaves are taken. At the beginning of the wilting period we noticed active rejection of *Hordeum bulbosum* stalks that got into cattle's mouths accidentally, whereas at the end of the wilting season, when most of the ears of that plant have been shed, cattle will also eat the stalks of the ears, especially since by that time the greater part of *Avena sterilis* has already been consumed. We also noticed that part of the grasses consumed during the wilting period are seeds picked up near ant-hills collected by the ants.

Electivity index as expression of food selectivity

Changes in the electivity index of species groups and of several additional species over the seasons are shown in Figures 10.15 - 10.23. Median, maximum and minimum values were calculated for each month in 1974-1980.

As can be seen in Figure 10.15, grasses as a group are generally preferred in all seasons of the year with the exception of April, when that season's negative electivity index indicates rejection of grasses. During the remainder of the year the electivity index is positive and subject to little change, generally in the region of 0-0.2.

As opposed to grasses, legumes are usually rejected during the greater part of the year, with the exception of April, as can be clearly seen in Figure 10.16. Particularly low values of electivity index were found in the winter months.

Other forbs, too, are generally being rejected during all seasons of the year (Figure 10.17), and their electivity index values are very low. A tendency towards lesser rejection and, at times, even preference, is noticeable in the spring months (April-May), and in high summer (August). *Quercus ithaburensis* generally shows a negative electivity index during all seasons of the year (Figure 10.18), and its electivity index values are lower than -0.8. Rejection tends to lessen in summer (July-September), and also in winter when the acorns are ripening.

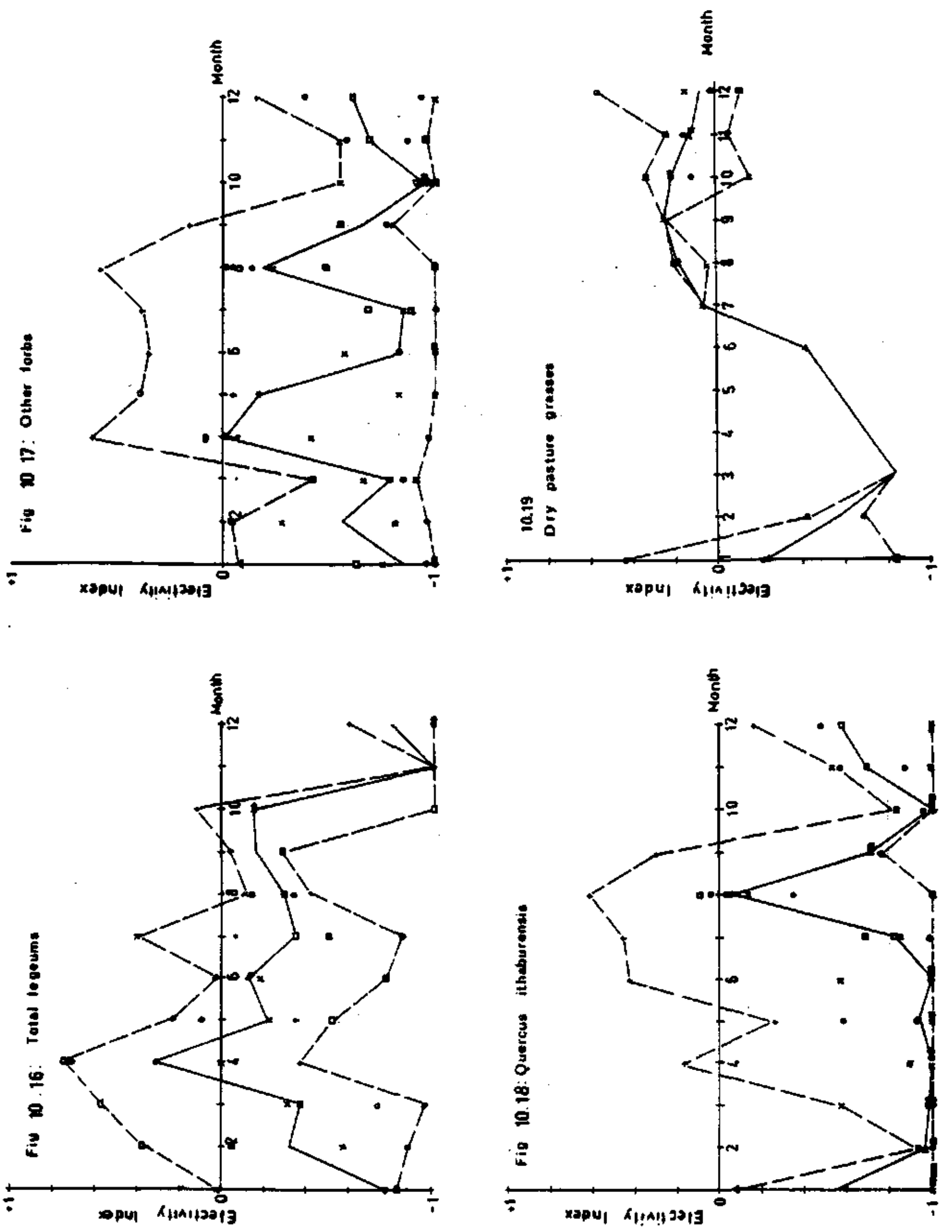
Dry grasses (Figure 10.19) are rejected by cattle in winter and spring, but preferred in summer and at the beginning of winter (July-December), although at values not generally exceeding 0.2.

Figure 10.20 demonstrates the changes in electivity index as regards *Avena sterilis* and unidentified grasses. Since unidentified grasses are usually *Avena sterilis*, and since they appear at a season where there are no data on *Avena sterilis*, we have presented them in the same figure. Electivity is generally positive and does not exceed 0.3, but in spring (April) there is clear rejection of *Avena sterilis*, and in autumn (October) there is rejection of *Avena sterilis* and of unidentified grasses.

Hordeum bulbosum (Figure 10.21) is generally rejected, although it is elected at the beginning of spring and at the beginning of autumn (February, September). The distribution of dots in the figure during these seasons indicates an absence of stability in preference for this species.

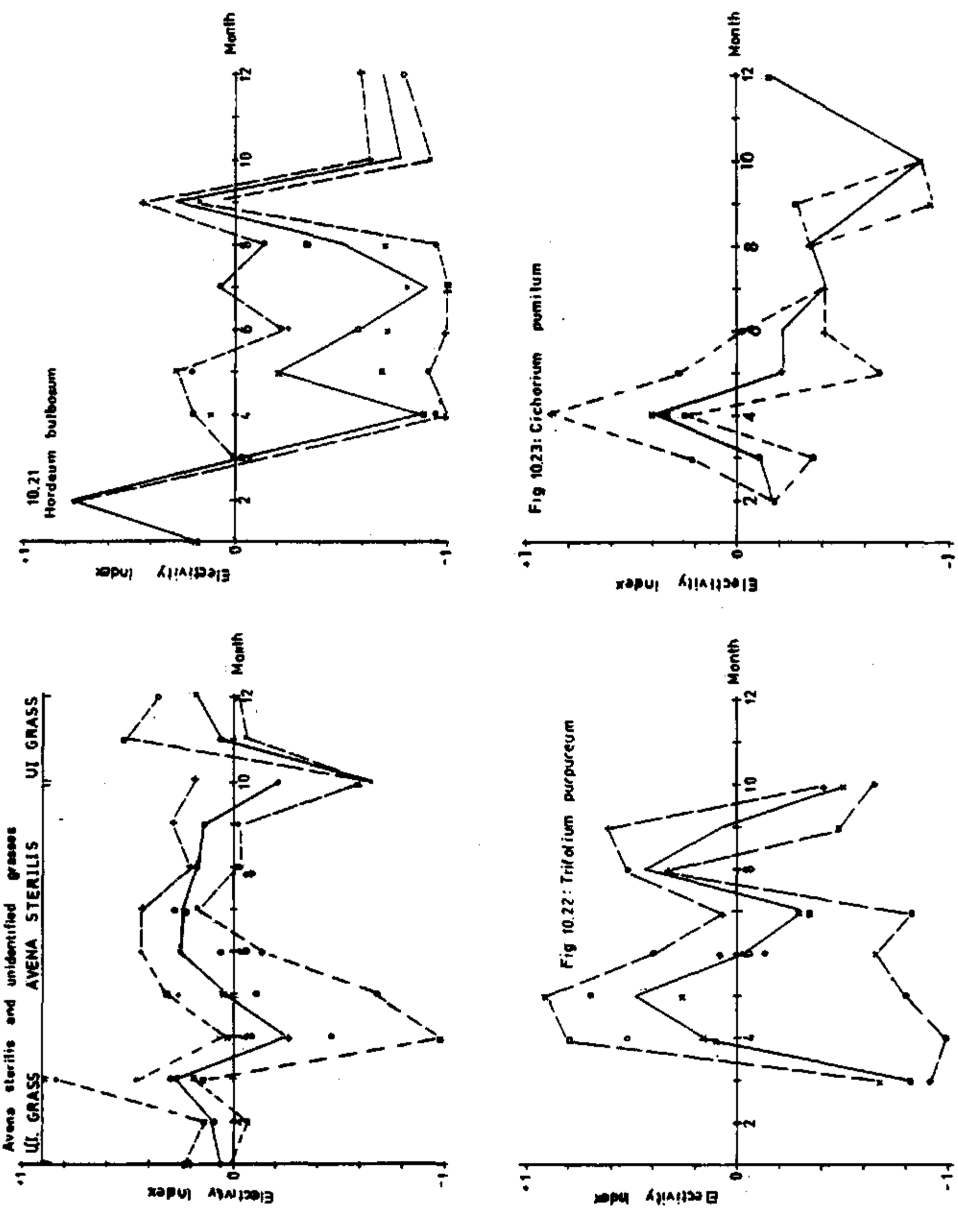
Trifolium purpureum (Figure 10.22) appears in the area only during March-

Figures 10.16 - 10.23: Median values of electivity index for cattle on pasture during 1974-1980, covering several species and species groups.



(Broken lines represent maximum and minimum values.)

Figures 10.16 - 10.23 (continued)



October. In that period, wide-range fluctuations in electivity are discernible, with a high tendency towards electivity in spring (April-May) and in summer (August) and towards rejection during the remainder of the period.

Cichorium pumilum is preferred by cattle in spring (Figure 10.23), and in February-June appears as a species in demand (though also under negative electivity). During the remaining months, electivity is negative and generally low, and observations are far between.

Earlier on we brought a graphic description of changes in the electivety index for main groups and species. Among additional species with low frequency of appearance, we would quote a few:

Lolium rigidum attains positive electivity index values in spring (April-May) and at the end of summer (September), whereas during the remaining seasons it is generally rejected by cattle.

Cynodon dactylon appears in the diet only in the summer and autumn months (June-October) and is generally greatly preferred by cattle (E.I = (-)0.5-0.9), although at times it may also be rejected (E.I = (-) 0.2 - (-) 0.3).

Trifolium pilulare is consumed mainly in spring and at the beginning of summer. The cattle show lack of consistency in electivity, vacillating between considerable preference (E.I = 0.8) and complete rejection (E.I = -1.0) in one and the same season.

Lack of consistency in electivity is also noticeable with regard to *Medicago rotata*, which is consumed in spring (February-May). As against this, *Hymenocarpos circinnatus* is preferred at the beginning of winter, with preference diminishing until it turns into rejection in late spring, and showing a slight tendency towards rise and positive electivity index values at the beginning of summer. *Trifolium argutum* is preferred in April (E.I = 0.6-0.9), and rejected in May and June (E.I = (-)0.4 - (-)0.6).

Scabiosa prolifera appears in the diet in winter and spring, usually with negative preference, and tendency towards greater preference in late spring (April-May). *Daucus bicolor* also figures in the diet during a short period, sometimes appearing as a preferred food component in spring, with electivity decreasing at the beginning of summer. *Senecio vernalis* figures in the diet in spring only (February-March) with negative, though generally stable, preference (E.I = (-)0.6 - (-)0.8).

Carlina hispanica, appearing as a food component during all seasons of the year, is mostly eaten in winter and at the beginning of spring (December -February) and figures in the diet under negative preference or absence of preference.

Synelcosciadium carmeli appears in the diet during a limited period, with a pronounced negative preference in February-March, and pronounced positive preference in April and May.

The low frequency of appearance of the remainder of species in the cattle's diet, sometimes accompanied by considerable dispersion of dots, renders the description of changes in electivity index during the seasons insignificant. Regarding these species we have therefore contented ourselves with a mean annual electivity index, which appears in Table 10.2 under column 5, for all the species in the diet.

10.4 Discussion

10.4.1 *Pasture management in the reserve and its effects on vegetation*

The physical conditions of the pasture in the reserve render possible a uniform distribution of grazing throughout the area. In most paddocks there are stream-beds with water and shade, contributing to the dispersal of the herd in the paddock, as compared with paddocks containing drinking troughs, causing the cattle to concentrate around them, and making for an uneven distribution of grazing pressure. Such paddocks are to be found in the south-eastern part of the reserve (Map 10.1).

The paddocks vary in size, but most of them are 100-200 ha. The western, relatively large (250-400 ha) paddocks, have irregular grazing distribution due to the existence of preferred and non-preferred areas within the paddock itself. Partition of paddocks 5, 6, 8 and 12 into smaller units would no doubt result in more uniform grazing.

The percentage of pasture exploitation by cattle was in most cases lower than planned, with the exception of a few paddocks. It is clear therefore that the present herd does not utilize to the full the 2/3 of forage units in the area that are permitted for exploitation under current grazing conditions. At the same time, there is quite uniform long-range grazing dispersal in the area (as can be seen from Map 10.1), extending from 20 to 60 grazing days per ha in the dry season, and from 20 to 40 grazing days per ha in the green season, with a tendence towards greater exploitation in the north-eastern paddocks, and lesser exploitation in the north western paddocks. Grazing dispersal over the area in the single years has not however been altogether uniform, as is apparent from Map 10.2.

Gutman (1979) found that primary production at the Karei-Deshe Farm was some 300 gr dry matter per sq.m., and we assumed that production would be the same in the Yahudia Reserve in view of the similar conditions obtaining there (10.11). The consumption of an average pasture cow in the region is about 8 kilos dry matter per day (according to Gutman, 1979). On the basis of the aforementioned grazing pressure, the consumption rate of cattle in the green season would be 160-480 kilos per ha, constituting some 5-15% of primary production, while the production rate in the dry season would be 160-320 kilos per ha, constituting 5-10% of primary production. It follows that total annual consumption is much lower than primary production.

Various researchers have discussed the changes in vegetation composition as a result of grazing. The stricter ones claim the removal of 50% of the primary production as being the cause of changes in vegetation (Johnson, 1966), wile other claim that removal of 45% of primary production in the growing season, and up to 40% in the dry season, would not cause harm to vegetation composition provided grazing were not continuous (Gutman & Seligman, 1979; Gutman, 1979). Researchers agree, as a rule, that under very heavy grazing plant composition tends to change, but then the grazing management in the Yahudia Reserve does not envisage a heavy grazing regime. And indeed, in a survey of vegetation composition in paddocks under cattle grazing, as compared with paddocks not under grazing (5.3.5), no significant differences in vegetation composition were found, except for local difference in areas with particularly heavy grazing, near feeding and drinking troughs, with a preponderance of forbs (Table 9.2).

As emphasized in Table 10.1, grazing planning shows a rotational pattern, with each herd of 150-200 head of cattle grazing 2-5 paddocks. Since the greater part of the cattle's pasture area is based on the reserve, there are no possibilities of deferred grazing that would give the pasture rest during the sprouting season, which would be preferable from the point of view of primary production and vegetation composition (see 10.1.1), though some of the paddocks do in fact enjoy such grazing in view of rotation.

Rotational grazing, leaving over a quantity of dry matter until the beginning of winter, affords cattle the advantage of being supplied with forage for the transition period between the dry and the green seasons, and of advanced germination in the paddocks in which dry matter has been left over (see Table 9.2). Rotational grazing results in a non-uniform grazing distribution in time in the short range, but leads to controlled grazing affording uniform dispersal over area and time in the long run. All the same, we found from Gutman (1979) and also in this research, that rotational grazing management had no influence on primary production. We have shown that, under the grazing pressures obtaining in the reserve, primary production, which has been estimated from herbaceous vegetation height and seedling density, does not suffer, although as mentioned there is a certain growth inhibition which is, however, compensated by the end of winter (Table 9.2). The primary importance of rotational grazing in a nature reserve lies in the conservation of its botanical composition (see 10.1.1), and such grazing would therefore appear to be a desirable management policy for the Yahudia Reserve.

10.4.2 *Pattern of behaviour and grazing of cattle on pasture*

10.4.2.1 Behaviour pattern: As we have seen, the cattle's activities change from season to season and from time interval to time interval during the 24-hour day, there being only small differences between the various days of the dame month, between months of the same season, and no great differences between the years.

We have seen that, in spring, cattle take almost no rest and number of activity cycles varies, while in summer activity is concentrated in one or two periods during the 24-hour day, with a tendency of rest during the remainder of time. As against this, almost no rest is recorded in winter, and the pattern of 2-3 cycles at more or less fixed hours is a characteristic one.

It appears that provision of supplemental food in summer results in cattle gathering around the feeding troughs and in a lowering of activity, while collection of roughage generally takes place over a short period of time. This is in contrast to what happens in spring when there is plenty of forage and a great choice of species and activity going on during the greater part of the 24-hour day. Also, in spring there is considerable selection of species, there are more species, and species that are rejected at other seasons are being eaten at this time.

It should, however, be stressed that the activity mean, which is similar in all seasons, demonstrates that there is no change in the total hours of activity, and that it is merely the distribution over the 24-hour day which is the main variable.

The significance of interactions of time intervals, month and year, proves that the pattern of activity is a changing factor, and no doubt depends on supply of forage, on the weather, etc. It should be pointed out that only 22-55% of change are explained by these variables, while the remainder must be attributed to seasonal factors in the bull himself, his social relations with other bulls in the herd, willingness or otherwise of particular cows, and so on, and also to envrionmental factors of forage supply, weather conditions, etc. It follows that in order to draw conclusions from the behaviour pattern, a more conclusive follow-up is required, that will take into account additional variables and extend the pattern to include a number of animals at one and the same time.

However, the important conclusion to be drawn for our purpose is that the total time devoted to activity does not greatly change during the seasons. As we have seen, this activity identifies, with more or less approximation, with the time devoted to grazing, with 5-10% deviation in summer and autumn - seasons in which scarcity of pasture forces the herd to walk over greater distances, partly with the object of reaching pastures, without feeding on the way.

10.4.2.2 Feeding habits and diet composition of cattle on pasture:

Seasonal changes in hourly food consumption: In the course of our work as well as in literature (Wangon *et al.*, 1960), we found the bite-weight to be low at the beginning of the season and high at its peak, and the number of bites to be numerous at the beginning of the growth season and low at its peak. From Figures 10.1 - 10.4 it follows that in spring the combination of tall grasses, high bite-weight and low number of bites produces a medium forage-collection rate (1600 gr dry matter per hour). In winter, with a combination of low grasses, small bites, and a high number of bites, the cattle do not manage to collect more than 400-1300 gr of dry matter per hour. It is possible that, in order to make up for this, the cattle extend their hours of activity or, alternatively, they require more chicken manure, but this has not been checked in our research.

What was unexpected is the result of hourly consumption at the end of summer and beginning of autumn (August-September), at which time the combination of medium grass height, quite high bite-weight and the low number of hourly bites produces the highest forage collection rate (2300-3200 gr of dry matter per hour). The increase in consumption at this season is not self-understood, since food of low value on the one hand, diminishes consumption in view of the lowered roughage digestion potential, but on the other hand the addition of chicken manure which contains protein, affords effective digestion and thus increases consumption. It is surprising that the main contribution to forage quantity derives from the big bites rather than from the number of bites, a fact which perhaps indicates that low growth is partly the result of trampling of vegetation which yet affords its utilization. It is also possible that diminution of selectivity and transition to grass consumption at the end of summer have an effect on bite-size, since grazing under conditions where there is a choice of species, or of parts of them, affects the diminution of bite-size.

Seasonal changes in food composition: We learned (Figures 10.5 - 10.8), that the chief contributors to the rise in hourly food consumption during August-September are the grasses and *Quercus ithaburensis* leaves, the bite-weight of which is several times higher than that of herbaceous plants. In spring on the other hand it is the legumes that make the main contribution to the diet. However, there is no doubt that grasses constitute the principal factor in the cattle's diet (Wangon, 1960, see 10.1.1), and this we also found to be the case during our research work, with the exception of the spring season.

Quercus ithaburensis: As pointed out above (10.1.1), the acorns of *Quercus ithaburensis* are the food which is most in demand with cattle. We have shown in this paper that acorns constitute a significant diet component during two months of the year (November-December), when they represent up to 1/3 of weight consumed in 1% of the time only (Figures 10.7 and 10.8). It is interesting to compare this datum with Wangon (1963) (see 10.1.1), who, while indicating a high acorn consumption, shows that cattle devote only about a quarter of their time to their ingestion. The advantage of acorns in cattle foraging at this time of the year is considerable, since it is the poorest season for herbaceous forage, dry vegetation have already partly decomposed or been consumed, and green vegetation only just beginning to germinate. Their high energetic value and easy digestibility (see 7.2) make the acorns a most important factor in the diet. The tannins contained in the acorns, the significance of whose influence on protein digestion is not clear, do not affect palatibility (Rodriguez *et al.*, 1973).

The practice of giving food supplements in the form of chicken manure, and even concentrated supplemental food during the transition period in autumn, is an accepted procedure for meat cattle in Israel. We believe that in the Yahudia Forest some 50 days of food supplementation can be economized by directing cattle to the forest plots, a possibility which is not being taken advantage of by the cattle growers in the reserve. As far as the likelihood of harming germination is concerned, it has already been shown that consumption of acorns by cattle prevails over consumption by wild boar (see 7.2.2.2), and the germination prospects of an acorn depend to a greater extent on where it falls down (cairn or open field), or on it being trodden into the ground by cattle or wild boar, than on it being or not being eaten by cattle (see 8.4.2); and indeed, as we have seen, consumption of acorns by cattle takes place mainly in places that are easily accessible, and less frequently on cairns where cattle have greater difficulty in walking as well as in extracting acorns from among the stones.

Apart from the economic significance of having cattle feed on acorns and the resulting saving on supplementary food, there is also a diminution in the quantities of outside nutrients introduced into the reserve by such food, and a rise in the rotation of food factors within it.

In general, *Quercus ithaburensis* has negative preference during all seasons of the year. Consumption of leaves is usually at a lower rate than the relative cover of trees in the area (Figures 10.12 and 10.18), and is certainly low relative to the biomass of the trees the greater part of which is not available to the cattle. During July-September, in which period the leaves constitute a more significant food component (Figure 10.7), the electivity index, too, usually approaches 0.0 and sometimes even attains positive values. Herbaceous vegetation in this season is dry and poor in value, and hence an increase takes place in the consumption of *Quercus ithaburensis* leaves which constitute almost the only green food in the area. In the dry season, browse is relatively rich in protein and in greater demand by herbivores (Field, 1975).

With the onset of autumn colouring, there is a decrease in consumption of *Quercus ithaburensis* leaves, and hence the cattle, during autumn and winter (except in the acorn season), prefer open areas with high herbaceous cover to the *Quercus ithaburensis* forest areas.

These facts tally with what has been said above (10.1.1) on the subject of the low percentage of browse in forage, the high preference of grassland and low preference of dense forest.

The effect of cattle on tree-shape is also noticeable. Browsing on leaves and twigs up to a height of 1.50 m, results in "pruning" or trees, in raising of crowns, and in the forming of a single trunk which is a basic characteristic of the *Quercus ithaburensis* tree if undisturbed by felling or burning. This structure diminishes the tree's vulnerability to damage by fire. On the other hand, in very sparse *Quercus ithaburensis* forest, or in an area where there is regrowth of forest with low tress, heavy grazing prevents trees growing to a height and exerts strong pressure on single trees. Given the fact that main consumption of leaves occurs in July-August, it is desirable to abstain from having cattle graze in areas of sparse, young, or regrowing forest during these months.

Grasses: The proportion in the diet of the grass group is usually higher than its proportion in the field, and shows a tendency towards a big rise in consumption in high cover percentages at a relatively high rate of cover increase (Figure 10.9). During most months of the year grass consumption exceeds 80% of the diet (Figure 10.5), and shows a positive electivity index in nearly all months of the year.

The tendency towards a decrease in electivity and diet composition of grasses in spring, notwithstanding the non-diminution of supply in the field, derives from preference during these months for other groups, and from an increase in the variety of forage components (Table 10.2, Column 3). The contribution of grasses to the species variety in the daily diet which amounts to only 2-3 species, is more or less constant throughout the year.

In summer, the dry grasses constitute the main food component. Dry vegetation in fact consists of several species, but *Avena sterilis* is the decisive component, and *Hordeum bulbosum* the next important component, which however is much smaller than the first one. Conspicuous in Figures 10.12[1] and 10.19 is the fact that in summer the electivity index of dry vegetation is high, and consumption increases at a higher rate than that of the cover increase in the field with the rise in cover. As against this, in winter the dry vegetation has a conspicuously negative preference due to its low quality as compared with green vegetation, and perhaps due also to its low cover. It appears that in medium covers of 20-50% there are no clear preferences or rejections of dry vegetation by cattle, and the consumption rate matches cover rate in the field.

Avena sterilis: enjoys clear preference during the greater part of the year. A rate of consumption exceeding the cover in the field is discernible in all cover grades of this species, and there is a tendency towards an increased rise in consumption, particularly in high covers. If we regard the "unindentified grasses" as *Avena sterilis*, which is generally justified, we shall see that negative electivity is apparent only in spring and autumn (Figure 10.20). Spring rejection, as pointed out above, derives mainly from a preference for legumes, while autumn rejection can be put down mainly to increased electivity of *Hordeum bulbosum* in that season (Figure 10.21).

Hordeum bulbosum has in general a negative electivity, and its rate of consumption - particularly in relatively low cover percentages - is smaller than its rate of cover in the field (Figure 10.14), but a decisive preference for it exists in early spring and in autumn. Electivity in early spring can be related to the advantage enjoyed by *Hordeum bulbosum* in being a perennial plant with early growth and leaf production, while electivity in autumn can be put down in the main to shedding of ears. We have seen that cattle do not consume the ear stalks of *Hordeum bulbosum* in summer because of the thorny ears and husks, and that electivity increases with the shedding of ears at the end of summer.

Lolium rigidum is a quantitatively small component of the diet, in which it however appears during most months of the year with a slightly negative preference.

In summer and autumn, *Cynodon dactylon* represents a significant forage component and is being preferred by the cattle. Its advantage over other herbaceous plants lies in the fact that it remains green throughout the summer, turning yellow only in the autumn, and it is therefore preferred in this season when the remainder of grasses are dry (Table 10.2).

Legumes: This group does not enjoy particular preference, and is even rejected in relatively low cover percentages (Figure 10.10). Rejection is more pronounced mainly in the winter months, whereas during the remaining months there is less rejection, with a clear electivity trend in spring (Figure 10.16). This finds expression, too, in the composition of forage (Figure 10.6), and also in the monthly contribution to the species variety in the diet made by the grasses (Table 10.2, Column 3).

The three principal components in the legumes group are: *Trifolium purpureum, Trifolium pilulare* and *Medicago rotata*, representing together only about 4% of the total diet. Electivity of these species is generally negative, although in the spring months they constitute a significant component of the diet. *Trifolium purpureum* is preferred in spring and at the end of summer (Figure 10.22). The fact that it is elected also at the end of summer is worth mentioning, and it is to be assumed that this is due to the species' morphological characteristics. While the remainder of legumes in the diet (with the exception of *Psoralea bituminosa*) are 'spreading' species, *Trifolium purpureum* grows upright, reaching a height of about 40 cm, a characteristic that affords a greater length of time during which it can be consumed by the cattle.

Other Forbs: As a rule, this group is not elected by cattle (Figure 10.17), and its rate of consumption is lower than its composition in the field, without dependence on the relative cover of the species there (Figure 10.11). A trend of increased consumption, and at times even electivity, is noticeable in spring and at the end of summer. The percentage of this group in the forage composition is generally low and constitutes a significant component only in late spring (April-May) when it attains a rate of up to 20% of the diet (Table 10.2, column 1). On the other hand, this group is the main contributor to the wide range of forage species in spring (Table 10.2, column 3).

Among the species in this group being consumed more frequently, we can name *Cichorium pumilum*, *Scabiosa prolifera*, *Daucus bicolor*, *Enthemis bornmuelleri*, *Dianthus polycladus*, *Crepis sp. carlina hispanica* and *Synelcosciadium carmeli*. *Cichorium pumilum* is a species which is being consumed almost during the whole of the year, and even preferred in spring (Figure 10.23), whereas the others are consumed during more limited period, mainly in spring, and their electivity is generally negative. An exception in this group is *Carlina hispanica*, which is consumed mainly in winter, a fact which on the one hand can be related to this being a per ennial plant (similar to *Hordeum bulbosum*, as stated above), and on the other to the plant's spinosity which is less prominent in the young leaves sprouting in winter or autumn in the wake of a fire.

Selectivity: By nature, grazing is selective with regard to species, and the proclivity of species in pasture areas is that they enjoy electivity by cattle and are also resistant to grazing (Ellison, 1960). In contrast to the harvest procedure, during which the whole shoots are cut down indiscriminately all at once, grazing removes portion by portion, with a choice of preferred species, and the harvest does not therefore fulfill the same ecological rôle that does grazing (Gutman, 1979). The less lignin and fibres, and the more protein the parts of a plant contain the more are they preferred by cattle (Heady, 1964). It thus also appears that winter grazing in the Yahudia Reserve is not selective, and that nearly all the existing species, most of which rich in proteins during that season, are consumed by the cattle. It seems that the key to their consumption is to be found mainly in the height of plants, and indeed, at the beginning of winter grasses are the tallest plants and are consumed by preference, whereas in paddocks that were burned in the preceding year, and in which there has been growth inhibition, legumes and grasses attain similar heights and are consumed at similar rates of preference.

10.4.3 *Other herbivores in the Reserve*

The rôle of herbivores that existed in the region in the past, or are existing there now in limited numbers (Table 4.1, 4.2.1), is today filled by cattle. Harrington (1978) found that there was little overlapping of botanical species consumed by the domestic herbivore species (cow, sheep and goat), though in other researches mentioned, some overlaps were found (see 10.1.3). The extent of forage overlapping among herbivores was measured by Stoddard & Rasmussen (1945) by competition index calculation proportional to the multiplication of the percentage of area exploited by two herbivores by the percentage of species consumed by both.

In the Yahudia Reserve, the decisive biomass of herbivores, exclusive of cattle, falls into two species. The estimated population of the mountain gazelle (*Gazella gazella gazella*) in the Yahudia Reserve is 200-350 head, and that of the wild boar (*Sus scrofa*) 200-400 head (see Table 4.1).

The wild boar, the consumption rate of which in Yahudia Forest Reserve conditions is unknown, but whose forage composition, as stated above (10.1.3) conditions is unknown, but whose forage composition, as stated above (10.1.3) greatly differs from that of cattle, will show a very low index of competition with cattle and gazelles. The gazelles, whose consumption according to Baharav (1975) reaches up to 600 gr dry matter per head a day in winter, and up to about 500 gr dry matter per head a day in summer, and whose density in the Yahudia Forest is only about 0.05 head per ha (Table 4.1), consume only 1/3% of the primary production. Although it was found by Field (1975) that small herbivores are able to be more selective than cattle because of their smaller mouths and greater physical ability to distinguish between botanical species, we can assume only with difficulty that consumption by gazelles could be significant from the point of view of primary production and plant composition with regard to the competition index as compared with cattle.

11 GENERAL DISCUSSION

11.1 Introduction

In this paper we have been dealing with 6 main subjects:

- physical conditions in the Yahudia Reserve;
- inventory of vertebrates;
- inventory and mapping of vegetation;
- *Quercus ithaburensis* in its various aspects, with emphasis on germination and establishment;
- fires and their effects on the ecological system, and
- cattle grazing and its effects on the ecosystem.

Each subject has been discussed separately, and its connection with the other subjects has also been touched upon.

Each subject is regarded by us as having its own intrinsic value in contributing to the "Reserve Book", whether by way of information on physical conditions, whether as inventory of wild and plantlife, or as a description of the principal processes affecting the reserve.

The inventory and the processes are the tools for working out a suitable biological management policy for the reserve.

11.2 Principal interrelations of central factors

Figure 11.1 describes, in a condensed form, the mutual relationships of the central factors in the reserve. The figure does not pretend to be a representation of the entire system of relations between factors, but only of such relationships as have a decisive impact and have been touched upon in this paper.

FIG. 11.1

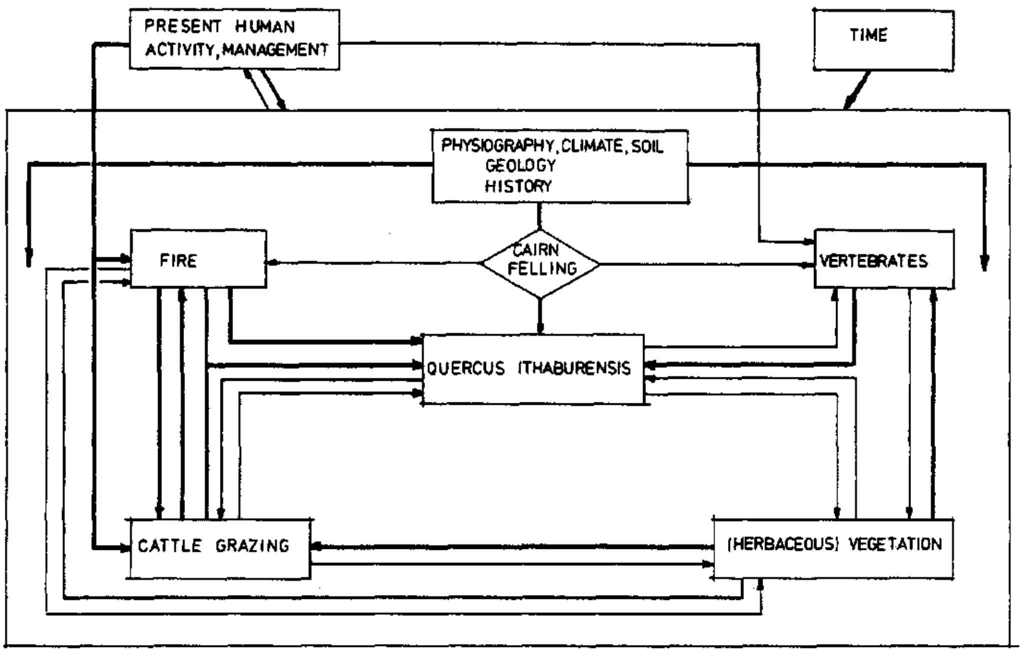


Figure 11.1: Mutual relations between physical conditions, wildlife, vegetation, fires and grazing in the Yahudia Reserve. Direction and relative width of darts are quantitative relativity measurements for gauging relationships between factors.

The *Quercus ithaburensis* Forest Park is the dominant factor in the Yahudia Reserve, partly because of its importance as a forest park of *Quercus ithaburensis* growing on basalt, such as cannot be found growing in association anywhere else in Israel, and partly because of the size of wooded area within a, for Israel, relatively big nature reserve sustaining vegetation associations and dynamic wildlife populations. What follows is a summary of the central factors having an impact on the system at the heart of which stands *Quercus ithaburensis*.

The basic physical conditions, such as climate, rock and soil, have an influence on the entire system, including *Quercus ithaburensis*, although the latter is not particularly selective with regard to these factors. As against this, the most significant habitat within the system is the cairn, whether natural or man-made; it is the preferred habitat of *Quercus ithaburensis* and rodents, and within it there is almost no vulnerability to fires.

Burning and grazing affect the survival of *Quercus ithaburensis*. The phenomenon of fire plays a most significant rôle in reduced seedling-survival and tree yield. Grazing, too, has a direct effect through reduced competition with herbaceous vegetation and through prevention or reduction of fire damage. Cattle grazing under Yahudia Forest conditions has proved to be a positive factor in the survival of *Quercus ithaburensis* trees. *Quercus ithaburensis* affects pasture mainly by supplying green leaves in summer and acorns in autumn when lack of pasture is making itself felt and outside supplemental food has to be given. Fires on their part affect pasture in a decisive way since they in fact destroy the cattle's natural source of forage - the herbaceous vegetation.

The cattle in turn affect the herbaceous vegetation at two levels: in the short run, very heavy grazing influences the change in species composition in the direction of ruderal plants, whereas moderate and light grazing has in fact no influence on composition. In the long run, grazing leads to the development of grazing-resistant plant associations; this is actually an "inheritance" of thousands of years of grazing - an inheritance which must be preserved. Similar mutual effects exist between the other herbivores and herbaceous vegetation.

The link between *Quercus ithaburensis* and the other vegetation components is that, together, they form plant associations which are combinations of species components. Apart from this, competition with the herbaceous vegetation has a negative effect on the establishing potential of *Quercus ithaburensis*. The *Quercus ithaburensis* forest is the habitat of different species of vertebrates. Some of these, such as for instance *Acomys cahirinus* and *Apodemus mystacinus*, are closely connected with the cairns and with *Quercus ithaburensis*, and there are others which are connected with *Quercus ithaburensis*, such as *Sus scrofa*, a considerable part of whose sustenance in winter is based on acorns. On the other hand, notwithstanding the fact that these animals are acorn consumers, they also encourage germination by hiding the acorns in caches (rodents) or stamping them into the ground (wild boar, cattle).

The whole system is subject, of course, to the effects of time, mainly as regards changes in plant- and wildlife associations, and also to human influences which are expressed on the one hand in external impact through development, which has a damaging effect on landscape as well as on the water system through pumping and sewage, and on the other in exploitation of the reserve's resources for touristic purposes. Man, of course, constitutes a central factor in the management of the reserve, and this includes grazing.

11.3 *Quercus ithaburensis* - its place within the region and in the Reserve's plant associations

Quercus ithaburensis is a deciduous tree, whose region of distribution is the Eastern Mediterranean. The fact that it sheds its leaves in winter proves that the tree has not adjusted itself to the climate of the region where winters ar not particularly cold and plant growth is indeed possible, especially in view of the fact that winter is also the rainy season.

Shmida (Shmida, A., personal information) believes that the deciduousness of about fifty percent of Mediterranean forest trees points to a more continental origin with cold winters where no growth is possible. Zohary (1973) sustains this contention and maintains that *Quercus ithaburensis* and *Pistacia atlantica* (which latter is also a deciduous tree) are relics of a period when Irano-Turanic species were dominant in our region. Rabinovitz (1977) concludes on the basis of the variety of *Quercus ithaburensis* habitats, that this species is at the beginning of its expansion, and likely to conquer other species at the fringes of their distribution. And indeed, on the Golan we have noticed that *Quercus ithaburensis* is expanding northwards and penetrating regions in which *Quercus calliprinos* and *Quercus boissieri* are the climax.

It is interesting in this context to examine the place of *Ziziphus lotus*, which occupies the belt above the *Quercus ithaburensis* Park Forest. Its distribution today includes the irano-turanic phytographic zone, with penetrations into the sudano-decanic and mediterranean zones (Zohary & Feinbrun, 1962). Berliner (1978) points out that along the declivities sloping towards the Jordan Valley between the Dead Sea and Lake Tiberias, *Ziziphus lotus* appears in association only in the northern part, gradually disappearing towards the sout. Zohary (1973) describes this region as being the primary habitat of *Ziziphus lotus*, and the cleft forests of *Quercus ithaburensis* as being its secondary habitat. In the light of all this, and in the light of the historical data supplied by us, the *Ziziphus lotus* belt above the *Quercus ithaburensis* Park Forest can be regarded as a *Quercus ithaburensis* climax region.

A different picture is obtained if we examine the distribution of the *Ziziphus spinachristii* association below the *Quercus ithaburensis* Park Forest. Distribution of *Ziziphus spinachristii* extends over the sudano-decanic phytogeographical zone, with penetrations into the saharo-sindi and tropical region (Zohary & Feinbrun, 1962), and it appears that its location at the lower fringes of the *Quercus ithaburensis* Park Forest, by way of continuation into its more southern distribution region, does indeed constitute its primary habitat.

As pointed out earlier on, *Quercus ithaburensis* is a water-squandering tree, and this is one more reminder of its non-adjustment to the mediterranean climate in which the dry season extends over some 7 months in the year. This tendency makes for an open landscape of park forest in which the root system of each tree is occupying much space. Nor do the acorns retain their water for a long period, and loss of water within the first week of shedding causes them to lose their germination potential.

Despite all this, certain properties ensure the survival of this species in our region. During the initial stage of germination, the acorns send forth deep roots which may reach a length of nearly one metre in the first months before the first leaves have appeared. This property ensures a water supply for the seedling in summer. We have noticed the phenomenon of shedding of branches, which may be a mechanism for regulating crown size and for the adjustment of rate of transpiration to the roots' water-absorption potential. The seedling's ability to advance the shedding of leaves, a process which shortens in fact the period of transpiration, is a property which greatly enhances the seedling's survival potential.

11.4 Descriptive model of establishment and development of *Quercus ithaburensis*

The age division of *Quercus ithaburensis* in the Yahudia Forest points to two felling periods during the last hundred years, identified by us with the period of circassian settlement (the 70's of the 19th Century), and the final period of the turkish regime up to the end of the First World War (1905-1918). Regrowth occurred in part of the trees from the more adult stumps whose age we have been unable to establish. But the conspicuous fact is that a gap exists between trees (whether regrown from stumps or not) and seedlings. We attribute this gap to growth inhibition and to seedling mortality at an early age. We have no doubt that fires are most significant as regards the *Quercus ithaburensis* species. Relative fire resistance of the adult trees notwithstanding, the decrease in acorn yield, and in particular the low seedling-survival rate, prove that *Quercus ithaburensis* as a species is non-resistant. Relative resistance of oak species adults was also found by Plumb (1979), and we, too, found the mortality rate in adult trees to be low. Browsing enhances a tree's survival prospects, leading as it does to a heightening of the crown and to formation of a single trunk.

Interactions of fire and grazing, and those of fire, grazing and vegetation, are complex. The rate of recovery of *Quercus ithaburensis* trees and seedlings after fire is the greater the heavier has been the grazing in the vicinity, and this can be attributed to fire intensities being the lower the greater quantities of grasses have been consumed. The likelihood of a tree being harmed by fire in a pasture area is smaller, because fires cover a more limited area in an absolute as well as in a relative sense; they are of lower intensity although their absolute number is greater.

Fires and summer grazing have similar effects on growth inhibition in herbaceous vegetation in the following winter, with no interaction of fire and grazing occurring with regard to this subject. Effects of fires and grazing on herbaceous vegetation composition are generally marginal, too, although under very heavy grazing, changes will take place in the composition of herbaceous vegetation, and after a fire there is a tendency towards a slightly lower cover of *Graminae* and a slightly higher one of *Leguminosae*. All in all, it can be said that the small changes in herbaceous plant composition in the wake of fire or grazing are proof of the fire and grazing resistance of the herbaceous plant associations, while the same cannot be said of the trees, at least not where fires are concerned.

Fire frequency is lower in the *Styrax officinalis - Ferula tingitana* alliance within the *Quercus ithaburensis* formation on the rocky declivities where there are less herbaceous plants, and where trees are more crowded. The *Salix acmophylla - Nerium oleander* formation, too, is less vulnerable to fire due to it remaining green during the high-frequency fire period, and to it growing partly in water.

Among the animals (excluding cattle) that can be named as having an impact on vegetation in general and on *Quercus ithaburensis* in particular, *Sus scrofa* is dominant. This animal particularly affects germination through acorn consumption on the one hand and burying of acorns by trampling on the other. The rodents, which are also acorn consumers, have no significant effect on quantity of acorns, but it is interesting to observe the stimulus to their populations as a result of suppression of wild boar. This can be attributed to the absence of competition for acorns, and perhaps also to absence of predation of young or other disturbing factors.

Small as they are, the herbivores' selectiveness of food is considerable (Field, 1975). According to this principle, the gazelles are much more selective than cattle. There are not enough direct data on food composition of gazelles in this research, and observations need to be carried out in denser populations, such as can be found on the slopes of the southern Golan, for instance. The impact of gazelle populations on vegetation is negligible in comparison with that of cattle. Cattle have an effect mainly on quantity of grass and less so on its composition, and they affect *Quercus ithaburensis* through consumption of leaves and acorns.

Consumption of acorns, although they may constitute up to 1/3 of the weight of cattle forage in the acorn season and relatively little energy is invested in obtaining them (about 1% of the time), is also low if compared with the rate of acorn consumption by wild boar. The main impact of the cattle is positive, and this is expressed chiefly by improved germination and rate of survival, and in the shaping of high-crowned, single-trunked trees, which latter properties afford the tree fire-resistance, and a higher specific value as far as recreational purposes are concerned through enlargement of the shadow zone.

We have seen that cairns are a preferred habitat of *Quercus ithaburensis* where trees have better prospects of germination and establishment, and where most trees and seedlings are to be found. We have attributed the stability of the *Quercus ithaburensis* forest population to the theory of "all sites are occupied", and to the self-inhibition mechanism which prevents physiological maturation of young trees in the vicinity of adult trees. On the basis of the vegetation map (Map 5.1), we can see that there are "free sites" at the fringes of typical *Quercus ithaburensis* forest (QA), and particularly in the *Ziziphus lotus* region and on the slopes of the Sheikh Ali fault. And in fact, we found that there has been an increase in tree density in these areas during the last few decades.

The main problem of the forest's expansion lies in the seed source. As there are no animals which can transfer acorns over distances, expansion depends on the rate of physiological maturation of trees able to supply seeds for further expansion at the new fringes of the forest. When we ourselves took over this role we found that the establishment rate and survival rate in the *Ziziphus lotus* and *Ziziphus spinachristii* region was the same as in the *Quercus ithaburensis* regions. In other words, these regions are potential "free sites" for *Quercus ithaburensis*.

A question which arises concerning the connection between *Quercus ithaburensis* and the cairns is: which came first? Did the cairns create the habitat in which *Quercus ithaburensis* arrived from nearby regions, or did *Quercus ithaburensis* also exist in the area earlier but has survived only in the cairns?

As already pointed out above (5.1.1) a pollen analysis showed that *Quercus ithaburensis* had been in the region as early as the Pleistocene, though it is possible that at that period it occupied only slope habitats populated today by the *Styrax officinalis - Ferula tingitana* alliance, but when the cairns were created, these too were seized by *Quercus ithaburensis*.

It is quite possible that the prevailing conditions enabled *Quercus ithaburensis* to exist also outside the cairns, and that the increase in the numbers of wild boar, resulting from the extermination of the big predators, and the increase of fires and deforestation in non-stony regions for agricultural purposes, have been responsible for pushing *Quercus ithaburensis* to the cairns.

It does not look as though it will be possible for us, within the framework of our research, to give an answer to this question, though it is clear that under conditions obtaining today, the cairn habitat is more or less a must for the existence of the *Avena sterilis - Hordeum bulbosum* alliance within the

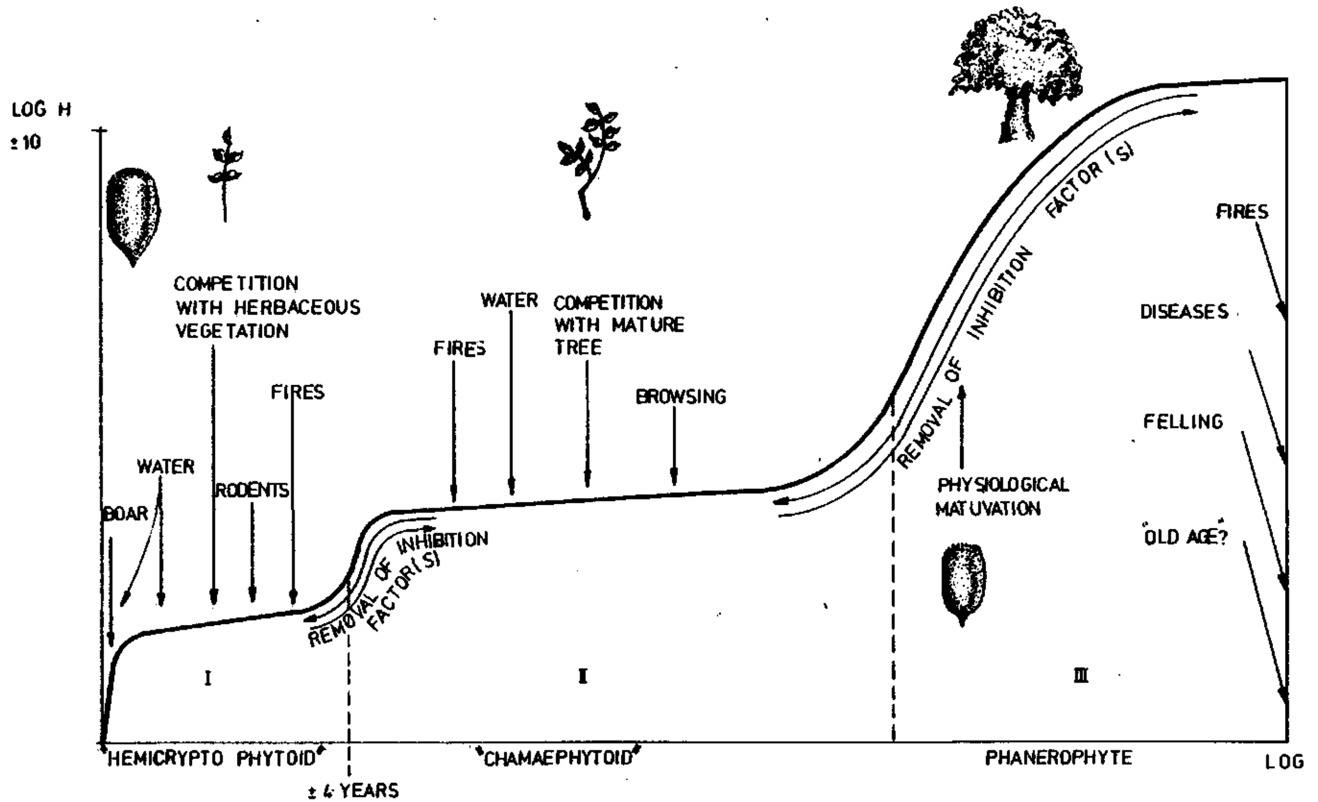


FIG 11,2: THEORETHICAL MODEL DESCRIBING ESTABLISHMENT AND DEVELOPMENT OF QUERCUS ITHABURENSIS AND THE FACTORS EFFECTING THIS PROCESSES.

Quercus ithaburensis formation which constitutes the typical *Quercus ithaburensis* Park Forest.

We have seen that the forest's expansion to "free sites" depends on the physiological age of the trees on the fringes, and we have already pointed out earlier (8.4.4) that it is the physiological, and not the chronological age which determines the start of a tree's production, and we have also included a graph (Figure 8.18) in which the one is confronted with the other.

Figure 11.2 is a different presentation of the aforementioned graph, including factors having an influence at each and every stage. During the germination stage, the decisive factors having a bearing on the success of the process are wild boar and water. During the first inhibition stage, in which the seedling has been called "hemicryptophytoid", the direct influence of water, or the competitions with herbaceous plants for water together with fires, are the decisive factors the absence of which will cause the seedling to attain a higher stage of development. This seedling, which we have called "chamaephytoid" is also affected in a decisive manner by fire, and also by water - either direct or in competition for it with adult tree and herbaceous vegetation. Should one of these factors have a drastic effect, a seedling at this point is also likely to revert to the first inhibition stage, and this is especially true in the case of fire. If some of the inhibition factors are absent at this stage, the seedling is also likely to pass to the stage of "phanerophyte". Transition from stage II to stage III is slow, and during the process the plant attains physiological adulthood and continues to develop until it has reached the usual height of 8-10 m. As a result of a strong conflagration, or felling, a fully developed adult tree is also likely to revert to the "inhibited seedling" stage and, after a shorter or longer period, may perish as a result of fire, felling, disease, or it may die a "natural death".

12 PRINCIPLES OF MANAGEMENT IN THE YAHUDIA RESERVE

12.1 Variety in space and stability in time

Van Leeuwen's theory (1966) mentioned by us earlier on 2.1.1, considers variety in space (pattern) and stability in time (process) to be one of the principles of nature conservation and management.

Stability in time, achieved in undisturbed habitats, gives expression to the natural variety existing in the area which it is desired to conserve on a long-term basis. In nature reserve management it is not enough to strive for variety for variety's sake, but this should be defined, as should be the aims one wishes to achieve, and the ways and means by which one hopes to achieve them.

In the botanical sphere, we learned that in the north-western part of the reserve the *Quercus ithaburensis* forest is quite uniform in its composition, but highly variegated as far as spring stream and stream bank vegetation is concerned. The south-eastern part of the reserve has a greater variety of water plant stream bank and grassland habitats. This part is also more variegated from a geological point of view, containing not only ancient volcano craters but also limestone layers of the Neogene period. The connection between geological and botanical variety springs to the eye if we look at Maps 3.3 and 5.1. A similar pattern of variety shows up from the landscape point of view, with uniformity characterising the level heights of the *Quercus ithaburensis* Forest Park, and variegation characterizing the streams and stream banks, and in particular the waterscapes, the waterfalls, the Hexagon pools and the canyons scenery. The south-eastern part is characterized by similar sceneries with, in addition, impressive landscape views and mighty canyons.

The faunistic variety presented by us covers only vertebrates, and these only in part on the basis of accurate surveys, and most of them on the basis of chance observations. A clear picture can be obtained only upon additional research into invertebrates, and a fundamental survey of vertebrates, and in particular of reptiles and mammals.

12.2 Main objectives in Reserve Management

12.2.1 *Botanical objectives*

We attach little importance to the extent of naturalness or unnaturalness of vegetation in the Yahudia Forest, because in a region of ancient human civilization such concepts can be defined only with difficulty and are often irrelevant. Of course, vegetation - as presented in the vegetation map of the Yahudia Forest - is the result of natural and human conditions which have evolved in the course of thousands of years. The relevant question here is whether the vegetation potential as we want it to be in the Reserve, is that represented in the map or not. It seems to us that it is important to preserve a variety of vegetation that includes park forests in the plains, and dense and more variegated forests on the declivities, savannoid of *Ziziphus lotus* and *Ziziphus spinachristii*, grassland, and stream and springs vegetation. Recovery of trees on the steep slopes is a very important process, and one which is continuing without any intervention. Intervention is necessary on those upper plateaus in the sout-east of the reserve where there are treeless grasslands without regrowth but where there are "free sites" for the establishement of *Quercus ithaburensis*. Regrowth of forest such as existed in this region in the last century, is most important, and the success of steps taken in this direction is evident in a small plot in which we planted *Quercus ithaburensis* and *Pistacia atlantica* (see M, Map 3.2). Renewal of *Quercus ithaburensis* forests is of importance also outside the reserve in the entire central and southern part of the Golan where such forests have existed in the past.

12.2.2 *Zoological objectives*

The scanty data we collected make it difficult for us to define as yet non-existing objectives to be achieved in the reserve. We attach considerable importance to the herbivores - the group which has the greatest impact within the system and whose presence is vital. Direct circulation of primary production in the system means growth and decomposition processes without the presence in the circuit of herbivores and their predators, and of invertebrates and the micro-organisms connected with this circuit (Kydd, 1966). The contribution of this circuit to species and habitat variety is considerable.

Various herbivores exploit the system in different ways as concerns space and time, and as concerns, too, the basic character of their forage requirements (browsers, grazers, root consumers) and specific selection of species consumed. A rich variety of herbivores can thus lead a balanced existence (Bell, 1971; Eisenberg & Lackhart, 1972). A balance between the various herbivores, and between herbivores and vegetation, exists in a stable system, with fluctuations depending on the extent of dependence of plants on herbivores, and of one herbivore species on the other (Caughley, 1976).

In the system presented here, and given the present size of population, the herbivore species are not apparently dependent one on another, and the herbaceous vegetation system seems stable. Thus, the general trend in the Yahudia Reserve should be towards augmentation of the present natural herbivore population, or reintroduction to replace such species as existed in the past but were exterminated. When a state is reached where there is competition between the cattle and natural or reintroduced herbivores, it will be necessary to reduce, or even suppress, cattle grazing. This trend is important for the sustainment of larger wildlife populations in the reserve on the one hand, and for a more balanced exploitation of vegetation by the wildlife on the other (Darling, 1960). However, with a gazelle density of 30 head per sq km (Baharav, 1975), damage to agriculture is apparent, and high density in the reserve of wild boar will also lead to damage in agricultural areas in the vicinity, which will perhaps require a thinning-out of their population.

It appears that the factor at present inhibiting the growth of population in the reserve is not necessarily that of forage, but seems to be connected with other, social factors within the wildlife populations, as well as on human factors. It does not therefore seem likely in the near future that primary production will be exploited to the desired extent by wildlife alone.

Apart from the aspect of encouragement of existing populations, the Yahudia Reserve, in view of its size and habitat variety, seems to us a potential place for reintroduction of wildlife species which have become extinct here. The reintroduction of gazelle populations appears to have been a success, and as already stated earlier (4.2.1), *Capra aegagrus* existed in this region, and, we are convinced, could be restored to it. Restoration of additional species would require consideration and additional research exceeding the terms of reference of this paper.

Establishment of herbivores would make possible also establishment of predator populations, such as *Panthera pardus* and *Canis lupus*, and would help balance the *Canis aureus* population which, in the opinion of several researchers, has reached outsize proportions on the Golan and is the cause of decrease in the populations of *Alectoris graeca* by violating their nests (Mendelssohn, H, personal information). Predation of new-born calves by jackals during August-November, is a widespread phenomenon within the reserve and outside it, and there have been attempts at unlawful poisonings of jackals outside the reserve, causing the death of at least 6 specimens of *Gyps fulvus* in 1980. Given this situation, a thinning-out of the jackal population has to be considered, but more research is necessary in this connection.

We believe that breeding of birds of prey in the Reserve does not attain its full potential either, considering the existence of suitable habitats and the fact that in some years nests are plentiful.

12.2.3 *Scenery and tourism objectives*

The touristic potential of the Yahudia Reserve, and its intrinsic value, necessitate planning which will obviate damage to natural assets, populations and reserve landscapes.

Part of the plan is concerned with external factors connected with development outside the reserve affecting its scenery and in particular its water resources. The scarcity of clean, perennial streams in Israel requires efforts to be made to prevent pollution of the streams and to preserve the volume of their waters. Planning of outside factors sometimes affects also the reserve itself, in cases of attempts being made to deprive the reserve of land for agricultural purposes, or water being pumped from the reserve for agricultural and drinking purposes. As a principle, the reserve and its waters should be preserved, and excess pumping allowed only from the lower reaches of streams outside the reserve.

The pattern of integration of the visiting public is envisaged at several levels:

1. Strict Reserve: Reserve zones to which the public has no access, and in which all the habitats are represented. Such zones will be preserved as undisturbed areas, and within them there will be continual follow-up, particularly on wildlife.
2. Zones open to the public on footpaths covering routes of from one hour up to one day.
3. Zones for intensive development covering relatively small areas and being

located at sites which are attractive to the public and not vulnerable in terms of nature conservation. These zones will contain short walking routes, a picnic area and an information centre which may possibly contain a display and supply guidance.

4. A zone for housing existing wildlife or reintroduced animals, with observation points at the fringes of the reserve, with possibility of visitors being driven by reserve staff within the zone densely populated by wildlife, along a fixed, short route that will penetrate into the reserve not more than 1-2 km.

12.3 Recommendations for Management of the Reserve

12.3.1 *Fire prevention*

Preventive measures against fires are the sprayed firebreaks, which we recommend should be continued with. However, in the absence of suitable control and fire-extinguishing by reserve staff and by the herdsmen grazing their cattle in the reserve, the effectiveness of these firebreaks is small. We have seen that in the northern part, where we have the main concentration of *Quercus ithaburensis* forest, fire frequency is higher in June-July, and hence in these months observations should be made from high points at frequent intervals during the entire day, so that fires can be spotted as soon as they break out. Special attention should be given to the north-western part, where fires are more frequent and whence the risk of fire to the reserve is greatest due to the prevalence of westerly winds in all the summer months. Attention should be paid to education of tourists and advertising the risks of fires and means to prevent them.

Fires are less significant in the southern part. One of the forest plots (T, see Map 3.2) serves as control plot for comparison between a grazing regime with infrequency of fires obtaining in most parts of the forest, and a non-grazing regime with frequent fires obtaining in that plot. The remaining part, consisting of grassland and springs, and also of regrowing forest on steep and rocky declivities, is less vulnerable to fire. In the short run, the area is subject to a fire regime, in view of its location within a military training area, and we have therefore recommended that the fire-break there should not be sprayed, since this is in any case not effective, and that these measures should be directed at the vulnerable north-eastern part of the reserve. In the long run, endeavours should be made to put a stop to the fire-regime there. This would undoubtedly encourage regrowth of timber vegetation and oblige the reserve management to find out whether the grassland and savannoid areas of *Ziziphus spinachristii* will be preserved also in the absence of fires - and if this is not the case, to endeavour to preserve this diversity by grazing of indigenous or reintroduced herbivores, or by controlled burning of small areas.

The principal means of fire prevention is grazing.

12.3.2 *Grazing*

Herd size: We recommend cattle grazing of 1200 mother cows with accompanied bulls and calfs.

Annual planning: In the pattern presented above, planning is done once a year, in autumn. Greater emphasis should be put on spring grazing in regions vulnerable to fire, particularly in the north-west of the reserve, and autumn grazing should be planned in *Quercus ithaburensis* forests at the time of acorn ripening, hand in hand with a lowering of outside fodder supplies to cattle. A number of paddocks should be reduced in size by dividing them into smaller paddocks of about 150 ha each. Thus, uniform exploitation of pasture would be achieved, which is of particular importance in winter and in spring towards the fire season, so that all paddocks will stand a more or less equal chance of reduced fire risk in the dry season.

12.3.3 *Afforestation*

We recommend that there should be no intervention in botanical processes, with the exception of the high-lying grasslands in the south-eastern part, where *Quercus ithaburensis* should be planted, and this goes also for areas outside the reserve.

As a result of our experiences, we have recommended the following methods (see applications, 7.3.3.2).

Sowing or planting in cairns: Preference to be given to direct sowing of big, fresh, ripe acorns 3 cm deep in the soil, where no interference by wild boar is envisaged. Where there is fear of such interference, it is preferable to grow seedlings in nurseries, and transplant them in the following winter. If there is a possibility of irrigation, it is recommended to transplant the seedlings in the second winter after pruning their roots. It is important to keep the ground around the seedlings free of grasses during the first few years, and it is desirable to give water in late spring and in summer.

12.3.4 *Tourism and Hinking*

In accordance with the objectives set out above (12.2.3), we recommend that utilization of the area should take the following form.

1 Strict zones : -*Quercus ithaburensis* forest - between the Meshoshim and Zavitan streams;
-Grasslands, savannoid vegetation and springs - between the Yahudia and Daliot streams;
-Streams: Taybeh, Batra, Daliot and Gamla streams, with exception of the reaches above the Daliot and Gamla stream waterfalls.

In fact, the whole area between the Yahudia and Daliot streams is closed to the public, and this area is also earmarked for being populated with wildlife (see below).

All the strict protected habitats are represented also in the area to which the public have access.

2 Walking routes: -the upper reaches of the Daliot and Gamla streams;
-the Gamla antiquities;
-the Yahudia, Zavitan and Meshoshim streams;
-forest areas between the Yahudia and Zavitan streams and east of the Meshoshim stream;

3 Intensive development areas : -Gamla - visitors centre, including exhibits and guidance on the Gamla antiquities, water scenery and nests of raptors;
-Yahudia - central starting point for walking tours, picnic area and information centre;
-Karane - observation point, picnic area, starting point for visits to Meshoshim pool;

4 Wildlife sanctuary : -In the Batra area (T, see Map 3.2), with acclimatization enclosures and various facilities at the border of the reserve, and a route of about 2 km for guided tour in

reserve vehicles along fringes of animal sanctuary.
Suitably equipped observation points around area.

12.3.5 *Research*

In this research we have not elicited all the information we could from the Yahudia Reserve. Many spheres have not been covered, and others have been covered only partly. We recommend that research and information should be enhanced, particularly in the following fields:

- Primitive plants of the Thallophyta groups and Bryophyta phylum;
- Aquatic flora and fauna;
- Quantitative and qualitative invertebrates survey;
- A more intensive research of vertebrates;
- Applied research on agricultural damage, such as finding a suitable solution with regard to jackal population size;
- Populating the reserve with wildlife. Research of methods and of species to be reintroduced.

13 SUMMARY

6 main subjects connected with the ecology of the Yahudia Forest Reserve are discussed in this paper, following a general survey of the history of nature conservation in Israel against the background of the neighbouring countries. We have described the physical and historical background of the Yahudia Forest; the inventory of vertebrates; the inventory of vegetation, analysing composition and mapping; described and researched *Quercus ithaburensis* from various aspects, with emphasis on phenology, germination, establishment and survival, and have also described and researched fires and cattle grazing in the Reserve.

The Yahudia Forest is a nature reserve situated in the central part of the Golan, north-east of Lake Tiberias. The reserve, which extends over some 6600 ha, is located mostly 0-300 m above sea level. Level in its greater part, the reserve is cleft by deep canyons of perennial streams. Its soil, mostly basaltic-montmorilonitic, overlies mother rock of cover basalt which erupted in the Upper Pliocene and the Pleistocene epochs. A few limestone exposures from the Neogene can be found in the southern part. The climate is mediterranean, with annual precipitation of about 500 mm.

In our survey of vertebrates we found 172 species. A more detailed survey was made of rodents and birds. As for mammals, our main interest was centred on wild boar, gazelles and rodents in context with their impact on vegetation in general and on *Quercus ithaburensis* in particular.

The vegetation survey was analysed by the nodal ordination method, and vegetation units were established accordingly. The central vegetation unit is the *Quercus ithaburensis* formation whose principal alliance of associations is that of a *Quercus ithaburensis* park forest, with grasslands of *Avena sterilis* and *Hordeum bulbosum* occupying the greater part of the plane areas. The higher areas of the *Quercus ithaburensis* Park Forest contain a unit of *Ziziphus lotus* savannoid vegetation, which appears to be a secondary vegetation following deforestation. In the low-lying regions of the forest park we have a unit of *Ziziphus spinachristii* savannoid vegetation. On the steep declivities grows an alliance of *Styrax officinalis* and *Ferula tingitana* associations which creates a denser forest. The aquatic vegetation is represented by the *Salix acmophylla*-*Nerium oleander* formation, and on the limestone exposures we have the *Salsola vermiculata* - *Salvia dominica* formation.

The phenology of *Quercus ithaburensis* has been researched and described, and the formation of cambial rings examined. It was found that normally one annual ring is formed, and that a direct connection exists between the quantity of annual precipitation and ring-width. On the basis of this connection and correlation between surface of sections and ages of trees, we drew up a diagram of distribution of tree ages which shows a high frequency of 40-60 years old trees and a low frequency of trees over 100 years old. On the basis of this diagram and historical evidence, we came to the conclusion that most fellings of trees in the forest occurred in the periods of Circassian settlement during the latter half of the 19th Century and during the period of the First World War. The relatively high frequency of seedlings and mature trees, and the low frequency of middle-aged trees, led us to a deeper research of the subject of seedling germination, establishement and survival.

We examined the fertility of *Quercus ithaburensis* trees and the extent of acorn consumption by animals, and found great variability in acorn production, though the average yield per tree was 800 acorns. The greater part of the acorns are consumed by wild boar, and the smaller part by cattle and rodents. Acorns have a high germination potential, but lose it within a few days of having been exposed to dry weather conditions.

Over a period of 5 years observations were made of natural, hand-sown and transplanted seedlings under different grazing regimes (without wild boar or cattle; with wild boar and without cattle; with wild boar and cattle), and in different habitats connected with cairns on which grow most of the trees in the forest (top of cairn; slope of cairn; slope of cairn within tree's shade zone; bottom of cairn; open space outside cairn).

We found that there was more germination in open habitats, though only in the absence of wild boar. Where wild boar are present cairns have the advantage because not only are they more difficult of access to wild boar but desiccation of acorns is avoided there.

The positive reactions to irrigation and weeding have proved that water and competition are limiting factors in seedling establishment. It was found that acorns survive better in cairns where they are shielded from desiccation, competition with grasses, and to a relative extent also from fires. Satisfactory establishment was found under cattle-grazing regimes, where seedlings have less competition with herbaceous vegetation and fact lower fire frequency and intensity.

An analysis was made of the fire incidents in the Yahudia Forest - all of which man-made. In the southern part of the reserve which contains military training areas, a high frequency of fires was recorded in May. Here, a small number of fires consume large areas. In the northern part, which is under grazing, more fires occur although they are of lower intensity and consume smaller areas, and frequency is highest in June-July. A fire-frequency map was drawn up, enabling forecasts to be made of fire-prone areas, and accordingly a policy of fire-break spraying and control was recommended. It was found that notwithstanding the relative fire resistance of the adult tree, the impact of fire on seedlings and acorns is of tremendous significance for the forest's existence.

Cattle-grazing in the reserve has been examined with regard to its effects on herbaceous vegetation and on *Quercus ithaburensis*. A quantitative analysis of forage composition and cattle behaviour on pasture was made. It was found that only heavy grazing affects the composition of herbaceous vegetation and causes a relative rise in the growth of ruderal species. *Quercus ithaburensis* was found to form an important component of the cattle's diet, with leaves being consumed in summer, and acorns in winter. The quantity and nutritional value of acorns consumed made them a factor that should be taken into account in pasture planning.

A theoretical model describing the processes of germination, establishment and survival of *Quercus ithaburensis* has been brought, as have the various factors affecting the two main inhibition periods in the life of the seedling. The main factors were found to be fire, water regime, and competition with grasses and adult trees, whereas rodents and wild boar have positive as well as negative effects, particularly during the germination period.

We have recommended that reserve management be based on programmed cattle-grazing of about 1200 mother cows in the northern part of the reserve, and on a fire-prevention regime with emphasis on the self-same area.

We have worked out a policy of regulating visitor intensity in accordance with the vulnerabilities of the various reserve areas, based on strict zones in the cental part of the reserve; zones for walking tours, and intensive development zones. Recommendation has been made to concentrate wildlife and reintroduce wild animal species that existed in the region in the past into the central area of the reserve's southern part, and to afford the public limited access to this area.

As far as vegetation is concerned, no intervention appears to be necessary, with the exception of afforestation of *Quercus ithaburensis* and *Pistacia atlantica* in the high-lying, unforested parts, and to extend such afforestation also to regions outside the reserve that were covered with forest in the past. A technique for planting *Quercus ithaburensis* trees has been recommended.

In this paper, we have dealt with the processes and main problems of the reserve, with a view to gaining tools for its management and with the intention that it may also serve as a model for researches in other nature reserves in Israel and comparable areas elsewhere. We are aware that there is still much room for research and accomplishment in spheres which have not found expression in this paper.

SAMENVATTING

In deze publicatie worden 6 belangrijke onderwerpen, verband houdende met de ecologie van het Yahudia Bos Reservaat, besproken in aansluiting op een algemeen overzicht van de geschiedenis van de natuurbescherming in Israël, bezien in groter verband met die van de aangrenzende landen. De fysische en de historische achtergrond van het Yahudia bosgebied wordt beschreven met een inventarisatie van de vertebraten-fauna en een inventarisatie van de vegetatie, waarbij de samenstelling wordt geanalyseerd en in kaart gebracht. *Quercus ithaburensis* wordt beschreven en vanuit verschillende aspecten onderzocht.
In het bijzonder wordt aandacht gegeven aan de phenologie, het kiemen, het aanslaan en het overleven. Tevens werden het optreden van branden en de begrazing door vee beschreven en onderzocht.

Het Yahudia Bos natuurreservaat is gelegen in het centrale deel van de Golan, ten Noord-Oosten van het Meer van Tiberias.
Het reservaat, dat een oppervlakte heeft van 6600 ha, is gelegen op 0-300 m boven zeeniveau. Het is grotendeels vlak, maar het reservaat is doorsneden door diepe canyons van riviertjes die het hele jaar door water bevatten.
De bodem, meest basalt-montmorilonietachtig, bedekt onderliggende rots van dekbasalt van erupties in het boven-plioceen en het pleistoceen. Een paar kalkgesteende opduikingen van het neoceen kunnen in het zuidelijke gedeelte worden gevonden.

Het klimaat is Mediterraan, met een jaarlijkse regenval van ongeveer 500 mm.

Bij de inventarisatie van de gewervelde dieren werden 172 soorten gevonden. Van de knaagdieren en de vogels werd een meer gedetailleerde inventarisatie verricht. Bij de grotere zoogdieren is de belangstelling vooral geconcentreerd op het wilde zwijn, de gazellen en de knaagdieren in verband met hun invloed op de vegetatie in het algemeen en op *Quercus ithaburensis* in het bijzonder.

De vegetatie werd geanalyseerd met de nodale ordinatiemethode en de vegetatie-eenheden werden op basis daarvan onderscheiden. De centrale vegetatie-eenheid is de *Quercus ithaburensis*-formatie. Het voornaamste verbond van associaties van deze formatie is dat van een *Quercus ithaburensis*-park-bos, met graslandvegetaties van *Avena sterilis* en *Hordeum bulbosum*, die het grootste deel van de vlakke gebieden bedekken. De hoger gelegen gedeelten van het *Quercus ithaburensis*-park-bos bevat een eenheid (gezelschap) van een *Ziziphus lotus* savannoïde vegetatie. Dit blijkt een secondaire vegetatie te zijn die zich ontwikkelt na ontbossing. In de laag gelegen gedeelten van het park-bos komt een eenheid (gezelschap) voor van een *Ziziphus spinachristii* savannoïde vegetatie. Op de steile wanden van de kloven groeit een verbond van *Styrax officinalis* en *Ferula tingitana*-associaties, die een dicht bos vormen.

De aan water gebonden vegetaties zijn vertegenwoordigd door de *Salix acmophylla - Nerium oleander*-formatie en op de kalkzandsteenopduikingen groeit de *Salsola vermiculata - Salvia dominica*-formatie.

De phenologie van *Quercus ithaburensis* wordt onderzocht en beschreven en de vorming van cambiumringen bestudeerd. Het lijkt dat er normaal jaarlijks een ring gevormd wordt en dat er een direkt verband bestaat tussen de hoeveelheid jaarlijkse neerslag en de breedte van de ring. Op grond van dit verband en de correlatie tussen de oppervlaktes van de secties en de leeftijd van de bomen, is een diagram gemaakt van de verspreiding van de leeftijden van de bomen. Dit levert een hoge frequentie op van 40-60 jaar oude bomen en een lage frequentie van bomen boven de 100 jaar.

Op grond van dit diagram en van historische gegevens wordt geconcludeerd dat de meeste bomen in het bos werden gekapt gedurende de periode van Circassische bewoning gedurende de tweede helft van de 19e eeuw en gedurende de eerste wereldoorlog.

Het veelvuldig voorkomen van zaailingen en volgroeide bomen en het feit dat er weinig bossen zijn met middelgrote bomen leidde tot een diepgaander onderzoek van het onderwerp betreffende het kiemen, het aanslaan en de overleving van de zaailingen.

Bij de bestudering van de vruchtbaarheid van de *Quercus ithaburensis*-bomen en de mate van eikelconsumptie door dieren, werd een grote verscheidenheid gevonden in de produktie van eikels, hoewel de gemiddelde opbrengst per boom 800 eikels bedroeg. Het merendeel van de eikels wordt genuttigd door het wild zwijn, minder door vee en knaagdieren.

Eikels hebben een hoog ontkiemingspotentiaal maar verliezen dat binnen enkele dagen na te zijn blootgesteld aan droge weersomstandigheden.

Over een tijdstip van 5 jaar werden waarnemingen verricht van natuurlijk verjongde, met de hand gezaaide en geplante zaailingen onder wisselende begrazingssystemen (zonder wild zwijn of vee; met wild zwijn, zonder vee; met wild zwijn en vee). Ook van verschillende habitats die verband houden met steenhopen waarop de meeste bomen van dit bos staan (de top van de steenberg; de helling; de helling van de steenhoop binnen het schaduwgebied van de boom; onder aan de steenhoop; open ruimte buiten de steenhoop).
Er werd meer ontkieming aangetroffen in de open habitats, hoewel slechts bij afwezigheid van wilde zwijnen.
Waar het wild zwijn voorkomt hebben de steenhopen het voordeel, omdat deze niet alleen moeilijker toegankelijk zijn voor wilde zwijnen, maar bovendien wordt hier een uitdroging van de eikels verhinderd.

De positieve reakties op irrigatie en wieden hebben bewezen dat water en concurrentie de bepalende factoren zijn in de vestiging van zaailingen. Het bleek dat eikels beter overleven in steenhopen waar zij beschermd zijn tegen uitdroging, concurrentie van grassen en tot op zekere hoogte ook van branden.
De vestiging bleek bevredigend bij veebeweidingssystemen waar zaailingen minder concurrentie van de kruidenvegetatie hebben en die een lagere frequentie van branden met geringere intensiteit veroorzaken.

Er werd een analyse gemaakt van de zich in het Yahudia bosgebied voordoende branden - deze waren alle door de mens veroorzaakt. In het zuidelijk deel van het reservaat, waar zich een militair oefenterrein bevindt, werd een hoge frequentie van branden in mei geconstateerd. In dit gebied werden grote gebieden door een gering aantal branden aangetast. In het noordelijk gedeelte, dat werd begraasd, kwamen meer branden voor, maar deze waren niet zo fel en zij tastten kleinere gebieden aan. Hun frequentie was het hoogste in juni/juli. Er werd een brandfrequentiekaart gemaakt, die het mogelijk maakt aan te geven welke gebieden op een gegeven moment het meest brandgevaarlijk zijn. Op grond daarvan wordt een beleid aanbevolen voor het bespuiten en het controleren van brandgangen.

Bij het onderzoek werd gevonden dat, niettegenstaande de relatief hoge vuurbestendigheid van de volgroeide bomen van *Quercus ithaburensis*, de invloed van brand op zaailingen en eikels van zeer grote betekenis is voor het bestaan van het bos.

De begrazing met vee in het reservaat werd onderzocht met het oog op zijn uitwerkingen op de kruidenvegetatie en op *Quercus ithaburensis*. Er werd een kwantitatieve analyse gemaakt van de samenstelling van grasvegetaties en van de gedragingen van het vee in het beweidingsgebied. Daarbij werd gevonden, dat slechts intensieve begrazing invloed heeft op de samenstellingen van de kruidachtige vegetaties en daar een relatieve toename veroorzaakt van de groei van ruderale soorten.
Quercus ithaburensis bleek een belangrijke component te zijn in het door het vee opgenomen voedsel, in de zomer werden de bladeren gegeten, in de winter de eikels. De kwantiteit en de voedingswaarde van de gegeten eikels maken dat zij voor het voedselpakket van het vee een faktor zijn waarmee rekening dient te worden gehouden bij het maken van plannen voor de beweiding. Er is een theoretisch model opgesteld dat een beschrijving geeft van het kiemen, het aanslaan, het overleven van *Quercus ithaburensis*, evenals van de verschillende faktoren die de twee belangrijkste moeilijke perioden in het leven van een kiemplant beinvloeden.

De belangrijkste faktoren bleken te zijn: vuur, waterhuishouding en concurrentie met grassen en met volgroeide bomen, terwijl knaagdieren en wilde zwijnen, zowel positieve als negatieve effecten hebben, speciaal in de periode van het kiemen.

Er is aanbevolen dat het beheer van het reservaat dient te worden gebaseerd op geprogrammeerde beweiding met vee (met ongeveer 1200 koeien in het noordelijke deel van het reservaat) en op een regime om branden te voorkomen speciaal in datzelfde gebied.

Er is een beleid uitgewerkt ter regulering van bezoekintensiteiten in overeenstemming met de kwetsbaarheden van de verschillende reservaatgedeelten.
Dit leidde tot de instelling van afgesloten strikte gebieden in het centrale deel van het reservaat, gebieden voor wandeltochten en gebieden voor intensieve recreatie-ontwikkeling.

Er is aanbevolen om speciale gebieden te beheren voor natuurwaarden om in het wild levende diersoorten, die vroeger in het gebied voorkwamen, weer terug te brengen in het centrale deel van het zuidelijk gedeelte van het reservaat.

Het publiek zou dit gedeelte in beperkte mate mogen betreden.

Voor wat de vegetatie betreft, blijkt er geen noodzaak te bestaan tot ingrijpen, met uitzondering van bebossing met *Quercus ithaburensis* en *Pistacia atlantica* op de hooggelegen onbeboste gedeelten en van uitbreiding van deze bebossing ook tot regio's buiten het reservaat, die in het verleden met bos bedekt waren.

Er wordt een techniek aanbevolen voor het planten van *Quercus ithaburensis*-bomen.

In deze publicatie worden de processen en de voornaamste problemen van het reservaat behandeld met het oogmerk middelen aan te dragen ten dienste van het beheer hiervan - met tevens de bedoeling dat deze ook als model zouden kunnen dienen voor onderzoek in andere natuurreservaten in Israël en in vergelijkbare gebieden elders.

Het is duidelijk dat er nog veel ruimte overblijft voor verdere studie en voor de aanpak van onderzoekgebieden die in deze publicatie niet ter sprake zijn gekomen.

14. סכום

14. Hebrew summary

6 נושאים מרכזיים הקשורים באקולוגיה של שמורת יער יהודיה נדונו בעבודה זו לאחר סקירה כללית של תולדות שמירת הטבע בישראל על רקע הארצות השכנות לה. תואר הרקע הפיסי וההסטורי של יער יהודיה, מצאי בעלי החוליות, מצאי הצומח, ניתוח הרכבו ותיפוצו. תואר ונחקר אלון התבור מהיבטים שונים תוך דגש על פנולוגיה, נביטה, התבססות והשרדות בחיים, וכן תוארו ונחקרו השריפות ורעית הבקר בשמורה.

יער יהודיה הנה שמורת טבע השוכנת במרכז הגולן, מצפון-מזרח לאגם הכנרת (ר' מפות 3.1, 3.2). שטח השמורה כ-66,000 דונם וברובה שוכנת בתחום הגבהים 300-0 מ' מעל פני הים התיכון. שטח השמורה מישורי ברובו ומבותר ע"י נחלים עמוקים ואיתנים. הקרקע הנה בזלתית מונטמורילוניטית בעיקרה, על סלע אם של בזלת כיסוי שפרצה בתקופת הפליוקן העליון והפליסטוקן. בדרום השמורה מחשופים גירניים מועטים מתקופת הנאוגן (ר' מפה 3.3 וציור 3.1). האקלים הנו ים תיכוני עם כמות משקעים של כ-500 מ"מ בשנה.

בסקר בעלי החוליות שערכנו מצאנו 172 מינים (ר' טבלה 4.1). סקר מפורט יותר ערכנו לגבי מכרסמים (ר' טבלה 4.2) ולגבי ציפורים (ר' טבלה 4.4). מבין היונקים גילינו ענין בחזירים, בצבאים ובמכרסמים בהקשר להשפעתם על הצומח בכלל ועל אלון התבור בפרט.

סקר הצומח שנערך נותח בשיטת האורדינציה המוקדית ונקבעו יחידות הצומח בהתאם (ראה טבלה 5.6). יחידת הצומח המרכזית היא תצורת אלון התבור אשר בתוכה אגד החברות העיקרי הוא יער פרק של אלון תבור עם בתה עשבונית של שבולת שועל נפוצה ושעורת הבולבוסין התופס את מרבית השטחים המישוריים. באזורים הגבוהים יותר מיער פרק אלון התבור ישנה חברה של שיזף השיח, היוצר נוף דמוי סוואנה, שהיא כנראה חברה משנית אחרי בירוא יער אלון התבור. באזורים הנמוכים מיער הפרק מופיעה חברה של שיזף מצוי היוצרת גם היא נוף דמוי סוואנה. במדרונות התלולים נמצא את אגד החברות של לבנה רפואי וכלך מרוקני היוצר יער צפוף יותר. צומח המים מהווה את תצורת ערבה מחודדת והרדוף הנחלים, ובמחשופים הגירניים גדלה תצורת מלחית אשונה ומרווה ריחנית. (ר' מפה 5.1 ונספח 5.2.1).

הפנולוגיה של אלון התבור נחקרה ותוארה (ר' ציורים 6.7-6.2), ונבדקה יצירת טבעות קמביאליות ע"י אלון התבור. נמצא כי בדרך-כלל נוצרת טבעת אחת בשנה, וכי היה קשר ישר בין כמויות המשקעים השנתיות ועוביי הטבעות (ר' ציור 6.8). על סמך קשר זה ומתאם בין שטח חתכי העצים וגילם, שורטטה דיאגרמה של התפלגות הגילים של העצים המראה תדירות גבוהה של גילאי 60-40 שנה ותדירות נמוכה מעל 100 שנה(ר' ציור 6.10). על סמך דיאגרמה זו, ועל סמך עדויות הסטוריות, הגענו למסקנה כי הכריתות העיקריות של עצי היער היו בתקופת

התישבות הצ'רקסים במחצית השניה של המאה ה-19, ובתקופת מלחמת העולם הראשונה. תדירות גבוהה יחסית של נבטים ושל עצים מבוגרים, ונמוכה של גילאי הביניים, הביאה אותנו למחקר מעמיק יותר של נושא הנביטה, ההתבססות וההשרדות של נבטים.

נבדקה פוריות עצי אלון התבור ומדת צריכת הבלוטים ע"י בעלי חיים ונמצא כי יש שונות רבה ביצור בלוטים, אך התנובה הממוצעת לעץ היא כ-800 בלוטים בשנה. רוב רובם של הבלוטים נאכלים ע"י חזירי בר ומיעוטם ע"י בקר ומכרסמים (ר' טבלה 7.1).

פוטנציאל הנביטה של הבלוטים גבוה, אך הם מאבדים את כושר נביטתם תוך ימים אחדים של חשיפה לתנאי יובש.

במשך כ-5 שנים נערכו תצפיות הן בנבטים טבעיים והן בנבטים שנזרעו או נשתלו במשטרי רעיה שונים (ללא חזירים וללא בקר, עם חזירים וללא בקר, עם חזירים ועם בקר), ובבתי גידול שונים הקשורים בגלי האבן עליהם גדלים מרבית העצים ביער (ראש הגל, מדרון הגל, מדרון הגל בצל העץ, תחתית הגל, שטח פתוח מחוץ לגל)(ר' ציור 8.1). מצאנו כי בבית הגדול הפתוח הנביטה רבה יותר, אולם רק בהעדר חזירים. בנוכחות חזירים יש יתרון לגל האבן, שם גם הגישה לחזירים קשה, ושם נמנעת התיבשות בלוטים.

תגובה חיובית להשקיה ולעשוב הוכיחה כי המים והתחרות עם העשבוניים הנם גורמים מגבילים בהתבססות הנבטים. השרדות נבטים טובה יותר נמצאה בגל האבנים, שם הם מוגנים מפני התיבשות, מפני תחרות עם עשבוניים, ויחסית גם מפני שריפות. התבססות נבטים טובה נמצאה במשטר של רעית בקר, שם יש לנבטים פחות תחרות עם הצומח העשבוני ותדירות ועוצמה נמוכות יותר של שריפות.

נערך ניתוח של ארועי השריפות ביער יהודיה שהן כולן מעשה ידי-אדם. בחלק הדרומי של השמורה, בו יש שטחי אימונים, תדירות גבוהה של שריפות נרשמה במאי. באזור זה ישנן מעט שריפות המבעירות שטחים גדולים. בחלק הצפוני, הנתון ברעיה, פורצות שריפות רבות יותר במספר, אך בעוצמה קטנה יותר ומכסות שטח קטן יותר ותדירותן גבוהה ביוני-יולי (ר' מפות 9.1). שורטטה מפה (מפה 9.2) של תדירות השריפות בשמורה המאפשרת לחזות את האזורים המועדים לשריפות, ובהתאם הומלצה מדיניות של ריסוס פסי אש ופקוח. נמצא כי למרות העמידות היחסית של עץ אלון התבור הבוגר, הרי הפגיעה של השריפות בנבטים ובבלוטים משמעותית ביותר לקיום היער.

מרעה הבקר בשמורה נחקר הן מבחינת ההשפעה על הצומח העשבוני והן על האלונים. נערך ניתוח כמותי של הרכב מזון הבקר (טבלה 10.2) והתנהגותו במרעה (נספח I 10.1) באמצעות תצפיות ישירות באכילת הבקר ומדידות מורכבות של התנהגותו. נמצא כי רק ברעיה חזקה משפיעה רעית בקר על הרכב הצומח העשבוני וגורמת לעליה יחסית של מינים רודרליים. אלון התבור נמצא כמרכיב חשוב במזון הבקר, כאשר בקיץ נאכלים העלים ובחורף נאכלים הבלוטים. כמות הבלוטים הנאכלת וערכם המזוני הופכים אותם לגורם שיש להתחשב בו בתכנון המרעה העשוי לגרום להקטנת כמויות המזון החיצוניות המואבסות לבקר.

הובא מודל תאורטי המתאר את תהליכי הנביטה, ההתבססות ואת השרדות אלון התבור (ציור 11.2), והובאו הגורמים השונים המשפיעים לחיוב ולשלילה בעיקר בשלב הנביטה.

הומלץ משטר שמורה המבוסס על רעית בקר מתוכננת של כ-1200 אמהות בחלק הצפוני של השמורה ומשטר של מניעת שריפות תוך דגש על חלק זה גם-כן. גובשה מדיניות של הכוונת תכיפות הביקור של מטיילים בהתאם לרגישות חלקים של השמורה, המבוססת על שטחים סגורים בלב השמורה, אזורים לטיול רגלי ואזורים עם פתוח מוגבר ותכיפות ביקורים רבה.

הומלץ לרכז חיות בר ולייבא מחדש (ראינטרודוקציה) חיות בר שחיו בעבר באזור, במרכז החלק הדרומי של השמורה, ולפתוח חלק זה באופן מוגבל לציבור.

לא נראה צורך להתערבות בנושא הצומח, למעט יעור של אלון התבור ושל אלה אטלנטית בחלקים הגבוהים, הלא מיוערים, של השמורה, ולהרחיב נטיעות אלו גם מחוץ לשמורה לאזורים שהיו מיוערים בעבר. הומלצו שיטות לנטיעות של אלוני תבור (ר' 7.3.3.2.2.).

בעבודה זו נגענו בתהליכים ובבעיות העקריות של השמורה מתוך מגמה לקבל כלי לניהולה, ומתוך כוונה שעבודה זו תשמש דגם גם לעבודות אחרות בשמורות טבע בישראל. אנו ערים לכך כי עדיין יש כר נרחב למחקר ולהשלמת התחומים שלא באו לידי ביטוי בעבודה זו.

15 References

Aaronsohn A., (1931): Florula Transiordanica Bul. de la Société Botanique de Genève. Vol. 22.

Agami M., (ed. 1975): Survey of plant and wildlife species which have become extinct, or are facing extinction in Israel. Environ. Prot. Ser. Pub. No. 75-01 (Hebrew).

Aloni R., Orshan G. (1975): A vegetation map of the lower Galilee. Isr. J. of Bot. 21: 209-227.

Anderson E.W., Scherzinger R.J. (1975): Improving quality of winter forage for elk by cattle grazing. J. of Range Manage 28: 120-125.

Arnold G.W., Dubzinski M.L., (1966): The behavioural responses controlling the food intake of grazing sheep. Proc. X Inter. Grass. Congr.: 367-370.

Aschmann H., (1977): Aboriginal use of fire. Symp. on the environmental consequences of fire and fuel management in Mediterranean ecosystems. U.S.D.A. Forest Serv. Rep. WO-3: 132-141.

Association of official methods of analysis, (1975): Official methods of analysis. Washington D.C.

Atkinson A., Beaumont P., (1971): The Forests of Jordan. Economic Bot. 25: 305-311.

Atlas of Israel, (1956): Land Survey Department. Bialik Inst.

Awishai M., (1967): Taxonomic-Geographic Studies in the Middle-East Oaks. M.Sc. thesis, Hebrew Univ. Jerusalem.

Baharav D., (1974): Notes on the population structure and biomass of the mountain gazelle (Gazella gazella gazella). Isr. J. Zool. 23: 39-44.

Baharav D., (1975): Energy flow and productivity in a mountain gazelle (Gazella gazella gazella, Pallas 1766) population. Ph.D.thesis, Tel Aviv Univ. (Hebrew, English summary).

Bell R.H.V., (1971): A grazing ecosystem in the Serengeti. Scien. Amer. 225: 86-93.

Berliner R., (1971): The post-Eocene volcanic sediments vegetation in Galilee. M.Sc. theses. Hebrew Univ. Jerusalem (Hebrew, English summary).

Berliner R., (1978): Proposals for Nature Reserves and Sites in Samaria that are worth preserving. Nature Reserves Authority. Surveys and Researches, No. 3.

Biran I., (1977): Effects of pruning of Quercus ithaburensis roots on growth rhythm and morphology of roots and above-ground growth. Hamamot U'Prahim 4(7): 45-46 (Hebrew).

Biswell H.H., (1977): Prescribed fire as a management tool. Symp. on the environmental consequences of fire and fuel management in Mediterranean ecosystems. U.S.D.A. Forest Serv. Rep. WO-3: 151-162.

Blattmann W., (1966): The effect of the first grazing date in spring on the botanical composition of permanent pasture swards. Proc. X Inter. Grass. Congr.: 168-171.

Bossema I., (1979): Jays and Oaks: An eco-ethological study of symbiosis. Behaviour 70: 1-2.

Bourliere F., (1962): Science and parks in the tropics. IUCN 1st World Conf. on National Parks: 63-68.

Bourliere F., (1967): The evolution of the concept of nature conservation. W.W.F. Int. Congr.: "Nature and Man", Amsterdam: 20-27.

Bowyer T.R., and Black V.C., (1979): Ecological relationships between southern mule deer and Calif. black oak. Proc. Symp. Ecol. Manage. Utiliz. Cal. Oak: 292-296.

Boyd J.M., (1965): International biological station. Azraq, Hashemite Kingdom of Jordan IBP/CT.

Braun-Blanquet J., (1932): Plant Sociology. McGraw-Hill, 1932.

Burt W.H., (1940): Territorial behaviour and populations of some small mammals in Southern Michigan. Misc. Pub. Mus. Zool. Univ. Mich. 45: 1-58.

Cain A., (1970): Preservation of natural areas and ecosystems; protection of rare and endangered species. UNESCO: Use and conservation of the biosphere: 143-153.

Carlisle A., Brown A.H.F., (1967): The influence of forest practices on woodland nature reserves. Symp. No. 3. Monks wood exp. station Nature Conservancy Britain. "The biotic effects of public pressures on the environments." ed. E. Duffey, 1967: 69-81.

Caughley G., (1976): Plant behaviour systems. Theoretical Ecology, May R.M. (ed.), Blackwell Sci. Pub.: 94-113.

Cnaani G., (1972): Studies of the ecology and the behaviour of the wild boar (Sus scrofa Lybicus, Gray 1868) in the Mt. Meiron region. M.Sc. thesis, Tel Aviv Univ. (Hebrew, English summary).

Cottam G., (1949): The phytosociology of an oak wood in southwestern Wisconsin. Ecol. 30: 271-287.

Crompton G., Walters S.M., (1964): Thriplow meadows management experiment. The Society's Handbook for 1964: 23-26.

Crowe S., (1972): The master plan for national parks and their regional setting. IUCN World Conference on National Parks U.S.A. Sept. 1972.

Dan.J., (1972): The Golan soils. Teva Ve Aretz 15: 12-18 (Hebrew).

Dan J., Singer A., (1973): Soil evolution on basalt and basic pyroclastic materials in the Golan Heights. Geoderma 9: 165-190.

Dan J., Yaalon D.H., Koyumdkisky H., Raz Z., (1975): The soil association map of Israel (1:500,000). Volcani Inst. Agric. Res., Israel Pam. No. 147.

Danin A., (1968): The vegetation of the Golan. Teva Ve Aretz 10: 162-167 (Hebrew).

Darling F.F., (1960): Wild life in an African territory. Oxford Univ. Press.

Dasmann R.F., (1964): Wildlife biology. John Wiley & Sons, New York.

Decaisne M.J., (1835): Liste des plantes recueillies par M. Bové dans la Palestine et la Syrie. Annales des Sciences Naturelles Série 2, 4: 343-360.

Dixon W.J., Brown M.B., (1979): Biomedical computer programs. P-series (BMDP): 517.1-517.13. Univ. Calif. Press.

Dinoor A., (1962): The effect of Quercus ithaburensis on its herbaceous associates. Bull. Res. Coun. Israel 11D: 1-16.

Dor M., (1965): Zoological Lexicon, Vertebrata. Dvir Publications (Hebrew).

Dubos R., (1970): Man and his ecosystem; the aim of achieving a dynamic balance with the environment, satisfying physical, economic, social and spiritual needs. UNESCO: Use and Conservation of the Biosphere: 177-189.

Duncan D.A., Clawson S., (1979): Livestock utilization of Calif. oak Woodlands Proc. Symp. Ecol. Manage, Utiliz. Calif. Oaks: 306-313.

Dybbro T., (1976): De Danske ynglefugels udbedelse. Danske Ornithologist Forening.

Edmond D.B., (1966): The influence of animal treading on pasture growth. Proc. X Inter. Grass. Congr.: 453-458.

Eig A., (1934): A historical-phytosociological essay on Palestine forests of Quercus aegilops L. ssp. ithaburensis (Desc) in past and present. Beihefte Botanischen Centralblatt 51B: 225-272.

Eisenberg J.F., Lockhart M., (1972): An ecological reconnaissance of Wilpattu National Park, Ceylon: The wild swine (Sus scrofa). Smithsonian Inst. Press. Washington No. 101.

Elan S., Gutman M., (1977): The rangelands of Israel. Unpublished communication. Agricultural Ministry, Israel.

Ellison L., (1960): Influence of grazing on plant succession of rangelands. Bot. Rev. 26: 1-78.

Epstein C., Gutman S., (1972): Archaeological Survey of the Golan Heights. Israel Archaeological Soc. (Hebrew).

Epstein C., (1974): The dolmens in the Golan. Qadmoniot 4: 37-40 (Hebrew).

Eygenraam J.A., Pieters J., (1966): Gräser für wildäcker und ihre behandlung. Zeitschrift für Jagdwissenschaft 12: 16-28.

Fahn A., (1953): Annual wood ring development in maquis trees in Israel. Pal. J. Bot. Jerusalem series 6: 1-26.

Felix J., (1968): Tree and forest on the Golan. Teva Va Aretz 3: 169-178.

Field C.R., (1975): Climate and food habits of ungulates on Golana Ranch. East Africa Wild. J. 13: 203-220.

Fisher J., Simon N., Vincent J., (1969): The red book: Wildlife in danger. Collins, London.

Fishman E., (1974): The importance of the edaphic factor to the woody vegetation of the Golan. Unpub. (Hebrew). Nature Reserves Authority, Jerusalem.

Firouz E., Hassinger J.D., Ferguson D.A., (1970): The wildlife parks and protected regions of Iran. Biol. Cons. 3: 37-45.

Fosberg F.R., (1968): Scientific need for parks and reserves. IUCN Pub. No. 10: 380-381.

Frischknecht N.C., Harris L.E., (1968): Grazing intensities and systems on crested wheatgrass in central Utah: response of vegetation and cattle. U.S.D.A. Tech. Bull.: 1388.

Gabrielson I.N., (1957): Management of natural reserves on the basis of modern scientific knowledge. IUCN 16th Tech. Meeting, Edinburgh, 1956.

Gal I., (1978): Israel Guide: Hermon and Golan (Itzchaki A., ed.). Keter, Israel (Hebrew).

Garrett W.N., Bond T.E., Pereira N. (1967): Influence of shade height on physiological responses of cattle during hot weather. Transactions Amer. Soc. Agri. Engineers 10: 433-438.

Gat Z., Lomas Y., (1969): Agroclimatic analysis of the Golan Heights (General Report). Israel Meteorological Serv. Rep. 4/69 (Hebrew).

Gat Z., Paster A., (1974): Agroclimate of the Golan Heights - Analysis of Precipitation. Israel Meteorological Serv. 2/74 (Hebrew).

Gat Z., Paster Z., (1975): Agroclimate of the Golan Heights - Temperature and Relative Humidity Analysis. Israel Meteorological Serv. Rep. 4/75 (Hebrew).

Geri G., Sottine E., (1970): In vitro digestibility of buds and leaves of some plants of the mediterranean maquis. Alimentaz. Anim. 14: 11-24.

Ghabbour S.I., (1971): Some aspects of conservation in Egypt. Biol. Con. 4: 66-67.

Gichon M., (1969): Carta's Atlas of Palestine from Bethther to Tel-Hai. Carta, Jerusalem (Hebrew).

Goldsmith F.B., (1974): Ecological effects of visitors on the country. Conservation in practice, ed. by A. Warren & F.B. Goldsmith: 217-231.

Goodall D.W., (1969): Simulation of the grazing situation. Biomathematics 1: Concepts and models of biomathematics ed. F. Heinmets: 211-227.

Grayevsky Y., (1978): Observation in comparative biology of rodents from the genera Apodemus. (Kamp 1829) in the Mt. Meiron region. M.Sc. thesis, Tel Aviv Univ. (Hebrew, English summary).

Griffin J.R., (1979): Animal damage to valley oak acorns and seedlings. Carmel Valley. Calif. Proc. Sym. Ecol. Manage. Utiliz. Calif. Oak: 242-245.

Grime J.P., (1973): Control of species density in herbaceous vegetation. J. Environ. Manage. 1: 151-167.

Grodzinski W., (1971): Food consumption of small mammals in Alaskan Taiga forest. Ann. Zool. Fennici 8: 133-136.

Cruenberg-Fertig I., (1966): List of Palestine plants with data on their geographical distribution. Hebrew Univ. Jerusalem (Hebrew, English summary).

Gutman M., (1979): Primary production of transitional mediterranean steppe. Agric. Res. Organ., Israel Pam. No. 212 (Hebrew, English summary).

Gutman M., Seligman, N.G., (1979): Grazing management of mediterranean foot-hill range in Upper Jordan River Valley. J. Range Mange. 32: 86-92.

Gutman S., (1977): Gamla. Geography of Israel. Dept of the Kibbutz Movement (Hebrew) Tel-Aviv.

Haiman R., (1980): The vegetation of humid habitats in Meshushim stream basin (Golan). M.Sc. thesis. Hebrew Univ. Jerusalem (Hebrew).

Halfon-Meiri A., (1958): The influence of edaphic conditions on the mineral composition, growth rate and anatomy of oak (Quercus ithaburensis

(Desne, Boiss). Ph.D. thesis, Hebrew Univ., Jerusalem (Hebrew, English summary).

Hallisey D.M., Wood G.W., (1976): Prescribed fire in scrub oak habitat in central Pennsylvania. J. Wild. Manage. 40: 507-516.

Harif I., (1974): First year development of leading species of plant communities in the Judean Hills and its role in succession. Ph.D thesis, Hebrew Univ. Jerusalem (Hebrew, English summary).

Harrington G., (1978): The implications of goat, sheep and cattle diet on the management of an Australian semi-arid woodland. Proc. I Inter. Range. Congr. 447-450.

Hart N.I., (1966): A system approach to park planning. IUCN Pub. No. 4.

Heady H.F., (1964): Palatability of herbage and animal preference. J. Range. Manage. 17: 76-82.

Heinzel H., Fitter R., Parslow J., (1972): The birds of Britain and Europe with North Africa and the Middle-East. Collins, London.

Helliwell D.R., (1969-a): Valuation of wildlife resources. Regional Studies 3: 41-47.

Helliwell D.R., (1969-b): Conservation of wildlife resources. Town and Country Planning 37: 124-126.

Helliwell D.R., (1971): A methodology for the assessment of priorities and values in nature conservation. Merlewood Research and Development, U.K. Nature Conservancy, Paper No. 28.

Horowitz A., (1971): Climate and vegetational developments in northeastern Israel during Upper Pleistocene-Holocene times. Pollen et Spores XIII: 257-278.

Horowitz A., (1979): The Quaternary of Israel. Quaternary pollen spectra, Academic Press: 211-242.

Howard W.E., Fenner R.I., Childs H.E., (1959): Wildlife survival in brush burns. J. Range. Manage. 12: 230-234.

Howard W.E., (1967): Ecological changes in New Zealand due to introduced mammals. IUCN 10th Tech. Meets. Lucern, 1966: 219-240.

Humphrey R.R., Mehrhoff L.A., (1958): Vegetation changes on a southern Arizona grassland range. Ecol. 39: 720-726.

Hydrological Service, (1973): The springs of the Golan Heights. Description of flow data and water quality for the period 1967/68 - 1970/71. Ministry of Agriculture, Water Commission, Israel (Hebrew).

Ilani G., (1979): Zoogeographical and ecological survey of Carnivora in Israel. Nature Preservation in Israel 3. Nature Reserves Authority, Israel (Hebrew).

Inbar M., (1970): Fluviomorphology of the Meshushum stream on the Golan Heights. M.Sc. thesis, Hebrew Univ. Jerusalem (Hebrew).

I.U.C.N., (1971): Environmental conservation education among populations of rural and woodland areas. IUCN Pub. No. 20.

Ivlev V.S., (1961): Experimental ecology of the feeding of fishes. Yale Univ. Press, New Haven, Conn.: 302.

Johnson W.M., (1966): Effects of stocking rates and utilization on herbage production and animal response on natural grasslands. Proc. X Inter. Grass. Congr.: 944-947.

Jones E.W., (1959): Biological flora of the British Isles: Quercus L.J. Ecol. 47: 169-222.

Katznelson J., (1956): On pasture improvement at Bet-Keshet. Meeting of the Natural Pasture in Israel Society Bet-Keshet, Israel (Hebrew).

Kaul R.N., Thalen D.C.P., (1971): Range ecology of the Institute for Applied Research on Natural Resources, Abu-Ghraib, Iraq. Nature and Resources 7: 10-15 (UNESCO Pub.)

Keshet, (1978): Observation on the Golan, Keshet Field School, Golan, Israel (Hebrew).

Kilgour R., (1975): Tips of management arising from animal behaviour studies. Paper presented to Lincoln College Farmers' Conf. New Zealand.

Knapp R., (1971): Influence of indigenous animals on the dynamics of vegetation in conservation areas. 11th Sym. British Ecol. Soc., Blackwell Sci. Pub.(ed. E. Duffey & A.S. Watt): 387-390.

Krueger W.C., Winward A.H., (1974): Influence of cattle and big game grazing on understory structure of a douglas fir - ponderosa pine - Kentucky bluegrass community. J. Range. Manage. 27: 450-453.

Kruger F.J., (1977): Ecology of Cape Fymbos in relation to fire. Symp. on the environmental consequences of fire and fuel management in mediterranean ecosystems. U.S.D.A. Forest Serv. Rep. WO-3: 230-245.

Kydd D.D., (1964): The effect of different systems of cattle grazing on the botanical composition of permanent downland pasture. J. Ecol. 52: 139-149.

Kydd D.D., (1966): The effect of intensive sheep stocking over a five-year period on the development and production of the sward. III. Ecological discussion. J. British Grass. Soc. 21: 298-302.

Land Survey Dept., (1979): Map of Israel 1:50,000, published by Land Survey Dept., Ministry of Labour, Israel (Hebrew).

Laor Y., Shaham G., Etkin A., (1977): Supply of drinking water to settlements in the Katzrin region. Water Plan. Israel Pub. 01/77/32 (Hebrew).

Laycock W.A., Conard P.W., (1967): Effect of grazing on soil compaction as measured by bulk density on a high elevation cattle range. J. Range Manage. 20: 136-140.

Leeuwen C.G. van, (1966): A relation theoretical approach to pattern and process in vegetation. Wentia 15: 25-46.

Le Houerou H.N., (1977): Fire and vegetation in North Africa. Symp. on the environmental consequences of fire and fuel management in mediterranean ecosystems. U.S.D.A. Forest Serv. Rep. WO-3: 334-341.

Leloup M., (1953): Grazing and forest economy. FAO Forestry and Forest Production Studies Nor. 4.

Liacos L.G., (1977): Fire and fuel management in pine forest and evergreen brushland ecosystems of Greece. Symp. on the environmental consequences of fire and fuel management in mediterranean ecosystems. U.S.D.A. Forest Serv. Rep. WO-3: 289-298.

Lincoln F.C., (1930): Calculating waterfowl abundance on the basis of banding returns. U.S. Dept. Agric. Circular 118: 1-4.

Liphshitz N., Waisel Y., (1967): Dendrochronological studies in Israel. I. Quercus calliprinos of Mt. Meron. La'Yaaran 17: 78-91, 111-115.

Litwak M., (1954): Water household of some Quercus ithaburensis varieties. M.Sc. thesis, Hebrew Univ. Jerusalem (Hebrew).

Love R.M., (1961): The range-natural plant communities or modified ecosystem. J. British Grass. Soc. 16: 89-99.

Maarel E. van der, (1971): Plant species diversity in relation to management. 11 Sym. British Ecol. Soc. Blackwell Scientific Pub.: 45-63.

Makin D., (1977-a): Survey of microchiroptera in Israel. Nature Preservation in Israel 2: 127-203 Nature Reserves Authority, Israel.

Makin D., (1977-b): Insect-Bats pose riddles. Teva Va Aretz 19: 74-80 (Hebrew).

Mann S., (1979): Garrulus glandarius is conquering new habitats throughout Israel. Teva Va Aretz 21: 148-152 (Hebrew).

Maoz Z., (1979): Jewish settlement and synagogues on the Golan. Society for the Protection of Nature, Israel (Hebrew).

Mason H.L., (1982): Economic values in parks and preserves. I.U.C.N. First World Conference on National Parks, 1982: 107-111.

Martin S.C., Ward D.E., (1969): Rotating access to water to improve semi-desert cattle range. U.S.D.A. Santa Rita Exp. Station Arizona.

Mellanby K., (1968): The effects of some mammals and birds on regeneration of oaks. J. Appl. Ecol. 5: 359-366.

Melville R., (1970): Plant conservation and the red book. Biol. Cons. 2: 185-188.

Menke J.W., Villasenov R., (1977): The California mediterranean ecosystem. Symp. on the environmental consequences of fire and fuel management in mediterranean ecosystems. U.S.D.A. Forest Serv. Rep. WO-3: 257-270.

Michaelson H., (1972): Hydrology of the Southern Golan. Water Planning for Israel, Tel Aviv HR/72/037 (Hebrew).

Michaelson H., (1974): Geology of the Southern Golan Heights. Teva Va Aretz 3: 115-122 (Hebrew).

Mor D., (1973): Volcanism of Central Golan Heights. M.Sc. thesis, Hebrew Univ. Jerusalem (Hebrew).

Mörzer Bruyns M.F., Westhoff V., (1963): Basic criteria for defining reserve areas and surrounding protective buffer zones in the Netherlands. I.U.C.N. Project Mar. Pub. Nor. 3: 192-197.

Mörzer Bruyns M.F., (1967): Value and significance of nature conservation. W.W.F. Int. Congr. "Nature and Man", Amsterdam: 37-47.

Nagle J.P., Harris G.A., (1966): Grazing compatibility of cattle and elk on mountain ranges. Proc. 10th. Inter. Grass Cong.: 994-997.

Nature Reserves Authority, (1980): Laws and Regulations, Israel (Hebrew).

Naveh Z., (1971): The scientific management of animal and plant communities for conservation. The 11th Symp. of British Ecol. Soc. Univ. East Anglia, Norwich, Blackwell Sci. Pub. (ed. E. Duffey & A.S. Watt).

Naveh Z., (1971): The conservation of ecological diversity of mediterranean ecosystems through ecological management. 11th Symp. British Ecol. Soc., Blackwell Sci. Pub. (ed. E. Duffey & A.S. Watt): 605-622.

Naveh Z., (1975): The evolutionary significance of fire in the mediterranean region. Vegetatio 29, 3: 199-208.

Naveh Z., Kinski J., (1975): The effect of climate and management on species diversity of a Tabor oak-savannah pasture in Israel. Technion - Israel Inst. Tech. Pub. No. 245.

Nicholson E.M., (1957): Nature Conservation and the management of natural areas. 16th Technical Meeting, Edingburgh, June 1956: 8-27.

Nie N.H., Hull C.H., Jenkins J.G., Steinbrenner K., Bent D.H., (1975): Statistical package for the social sciences (SPSS). McGraw-Hill Co.

Norman M.J.T., Green J.O., (1958): The local influence of cattle dung and urine upon the yield and botanical composition of permanent pasture. J. Br. Grass Soc. 13: 39-45.

Novo F.G., (1977): The effect of fire on the vegetation of Donana National Park (Spain). Symp. on the environmental consequence of fire and fuel management in mediterranean ecosystems. U.S.D.A. Forest Serv. Rep. WO-3: 318-325.

Noy-Meir I., (1971): Multivariate analysis of the semi-arid vegetation in South-Eastern Australia. I. Nodal ordination by component analysis. Proc. Ecol. Soc. Aus. 6: 159-193.

Noy-Meir I., (1975): Stability of grazing systems: an application of predator-prey graphs. J. Ecol. 63: 459-481.

Ofer Y., Seligman N., (1969): Fertilization on annual range in Israel. J. Range Manage. 22: 337-341.

Oppenheimer H.R., (1950): The water turn-over of Valonea oak. Palest. J. Bot. R. Ser. 7: 177-179.

Oppenheimer H.R., (1951): Light evading plants in the hills and plain of Israel. Pal. J. Bot. R. Ser. 8: 20-26.

Orshan G., Tadmor N.H., Noy-Meir I., (1971): Methods of vegetation survey in mediterranean environments in Israel. Dep. Bot. Hebrew Univ., Jerusalem (unpublished).

Pacific Southwest and Range Experiment Station, (1961):Annual Rep. U.S.D.A. Berkeley, Calif.: 27-34.

Papanastasis V.P., (1977): Fire ecology and management of phrygana communities in Greece. Symp. on the environmental consequences of fire and fuel management in mediterranean ecosystems. U.S.D.A. Forest Serv. Rep. WO-3: 476-482.

Parsons J.J., (1962): The acorn-hog economy of the oak-woodlands of South-western Spain. Geogr. Rev. 52: 211-215, illus.

Parsons D.J., (1977): Preservation in fire-type ecosystems. Symp. on the environmental consequences of fire and fuel management in Rep. WO-3: 172-182.

Passey H.B., (1966): Managing natural grasslands for big game animals. Proc. X Inter. Grass. Congr.: 991-994.

Paz U., (1980): The natural vegetation of Israel in the end of the Ottoman period. Teva Va Aretz 22: 48-50 (Hebrew).

Paz U., (1981): Nature reserves in Israel. Massada, Israel, Nature Reserves Authority (Hebrew).

Peters F.E., (1978): Romans and Bedouin in southern Syria. J. Near East Studies 37: 315-326.

Philpot C.W., (1977): Vegetation features as determination of fire frequency and intensity. Symp. on the environmental consequences of fire and fuel management in mediterranean ecosystems. U.S.D.A. Forest Serv. Rep. WO-3: 12-16.

Plumb T.R., (1979): Response of oaks to fire. Proc. Symp. Ecol. Manage. and Utiliz. of Calif. Oak: 202-215.

Pluygers L.H., (1952): Management of Nature Reserves. IUCN Tech. Meets., The Hague, 1951: 65-67.

Porter J.L., (1867): The giant cities of Bashan. Amer. Baptist Pub. Soc., Philadelphia.

Post G.E., (1896): Flora of Syria, Palestine and Sinai. Syrian Protestant College, Beirut.

Poulter C., (1803): Carte physique et politique pour servir à l'histoire de conquêtes de général Bonaparte en Orient. Paris.

Rabinovitch A., (1977): Remarks on the place of Quercus ithaburensis in the dynamics of plant associations in Israel. Nature Reserves Authority, Israel. Surveys and Researches 2: 47-62 (Hebrew, English summary).

Remeijn J.M., (1972): Photo-interpretation in forestry. I.T.C. Enschede, NL.

Ritte U., (1964): The dynamics of a population of small mammals in the Judean Hills. Hebrew Univ. Jerusalem. Lab. of Genetics (Hebrew, English summary).

Rocky Mountain Forest and Range Experimental Station, (1959): Annual Rep.

Rocky Mountain Forest and Range Experimental Station, (1960): Annual Rep. U.S.D.A. For. Collins, Colorado: 59.

Rodriguez B.J., Zamora L.M., Gomez C.A.C., Peinado L.E., Medina B.M., (1973): The shrub flora of the mediterranean and its evaluation. 2. The tannin content of some species eaten by animals. Archivos de Zootecnica 22: 79-92.

Ross-Macdonald M., (1971)(ed.): The world wildlife guide. Threshold Books, London.

Safrai Z., (1978): Jewish settlement on the Golan after the destruction of the Second Temple. Keshet Field School, Israel (Hebrew).

Schlotter J.H., Eli P., Williams W.T., (1975): Behaviour of beef cattle in equatorial lowlands. Aus. J. Exp. Agric. and Animal Husbandry 15: 725-730.

Schumacher C.E., (1888): The Joulan, London.

Seligman N.G., (1973): A quantitative geobotanical analysis of the vegetation of the Golan. Ph.D. thesis, Hebrew Univ., Jerusalem (Hebrew, English summary).

Seligman N., Gutman M., (1976-a): The effect of grazing systems on the botanical composition of range vegetation in a mediterranean hemicryptophytic batha. Hasadeh 56: 638-641, 874-877 (Hebrew, English summary).

Seligman N., Gutman M., (1976-b): Effect of grazing systems on productivity of herbaceous range in the mediterranean climate zone of Israel. Agricul. Res. Organ., Israel Pamp.: 151.

Senge T., (1972): Park facilities for the future. Scnd. World Conf. Nat. Parks. U.S.A. Sept. 1972. IUCN 2nd World Conf. on National Parks, Yellowstone.

Shimwell D.W., (1971): The description and classification of vegetation. Sidwich & Jackson, London.

Shmida A., (1980): On the problems of Quercus calliprinos maquis and forests in Israel. Teva Va Aretz 22: 52-57 (Hebrew).

Smit G.S., (1980): Use of landsat imagery for forest management. I.T.C. Enchede, NL, 1980-3: 563-576.

Stellingwerf D.A., Remeijn J.M., (1973): Measurements and estimation on aerial photographs for forestry purposes. I.T.C. Enschede, NL.

Stoddart L.A., Rasmussen D.I., (1945): Deer management and range livestock production. Agric. Exp. Sta., Utah State Agricul. College, U.S., circular 121.

Susmel L., (1973): Sviluppi e problemi attuali del controllo degli incendi nella foresta mediterranea. FAO, Rome.

Taber R.D., (1960): The black-tailed deer: ecology and management. IUCN Ecology and Management of wild grazing animals: 222-245.

Tainton N.M., (1974): Effects of different grazing elevations on pasture production. J. Br. Grassld. Soc. 29: 191-202.

Tchernov E., (1979): Quaternary Fauna. The Quaternary of Israel, Academic Press. (ed. A. Horowitz): 259-260.

Tilley J.M.A., Terry R.A., (1963): A two-stage technique for the in nitro digestions of forage crops. J. Br. Grass. Soc. 18: 104-111.

Traboud L., (1973): Experimental study on the effects of prescribed burning on a Quercus coccifera L. garrigue: early results. Proc. Tall Timber Fire Ecol. Conf. Talahassee, Florida: 13.

Traboud L., (1977): Comparison between the effect of prescribed fires and wild fires on the global quantitative evolution of the hermes scrub oak (Q. coccifera L.) garrigues. Symp. on the environmental consequences of fire and fuel management in mediterranean ecosystems, U.S.D.A. Forest Serv. Rep. WO-3: 271-282.

Tristram H.B., (1877): Natural history of the bible. Society for Promotion Christian Knowledge, London.

United Nations, (1971): U.N. List of national parks and equivalent reserves. Pub. by IUCN.

United Nations, (1972): Conference on human environment. Stockholm, June 1972.

Van Wagtendonk J.W., (1977): Fire management in the Yosemite mixed-conifer ecosystem. Symp. on the environmental consequences of fire and fuel management in mediterranean ecosystems. U.S.D.A. Forest Serv. Rep. WO-3: 459-463.

Vogl R.J., (1977): Fire frequency and site degraaation. Symp. on the environmental consequences of fire and fuel management in mediterranean ecosystems. U.S.D.A. Forest Serv. Rep. WO-3: 193-201.

Waisel Y., Friedman J., (1960): Germination and seedling survival of Quercus calliprinos. Laya'aran 9: 1-4.

Waisel Y., Liphshitz N., (1968): Dendrochronological studies in Israel. II. Juniperus phoenica of north and central Sinai. Laya'aran 18: 2-20, 63-67.

Waisel Y., Liphshitz N., (1979): Vegetation composition changes in Israel through historical periods. Israel Envir. Com. 4: 8-9 (Hebrew).

Wangon K.A., (1960): Cattle feeding trials with acorns and oak leaves. Calif. Agricul. 14(11): 10-12.

Wangon K.A., Albough R., Hart G.H., (1960): Beef cattle production. The Macmillan Company, New York.

Wangon K.A., (1963): Behaviour of beef cows on a California range. Calif. Agric. Exp. Station, Bult. 799.

Wangon K.A., (1968): Use of different classes of rangeland. Calif. Agricul. Sta. Bull. 838.

Wells T.C.E., (1969): Botanical aspects of conservation management of chalk grasslands. Biol. Cons. 2: 36-44.

Wells T.C.E., (1971): A comparison of the effects of sheep grazing and mechanical cutting on the structure and botanical composition of chalk grassland. 11th Symp. British Ecol. Soc. Blackwell Sci. Pub. (ed. E. Duffey & A.S. Watt): 495-515.

Westhoff V., (1967): Problems and use of structure in the classification of vegetation. Acta Botanica Neerlandica 15: 495-511.

Westhoff V., (1970): New criteria for nature reserves. New Scientist 46: 108-113.

Westhoff V., (1971): The dynamic structure of plant communities in relation to the objectives of conservation. 11th Sym. British Ecol. Soc. Blackwell Sci. Pub.: 3-14.

Werk O., Finger H., Ernst P., (1974): Investigations on feed times of grazing cattle. Växtodling 29: 193-196.

Wildfowl Trust, (1957): Some aspects of management of wild fowl refuges in Britain. IUCN 16th Tech. Meeting, Edinburgh, June 1956: 65-70.

Wirtz O.W., (1977): Vertebrate post-fire succession. Symp. on the environmental consequences of fire and fuel management in mediterranean ecosystems. U.S.D.A. Forest Serv. Rep. WO-3: 46-57.

Zeuner F.E., (1958): Dating the past. Methuen & Co. Ltd., London: 6-19.

Zivnuska J.A., (1977): Fire exclusion practice-cost and benefits. Symp. on the environmental consequences of fire and fuel management in mediterranean ecosystems. U.S.D.A. Forest Serv. Rep. WO-3: 146-150.

Zohary M., Feinbrun N., (1962): Analytical flora of Palestine. Hamagdir, Jerusalem.

Zohary M., (1966): Flora Palaestina 1: 32-33, p. 31. Israel Acad. Sci. Hum. Jerusalem.

Zohary M., (1973): Geobotanical foundations of the Middle-East. Gustav-Fischer Verlag, Stuttgart.

Zonneveld I.S., (1972-a): Land evaluation and land(scape) science. I.T.C. Textbook of photo-interpretation, Enschede, NL.

Zonneveld I.S., (1972-b): Lectures on vegetation science (ecology) and vegetation survey. I.T.C. Int. Inst. for aerial survey and earth, Enschede, NL.

CURRICULUM VITAE

Name	:	Yedidya Kaplan
Born	:	Jerusalem, Israel - 6 June 1945
Marital status	:	Married + 3 boys and 1 girl
1959	:	Graduated from elementary school, Jerusalem (8 years)
1959 - 1963	:	Graduated from High School, Jerusalem, where I studied in the mathematical-physical stream
1963 - 1965	:	Army service - part of which I spent stationed at the Ein-Gedi field school serving as a nature guide
1966 - 1970	:	I received my B.Sc. from the Hebrew University of Jerusalem, Faculty of Agriculture
1970 - 1972	:	I received my M.Sc. from the Hebrew University of Jerusalem, Faculty of Agriculture
1972 - 1973	:	I studied in the Agricultural University of Wageningen, Holland, for Doctorate degree in Nature Conservation
1973 - 1981	:	Research studies in the Yahudia Forest Nature Reserve, Golan, Israel, for Doctorate degree, while working as a Warden for the Nature Authority, Israel, in the Golan
1981 - present	:	Regional Biologist of the Nature Reserves Authority, Israel.

APPENDIX 5.2.I

YAHUDIA FOREST NATURE RESERVE - LIST OF PLANT SPECIES
(A B C of Codes name order)

100	2	1	ACANTHUS	SYRIACUS	ACASYR
35	8	2	ADONIS	AESTIVALIS	ADOAES
35	8	1	ADONIS	ALEPPICA	ADOALE
35	8	5	ADONIS	ANNUA	ADOANN
121	33	3	AEGILOPS	PEREGRINA	AEGPER
83	26	1	AINSWORTHIA	TRACHYCARPA	AINTRA
96	2	3	AJUGA	CHIA	AJUCHI
59	4	5	ALCEA	DIGITATA	ALCDIG
59	4	7	ALCEA	SETOSA	ALCSET
116	20	18	ALLIUM	NEAPOLITANUM	ALLNEA
116	20	40	ALLIUM	NIGRUM	ALLNIG
116	20	8	ALLIUM	PALLENS	ALLPAL
116	20	3	ALLIUM	PANICULATUM	ALLPAN
115	20	3	ALLIUM	PHANERANTHEUM	ALLPHA
116	20	19	ALLIUM	SCHUBERTII	ALLSCH
116	20	7	ALLIUM	STAMINEUM	ALLSTA
121	57	1	ALOPECURUS	MYOSUROIDES	ALOMYO
121	57	2	ALOPECURUS	UTRICULATUS	ALOUTR
45	32	7	ALYSSUM	MINUS	ALYMIN
83	8	1	AMMI	MAJUS	AMMMAJ
83	8	2	AMMI	VISNAGA	AMMVIS
51	11	0	AMYGDALUS	SP.	AMYSP*
85	3	1	ANAGALLIS	ARVENSIS	ANAARV
55	1	1	ANAGYRIS	FOETIDA	ANAFOE
94	15	4	ANCHUSA	AEGYPTIACA	ANCAEG
94	15	5	ANCHUSA	OVATA	ANCOVA
94	15	3	ANCHUSA	STRIGOSA	ANCSTR
94	15	1	ANCHUSA	UNDULATA	ANCUND
121	94	1	ANDROPOGON	DISTACHYUS	ANDDIS
35	4	1	ANEMONE	CORONARIA	ANECOR
6	1	1	ANOGRAMMA	LEPTOPHYLLA	ANOLEP
109	31	18	ANTHEMIS	BORNMUELLERI	ANTBOR
83	42	1	ANTHRISCUS	LAMPROCARPUS	ANTLAM
98	11	2	ANTIRRHINUM	ORONTIUM	ANTORO
109	31	19	ANTHEMIS	PALAESTINA	ANTPAL
83	5	2	APIUM	NODIFLORUM	APINOD
31	11	1	ARENARIA	DEFLEXA	AREDEF
31	11	2	ARENARIA	LEPTOCLADOS	ARELEP
121	72	2	ARISTIDA	CAERULESCENS	ARICAE
22	1	2	ARISTOLOCHIA	PARVIFOLIA	ARIPAR
123	4	1	ARISARUM	VULGARE	ARIVUL
83	33	1	ARTEDIA	SQUAMATA	ARTSQU
123	1	1	ARUM	DIOSCORIDIS	ARUDIO
121	54	1	ARUNDO	DONAX	ARUDON
123	1	3	ARUM	HYGROPHILUM	ARUHYG
116	21	2	ASPARAGUS	APHYLLUS	ASPAPH
92	4	1	ASPERULA	ARVENSIS	ASPARV
116	2	1	ASPHODELINE	LUTEA	ASPLUT
116	1	1	ASPHODELUS	MICROCARPUS	ASPMIC
116	21	1	ASPARAGUS	PALAESTINUS	ASPPAL
55	15	17	ASTRAGALUS	HAMOSUS	ASTHAM
55	15	25	ASTRAGALUS	MACROCARPUS	ASTMAC
109	73	3	ATRACTYLIS	CANCELLATA	ATRCAN
121	36	3	AVENA	BARBATA	AVEBAR
121	36	5	AVENA	STERILIS	AVESTE
96	22	1	BALLOTA	UNDULATA	BALUND
116	16	13	BELLEVALIA	DENSIFLORA	BELDEN
116	16	8	BELLEVALIA	FLEXUOSA	BELFLE
32	1	1	BETA	VULGARIS	BETVUL
45	43	1	BISCUTELLA	DIDYMA	BISDID
55	16	1	BISERRULA	PELECINUS	BISPEL
45	51	2	BRASSICA	NIGRA	BRANIG
121	3	3	BRIZA	MAXIMA	BRIMAX
121	23	10	BROMUS	ALOPECUROS	BROALO
121	23	3	BROMUS	FASCICULATUS	BROFAS
121	23	11	BROMUS	LANCEOLATUS	BROLAN
121	23	5	BROMUS	MADRITENSIS	BROMAD
121	23	9	BROMUS	SCOPARIUS	BROSCO
107	1	1	BRYONIA	SYRIACA	BRYSYR
83	4	1	BUPLEURUM	LANCIFOLIUM	BUPLAN
83	4	3	BUPLEURUM	NODIFLORUM	BUPNOD
111	1	1	BUTOMUS	UMBELLATUS	BUTUMB
109	45	3	CALENDULA	ARVENSIS	CALARV
55	5	1	CALYCOTOME	VILLOSA	CALVIL
108	1	7	CAMPANULA	ERINUS	CAMERI
108	1	8	CAMPANULA	RAPUNCULUS	CAMRAP

108	1	9	CAMPANULA	RETRORSA	CAMRET
108	1	3	CAMPANULA	STRIGOSA	CAMSTR
44	2	1	CAPPARIS	SPINOSA	CAPSPI
109	50	2	CARDUUS	ARGENTATUS	CARARG
109	50	1	CARDUUS	AUSTRALIS	CARAUS
127	3	2	CAREX	DIVISA	CARDIV
127	9	3	CAREX	EXTENSA	CAREXT
109	67	1	CARTHAMUS	GLAUCUS	CARGLA
109	72	2	CARLINA	HISPANICA	CARHIS
109	67	3	CARTHAMUS	NITIDUS	CARNIT
109	77	1	CATANANCHE	LUTEA	CATLUT
121	12	3	CATAPODIUM	RIGIDUM	CATRIG
109	63	3	CENTAUREA	CROCODYLIUM	CENCRO
109	63	17	CENTAUREA	IBERICA	CENIBE
33	1	0	CENTAURIUM	SP.	CENTA*
109	63	13	CENTAUREA	VERUTUM	CENVER
106	1	2	CEPHALARIA	JOPPENSIS	CEPJOP
31	16	3	CERASTIUM	GLOMERATUM	CERGLO
94	9	1	CERINTHE	PALAESTINA	CERPAA
43	2	1	CERATOCAPNOS	PALAESTINUS	CERPAL
54	2	1	CERATONIA	*SILIQUA	CERSII
54	1	1	CERCIS	SILIQUASTRUM	CERSIL
8	2	1	CETERACH	OFFICINARUM	CETOFF
33	36	1	CHAETOSCIADIUM	TRICHOSPERMUM	CHATRI
3	1	1	CHEILANTHES	FRAGRANS	CHEFRA
109	40	3	CHRYSANTHEMUM	CORONARIUM	CHRCOR
109	40	2	CHRYSANTHEMUM	SEGETUM	CHRSEG
50	2	1	CHROZOPHORA	TINCTORIA	CHRTIN
109	78	1	CICHORIUM	PUMILUM	CICPUM
35	5	1	CLEMATIS	CIRRHOSA	CLECIR
116	5	2	COLCHICUM	DECAISNEI	COLDEC
55	14	2	COLUTEA	ISTRIA	COLIST
93	2	15	CONVOLVULUS	ARVENSIS	CONARV
93	2	3	CONVOLVULUS	BETONICIFOLIUS	CONBET
93	2	3	CONVOLVULUS	DORYCNIUM	CONDOR
93	2	21	CONVOLVULUS	HUMILIS	CONHUM
93	2	13	CONVOLVULUS	PALAESTINUS	CONPAL
93	2	13	CONVOLVULUS	PENTAPETALOIDES	CONPEN
35	3	1	CONSOLIDA	RIGIDA	CONRIG
93	2	14	CONVOLVULUS	SCAMMONIA	CONSCA
121	52	2	CORNUCOPIAE	ALOPECUROIDES	CORALO
55	27	2	CORONILLA	ROSTRATA	CORROS
33	51	1	CORIANDRUM	SATIVUM	CORSAT
55	27	4	CORONILLA	SCORPIOIDES	CORSCO
49	1	1	CRASSULA	ALATA	CRAALA
51	10	2	CRATAEGUS	ARONIA	CRAARO
45	61	2	CRAMBE	HISPANICA	CRAHIS
109	103	10	CREPIS	ASPERA	CREASP
109	103	2	CREPIS	BULBOSA	CREBUL
109	103	1	CREPIS	PALAESTINA	CREPAL
109	103	11	CREPIS	SANCTA	CRESAN
121	26	1	CRITHOPSIS	DELILEANA	CRIDEL
113	2	4	CROCUS	ALEPPICUS	CROALE
92	3	2	CRUCIANELLA	MACROSTACHYA	CRUMAC
92	3	4	CRUCIANELLA	MEMBRANACEA	CRUMEM
93	5	0	CUSCUTA	SP.	CUSCU*
35	4	2	CYCLAMEN	PERSICUM	CYCPER
94	25	1	CYNOGLOSSUM	CRETICUM	CYNCRE
121	70	1	CYNODON	DACTYLON	CYNDAC
121	2	1	CYNOSURUS	ECHINATUS	CYNECH
109	56	1	CYNARA	SYRIACA	CYNSYR
127	3	3	CYPERUS	DISTACHYUS	CYPDIS
127	8	17	CYPERUS	LONGUS	CYPLON
121	5	1	DACTYLIS	GLOMERATA	DACGLO
33	30	5	DAUCUS	AUREUS	DAUAUR
33	30	1	DAUCUS	BICOLOR	DAUBIC
33	30	5	DAUCUS	CAROTA	DAUCAR
35	2	1	DELPHINIUM	ITHABURENSE	DELITH
31	9	3	DIANTHUS	POLYCLADOS	DIAPOL
121	93	1	DICHANTHIUM	ANNULATUM	DICANN
55	23	1	DORYCNIUM	RECTA	DORREC
121	76	1	ECHINOCHLOA	CRUSGALLI	ECHCRU
109	74	5	ECHINOPS	GAILLARDOTI	ECHGAI
94	11	2	ECHIUM	GLOMERATUM	ECHGLO
94	11	5	ECHIUM	JUDAEUM	ECHJUD
109	74	4	ECHINOPS	VISCOSUS	ECHVIS
14	1	3	EPHEDRA	CAMPYLOPODA	EPHCAM
79	2	1	EPILOBIUM	HIRSUTUM	EPIHIR
79	2	3	EPILOBIUM	TETRAGONUM	EPITET
57	3	5	ERODIUM	CICUTARIUM	EROCIC
57	3	3	ERODIUM	DESERTI	ERODES

57	3	11	ERODIUM	GRUINUM	EROGRU
57	3	7	ERODIUM	MOSCHATUM	EROMOS
45	59	1	ERUCARIA	HISPANICA	ERUHIS
83	2	3	ERYNGIUM	CRETICUM	ERYCRE
45	10	1	ERYSIMUM	REPANDUM	ERYREP
109	1	1	EUPATORIUM	CANNABINUM	EUPCAN
50	5	22	EUPHORBIA	EXIGUA	EUPEXI
50	5	14	EUPHORBIA	HELIOSCOPIA	EUPHEL
50	5	12	EUPHORBIA	HIEROSOLYMITANA	EUPHIE
50	5	15	EUPHORBIA	OXYODONTA	EUPOXY
50	5	1	EUPHORBIA	*PEPLIS	EUPPEP
83	20	1	FERULA	COMMUNIS	FERCOM
83	20	2	FERULA	TINGITANA	FERTIN
45	31	1	FIBIGIA	GLYPEATA	FIBCLY
18	1	1	FICUS	CARICA	FICCAR
109	15	5	FILAGO	CONTRACTA	FILCON
109	15	6	FILAGO	DAVISII	FILDAV
109	15	1	FILAGO	ERIOCEPHALA	FILERI
109	15	2	FILAGO	PYRAMIDATA	FILPYR
83	18	1	FOENICULUM	VULGARE	FOEVUL
38	2	1	FRAXINUS	SYRIACA	FRASYR
43	3	2	FUMARIA	MACROCARPA	FUMMAC
115	6	3	GAGEA	COMMUTATA	GAGCOM
92	5	8	GALIUM	APARINE	GALAPA
92	5	21	GALIUM	MURALE	GALMUR
92	5	13	GALIUM	PISIFERUM	GALPIS
121	38	1	GAUDINIA	FRAGILIS	GAUFRA
57	2	4	GERANIUM	DISSECTUM	GERDIS
109	81	1	GEROPOGON	HYBRIDUS	GERHYB
57	2	5	GERANIUM	MOLLE	GERMOL
57	2	10	GERANIUM	PURPUREUM	GERPUR
119	4	1	GLADIOLUS	ITALICUS	GLAITA
109	47	1	GUNDELIA	TOURNEFORTII	GUNTOU
119	5	1	GYNANDFIRIS	SISYRINCHIUM	GYNSIS
52	2	4	HAPLOPHYLLUM	BUXBAUMII	HAPBUX
109	92	1	HEDYPNOIS	RHAGADIOLOIDES	HEDRHA
94	2	8	HELIOTROPIUM	ROTUNDIFOLIUM	HELROT
109	18	1	HELICHRYSUM	*SANGUINEUM	HELSAN
73	3	2	HELIANTHEMUM	SALICIFOLIUM	HELSAL
83	46	1	HEPTAPTERA	CRENATA	HEPCRE
55	28	1	HIPPOCREPIS	UNISILIQUOSA	HIPUNI
45	53	1	HIRSCHFELDIA	INCANA	HIRINC
121	23	2	HORDEUM	BULBOSUM	HORBUL
121	29	1	HORDEUM	SPONTANEUM	HORSPO
55	19	1	HYMENOCARPOS	CIRCINNATUS	HYMCIR
97	2	6	HYOSCYAMUS	AUREUS	HYOAUR
121	92	1	HYPARRHENIA	HIRTA	HYPHIR
41	1	5	HYPERICUM	TRIQUETRIFOLIUM	HYPTRI
109	22	2	INULA	VISCOSA	INUVIS
119	1	15	IRIS	HERMONA	IRIHER
45	8	2	ISATIS	LUSITANICA	ISALUS
120	1	7	JUNCUS	BUFONIUS	JUNBUF
106	3	1	KNAJTIA	BIDENS	KNABID
109	99	2	LACTUCA	SERRIOLA	LACSER
109	99	1	LACTUCA	TUBEROSA	LACTUB
83	3	1	LAGOECIA	CUMINOIDES	LAGCUM
96	28	2	LAMIUM	AMPLEXICAULE	LAMAMP
121	1	1	LAMARCKIA	AUREA	LAMAUR
96	28	3	LAMIUM	MOSCHATUM	LAMMOS
55	41	14	LATHYRUS	APHACA	LATAPH
55	41	3	LATHYRUS	BLEPHARICARPUS	LATBLE
55	41	4	LATHYRUS	GORGONII	LATGOR
55	41	2	LATHYRUS	HIEROSOLYMITANUS	LATHIE
55	41	5	LATHYRUS	MARMORATUS	LATMAR
55	41	15	LATHYRUS	OCHRUS	LATOCH
59	2	2	LAVAFERA	PUNCTATA	LAVPUN
59	2	3	LAVATERA	TRIMESTRIS	LAVTRI
124	1	3	LEMNA	GIBBA	LEMGIB
45	44	2	LEPIDIUM	SPINESCENS	LEPSPI
98	7	0	LINARIA	SP.	LINAR*
59	1	9	LINUM	NODIFLORUM	LINNOD
59	1	1	LINUM	PUBESCENS	LINPUB
59	1	5	LINUM	STRICTUM	LINSTR
121	22	4	LOLIUM	RIGIDUM	LOLRIG
104	1	1	LONICERA	ETRUSCA	LONETR
121	40	1	LOPHOCHLOA	PHLEOIDES	LOPPHL
55	21	6	LOTUS	ANGUSTISSIMUS	LOTANG
55	21	13	LOTUS	CONIMBRICENSIS	LOTCON
55	21	5	LOTUS	PALUSTRIS	LOTPAL
55	21	7	LOTUS	PEREGRINUS	LOTPER
79	1	1	LUDWIGIA	STOLONIFERA	LUDSTO

55	5	5	LUPINUS	ANGUSTIFOLIUS	LUPANG
55	5	1	LUPINUS	VARIUS	LUPVAR
96	6	1	LYCOPUS	EUROPAEUS	LYCEUR
77	2	4	LYTHRUM	HYSSOPIFOLIUM	LYTHYS
77	2	2	LYTHRUM	JUNCEUM	LYTJUN
77	2	1	LYTHRUM	SALICARIA	LYTSAL
77	2	5	LYTHRUM	THYMIFOLIA	LYTTHY
96	8	1	MAJORANA	SYRIACA	MAJSYR
69	5	3	MALVA	NICAEENSIS	MALNIC
33	23	1	MALABAILA	SEKAKUL	MALSEK
97	5	1	MANDRAGORA	AUTUMNALIS	MANAUT
55	35	3	MEDICAGO	BLANCHEANA	MEDBLA
55	35	10	MEDICAGO	CORONATA	MEDCOR
55	35	13	MEDICAGO	DOLIATA	MEDDOL
55	35	23	MEDICAGO	GRANADENSIS	MEDGRA
55	35	21	MEDICAGO	MUREX	MEDMUR
55	35	5	MEDICAGO	ORBICULARIS	MEDORB
55	35	13	MEDICAGO	POLYMORPHA	MEDPOL
55	35	3	MEDICAGO	ROTATA	MEDROT
55	35	5	MEDICAGO	SCUTELLATA	MEDSCU
96	11	1	MELISSA	OFFICINALIS	MELOFF
55	36	3	MELILOTUS	SULCATUS	MELSUL
96	5	3	MENTHA	LONGIFOLIUM	MENLON
60	3	1	MERCURIALIS	ANNUA	MERANN
109	12	1	MICROPUS	SUPINUS	MICSUP
31	12	7	MINUARTIA	FORMOSA	MINFOR
96	27	2	MOLUCELLA	SPINOSA	MOLSPI
116	19	2	MUSCARI	COMMUTATUM	MUSCOM
78	1	1	MYRTUS	COMMUNIS	MYRCOM
117	4	1	NARCISSUS	TAZETTA	NARTAZ
45	25	1	NASTURTIUM	OFFICINALE	NASOFF
96	19	1	NEPETA	CURVIFLORA	NEPCUR
90	2	1	NERIUM	OLEANDER	NEROLE
35	1	3	NIGELLA	CILIARIS	NIGCIL
35	1	1	NIGELLA	UNGUICULARIS	NIGUNG
109	53	1	NOTOBASIS	SYRIACA	NOTSYR
45	4	1	OCHTHODIUM	AEGYPTIACUM	OCHAEG
99	3	1	OLEA	EUROPAEA	OLEEUR
55	32	15	ONONIS	ALOPECUROIDES	ONOALO
94	8	1	ONOSMA	*ALEPPICA	ONOALP
55	32	1	ONONIS	ANTIQUORUM	ONOANT
55	30	3	ONOBRYCHIS	CAPUTGALLI	ONOCAP
109	55	2	ONOPORDUM	CARDUIFORME	ONOCAR
55	30	7	ONOBRYCHIS	CRISTAGALLI	ONOCRI
109	55	8	ONOPORDUM	CYNAROCEPHALUM	ONOCYN
94	3	2	ONOSMA	FRUTESCENS	ONOFRU
55	32	11	ONONIS	HIRTA	ONOHIR
55	32	14	ONONIS	MITISSIMA	ONOMIT
55	32	2	ONONIS	NATRIX	ONONAT
55	32	9	ONONIS	PUBESCENS	ONOPUB
55	30	3	ONOBRYCHIS	SQUARROSA	ONOSQU
123	5	7	OPHRYS	CARMELI	OPHCAR
116	12	6	ORNITHOGALUM	MONTANUM	ORNMON
101	2	0	OROBANCHE	SP.	OROBA*
109	24	1	PALLENS	SPINCSA	PALSPI
42	1	5	PAPAVER	POLYTRICHUM	PAPPOL
42	1	1	PAPAVER	SUBPIRIFORME	PAPSUB
42	1	3	PAPAVER	SYRIACUM	PAPSYR
31	27	3	PARONYCHIA	ARGENTEA	PARARG
19	2	1	PARIETARIA	JUDAICA	PARJUD
121	79	1	PASPALUM	PASPALOIDES	PASPAS
121	82	2	PENNISETUM	SETACEUM	PENSET
121	55	2	PHALARIS	BRACHYSTACHYS	PHABRA
121	55	4	PHALARIS	PARADOXA	PHAPAR
109	16	1	PHAGNALON	RUPESTRE	PHARUP
121	55	5	PHALARIS	TUBEROSA	PHATUB
121	53	1	PHRAGMITES	AUSTRALIS	PHRAUS
109	87	1	PICRIS	GALILAEA	PICGAL
109	87	5	PICRIS	SPRENGERIANA	PICSPR
83	12	5	PIMPINELLA	CRETICA	PIMCRE
83	12	1	PIMPINELLA	PEREGRINA	PIMPER
121	61	2	PIPTATHERUM	BLANCHEANUM	PIPBLA
121	61	1	PIPTATHERUM	MILIACEA	PIPMIL
64	1	1	PISTACIA	ATLANTICA	PISATL
55	42	1	PISUM	ELATIUS	PISELA
55	42	3	PISUM	FULVUM	PISFUL
64	1	2	PISTACIA	PALAESTINA	PISPAL
103	1	14	PLANTAGO	AFRA	PLAAFR
103	1	7	PLANTAGO	CRETICA	PLACRE
103	1	10	PLANTAGO	LAGOPUS	PLALAG
103	1	1	PLANTAGO	MAJOR	PLAMAJ

48	1	1	PLATANUS	ORIENTALIS	PLAORI
109	7	1	PLUCHEA	DISCORIDES	PLUDIS
56	1	1	PLUMBAGO	EUROPAEA	PLUEUR
121	7	4	POA	BULBOSA	POABUL
121	7	3	POA	TRIVIALIS	POATRI
34	7	1	PODONOSMA	ORIENTALIS	PODORI
25	1	1	POLYGONUM	EQUISETIFORMIS	POLEQU
25	1	5	POLYGONUM	LAPATHIFOLIUM	POLLAP
25	1	7	POLYGONUM	SALICIFOLIUM	POLSAL
31	21	1	POLYCARPON	TETRAPHYLLUM	POLTET
121	47	3	POLYPOGON	VIRIDIS	POLVIR
95	4	1	PRASIUM	MAJUS	PRAMAJ
53	2	1	PROSOPIS	FARCTA	PROFAR
121	21	1	PSILURUS	INCURVUS	PSIINC
55	12	1	PSORALEA	BITUMINOSA	PSOBIT
105	4	1	PTEROCEPHALUS	PLUMOSUS	PTEPLU
109	23	3	PULICARIA	ARABICA	PULARA
109	23	1	PULICARIA	DYSENTERICA	PULDYS
51	8	1	PYRUS	SYRIACA	PYRSYR
16	1	1	QUERCUS	BOISSIERI	QUEBOI
16	1	3	QUERCUS	CALLIPRINOS	QUECAL
16	1	2	QUERCUS	ITHABURENSIS	QUEITH
35	6	15	RANUNCULUS	AQUATILIS	RANAQU
35	6	12	RANUNCULUS	ARVENSIS	RANARV
35	6	5	RANUNCULUS	ASIATICUS	RANASI
35	6	3	RANUNCULUS	MARGINATUS	RANMAR
35	6	4	RANUNCULUS	MILLEFOLIUS	RANMIL
45	64	2	RAPHANUS	ROSTRATUS	RAPROS
45	60	1	RAPISTRUM	RUGOSUM	RAPRUG
57	1	4	RHAMNUS	ALATERNUS	RHAALA
57	1	2	RHAMNUS	PALAESTINA	RHAPAL
109	93	1	RHAGADIOLUS	STELLATUS	RHASTE
60	4	1	RICINUS	COMMUNIS	RICCOM
45	30	1	RICOTIA	LUNARIA	RICLUN
83	7	1	RIDOLFIA	SEGETUM	RIDSEG
119	3	1	ROMULEA	BULBOCODIUM	ROMBUL
49	3	1	ROSULARIA	LIBANOTICA	ROSLIB
51	1	1	RUBUS	SANCTUS	RUBSAN
92	9	2	RUBIA	TENUIFOLIA	RUBTEN
25	3	4	RUMEX	CYPRIUS	RUMCYP
25	3	12	RUMEX	DENTATUS	RUMDEN
25	3	10	RUMEX	PULCHER	RUMPUL
15	1	1	SALIX	ACMOPHYLLA	SALACM
95	29	9	SALVIA	DOMINICA	SALDOM
96	29	13	SALVIA	HIEROSOLYMITANA	SALHIE
96	29	18	SALVIA	HORMINUM	SALHOR
32	19	11	SALSOLA	VERMICULATA	SALVER
51	4	1	SANGUISORBA	MINOR	SANMIN
51	5	1	SARCOPOTERIUM	SPINOSUM	SARSPI
83	13	2	SCALIGERIA	HERMONIS	SCAHER
83	43	2	SCANDIX	IBERICA	SCAIBE
106	5	5	SCABIOSA	* PALAESTINA	SCAPAA
106	5	4	SCABIOSA	PROLIFERA	SCAPRO
127	1	9	SCIRPUS	HOLOSCHOENUS	SCIHOL
127	1	8	SCIRPUS	MARITIMUS	SCIMAR
109	75	1	SCOLYMUS	MACULATUS	SCOMAC
55	25	1	SCORPIURUS	MURICATUS	SCOMUR
109	62	3	SCORZONERA	PAPPOSA	SCOPAP
98	5	3	SCROPHULARIA	RUBICAULIS	SCRRUB
55	24	1	SECURIGERA	SECURIDACA	SECSEC
49	4	5	SEDUM	HISPANICUM	SEDHIS
109	44	5	SENECIO	VERNALIS	SENVER
109	61	1	SERRATULA	CERINTHIFOLIA	SERCER
92	2	1	SHERARDIA	ARVENSIS	SHEARV
96	15	3	SIDERITIS	PERFOLIATA	SIDPER
31	2	12	SILENE	AEGYPTIACA	SILAEG
31	2	25	SILENE	ARABICA	SILARA
31	2	15	SILENE	BEHEN	SILBEH
31	2	31	SILENE	COLORATA	SILCOL
31	2	23	SILENE	DAMASCENA	SILDAM
109	57	1	SILYBUM	MARIANUM	SILMAR
31	2	24	SILENE	PALAESTINA	SILPAL
31	2	3	SILENE	SWERTIIFOLIA	SILSWE
31	2	21	SILENE	TRINERVIS	SILTRI
31	2	4	SILENE	VULGARIS	SILVUL
45	52	1	SINAPIS	ALBA	SINALB
45	52	2	SINAPIS	ARVENSIS	SINARV
116	23	1	SMILAX	ASPERA	SMIASP
97	4	1	SOLANUM	LUTEUM	SOLLUT
109	95	1	SONCHUS	OLERACEUS	SONOLE
121	89	1	SORGHUM	HALEPENSE	SORHAL

31	18	2	SPERGULA	FALLAX	SPEFAL
~~96~~	~~24~~	~~7~~	~~STACHYS~~	~~ARABICA~~	~~STAARA~~
96	24	9	STACHYS	NEUROCALYCINA	STANEU
117	2	1	STERNBERGIA	COLCHICIFLORA	STECOL
31	14	1	STELLARIA	MEDIA	STEMED
~~31~~	~~14~~	~~2~~	~~STELLARIA~~	~~PALLIDA~~	~~STEPAL~~
121	60	2	STIPA	CAPENSIS	STICAP
37	1	1	STYRAX	OFFICINALIS	STYOFF
94	14	1	SYMPHYTUM	PALAESTINUM	SYMPAL
~~83~~	~~28~~	~~1~~	~~SYNELCOSCIADIUM~~	~~CARMELI~~	~~SYNCAR~~
74	2	4	TAMARIX	JORDANIS	TAMJOR
118	1	1	TAMUS	ORIENTALIS	TAMORI
55	22	2	TETRAGONOLOBUS	PALAESTINUS	TETPAL
~~96~~	~~1~~	~~11~~	~~TEUCRIUM~~	~~POLIUM~~	~~TEUPOL~~
81	1	1	THELIGONUM	CYNOCRAMBE	THECYN
20	2	2	THESIUM	HUMILE	THEHUM
109	55	1	THRINCIA	TUBEROSA	THRTUB
~~109~~	~~88~~	~~2~~	~~TOLPIS~~	~~VIRGATA~~	~~TOLVIR~~
83	25	1	TORDYLIUM	AEGYPTIACUM	TORAEG
83	38	2	TORILIS	ARVENSIS	TORARV
83	38	4	TORILIS	GAILLARDOTII	TORGAI
~~83~~	~~38~~	~~5~~	~~TORILIS~~	~~LEPTOPHYLLA~~	~~TORLEP~~
83	38	3	TORILIS	NODOSA	TORNOD
83	38	6	TORILIS	TENELLA	TORTEN
109	80	3	TRAGOPOGON	COELESYRIACUS	TRACOE
~~121~~	~~98~~	~~1~~	~~TRACHYNIA~~	~~DISTACHYA~~	~~TRADIS~~
55	37	35	TRIFOLIUM	ALEXANDRINUM	TRIALE
55	37	12	TRIFOLIUM	ARGUTUM	TRIARG
55	37	31	TRIFOLIUM	ARVENSE	TRIARV
~~55~~	~~37~~	~~7~~	~~TRIFOLIUM~~	~~BOISSIERI~~	~~TRIBOI~~
55	37	18	TRIFOLIUM	BULLATUM	TRIBUL
55	37	6	TRIFOLIUM	CAMPESTRE	TRICAM
55	37	23	TRIFOLIUM	CHERLERI	TRICHE
~~55~~	~~37~~	~~15~~	~~TRIFOLIUM~~	~~CLUSII~~	~~TRICLU~~
55	37	42	TRIFOLIUM	CLYPEATUM	TRICLY
55	37	29	TRIFOLIUM	DASYURUM	TRIDAS
121	32	1	TRITICUM	DICOCCOIDES	TRIDIC
~~55~~	~~37~~	~~45~~	~~TRIFOLIUM~~	~~ERIOSPHOERUM~~	~~TRIERI~~
55	37	3	TRIFOLIUM	ERUBESCENS	TRIERU
55	37	19	TRIFOLIUM	GLANDULIFERUM	TRIGLA
55	33	0	TRIGONELLA	SP.	TRIGO*
~~55~~	~~37~~	~~22~~	~~TRIFOLIUM~~	~~LAPPACEUM~~	~~TRILAP~~
55	37	2	TRIFOLIUM	NIGRESCENS	TRINIG
55	37	43	TRIFOLIUM	PAUCIFLORUM	TRIPAU
55	37	44	TRIFOLIUM	PILULARE	TRIPIL
~~55~~	~~37~~	~~25~~	~~TRIFOLIUM~~	~~PURPUREUM~~	~~TRIPUR~~
55	37	15	TRIFOLIUM	RESUPINATUM	TRIRES
55	37	11	TRIFOLIUM	SPUMOSUM	TRISPU
55	37	20	TRIFOLIUM	*STELLATUM	TRISTL
~~55~~	~~37~~	~~46~~	~~TRIFOLIUM~~	~~SUBTERRANEUM~~	~~TRISUB~~
55	37	17	TRIFOLIUM	TOMENTOSUM	TRITOM
73	2	1	TUBERARIA	GUTTATA	TUBGUT
126	1	2	TYPHA	AUSTRALIS	TYPAUS
~~49~~	~~2~~	~~1~~	~~UMBILICUS~~	~~INTERMEDIUS~~	~~UMBINT~~
116	13	2	URGINEA	MARITIMA	URGMAR
109	90	1	UROSPERMUM	PICROIDES	UROPIC
31	7	1	VACCARIA	HISPANICA	VACHIS
~~92~~	~~8~~	~~1~~	~~VALANTIA~~	~~HISPIDA~~	~~VALHIS~~
105	1	1	VALERIANA	ITALICA	VALITA
105	2	12	VALERIANELLA	KOTSCHYI	VALKOT
31	10	1	VELEZIA	RIGIDA	VELRIG
~~98~~	~~3~~	~~19~~	~~VERBASCUM~~	~~AGRIMONIIFOLIUM~~	~~VERAGR~~
98	14	2	VERONICA	ANAGALLISAQUATICA	VERANA
98	14	9	VERONICA	CYMBALARIA	VERCYM
98	3	6	VERBASCUM	GAILLARDOTII	VERGAI
~~95~~	~~3~~	~~1~~	~~VERBENA~~	~~OFFICINALIS~~	~~VEROFF~~
98	3	13	VERBASCUM	*ORIENTALE	VERORE
98	14	8	VERONICA	POLITA	VERPOL
98	14	5	VERONICA	SYRIACA	VERSYR
~~55~~	~~39~~	~~21~~	~~VICIA~~	~~*GALILAEA~~	~~VICGAI~~
55	39	15	VICIA	GALEATA	VICGAL
55	39	6	VICIA	HULENSIS	VICHUL
55	39	12	VICIA	HYBRIDA	VICHYB
~~55~~	~~39~~	~~13~~	~~VICIA~~	~~LUTEA~~	~~VICLUT~~
55	39	20	VICIA	NARBONENSIS	VICNAR
55	39	5	VICIA	PALAESTINA	VICPAL
55	39	19	VICIA	PEREGRINA	VICPER
~~55~~	~~39~~	~~17~~	~~VICIA~~	~~SATIVA~~	~~VICSAT~~
55	39	9	VICIA	TETRASPERMA	VICTET
95	1	1	VITEX	AGNUSCASTUS	VITAGN
95	1	2	VITEX	PSEUDONEGUNDO	VITPSE

457	1	1	VITIS	VINIFERA	VITVIN
121	8	3	VULPIA	CILIATA	VULCIL
121	8	1	VULPIA	MYUROS	VULMYU
109	30	1	XANTHIUM	STRUMARIUM	XANSTR
57	3	3	ZIZIPHUS	LOTUS	ZIZLOT
57	3	1	ZIZIPHUS	SPINACHRISTI	ZIZSPI

TOTAL NUMBER OF SPECIES = 487

YAHUDIA NATURE RESERVE Appendix 5.3.I

FAMILY NAMES AND CODES OF SPECIES LIST

(systematic order)

3	SINOPTERIDACEAE
6	GYMNOGRAMMACEAE
8	ASPLENIACEAE
14	EPHEDRACEAE
15	SALICACEAE
16	FAGACEAE
18	MORACEAE
19	URTICACEAE
20	SANTALACEAE
22	ARISTOLOCHIACEA
25	POLYGONACEAE
31	CARYOPHYLLACEAE
32	CHENOPODIACEAE
35	RANUNCULACEAE
41	HYPERICACEAE
42	PAPAVERACEAE
43	FUMARIACEAE
44	CAPPARACEAE
45	CRUCIFERAE
46	PLATANACEAE
49	CRASSULACEAE
51	ROSACEAE
53	MIMOSACEAE
54	CAESALPINIACEAE
55	PAPILIONACEAE
57	GERANIACEAE
59	LINACEAE
60	EUPHORBIACEAE
62	RUTACEAE
64	ANACARDIACEAE
67	RHAMNACEAE
A67	VITACEAE
69	MALVACEAE
73	CISTACEAE
74	TAMARICACEAE
77	LYTHRACEAE
78	MYRTACEAE
79	ONAGRACEAE
81	THELIGONACEAE
83	UMBELLIFERAE
85	PRIMULACEAE
86	PLUMBAGINACEAE
87	STYRACACEAE
88	OLEACEAE
89	GENTIANACEAE
90	APOCYNACEAE
92	RUBIACEAE
93	CONVOLVULACEAE
94	BORAGINACEAE
95	VERBENACEAE
96	LABIATAE
97	SOLANACEAE
98	SCROPHULARIACEA
100	ACANTHACEAE
101	OROBANCHACEAE
103	PLANTAGINACEAE
104	CAPRIFOLIACEAE
105	VALERIANACEAE
106	DIPSACACEAE
107	CUCURBITACEAE
108	CAMPANULACEAE
109	COMPOSITAE
111	BUTOMACEAE
116	LILIACEAE
117	AMARYLLIDACEAE
118	DIOSCOREACEAE
119	IRIDACEAE
120	JUNCACEAE
121	GRAMINEAE
123	ARACEAE
124	LEMNACEAE
126	TYPHACEAE
127	CYPERACEAE
129	ORCHIDACEAE

APPENDIX 5.5.I

Summarizing tables of vegetation analysis for the determination of vegetation units by means of nodal ordination.

Table 5.1: ORDIN 1 - Vegetation survey - "survey" transects and long point transects 1976, on the basis of the occurrence of species.

Table 5.2: ORDIN 1 - Vegetation survey - "survey" transects and long point transects 1976, on the basis of the dominance of species.

Table 5.3: ORDIN 8 - Vegetation survey - "survey" transects and long point transects, on the basis of the occurrence of species.

Table 5.4: ORDIN 8 - Vegetation survey - "survey" transects and long point transects, on the basis of the dominance of species.

The figures 3, 6, 15 at the left hand side of each row represent the rotation level. Figures above each cell represent the nodum number of the nodal ordination analysis.

Table 5.1: ORDIN 1 OCCURRENCE

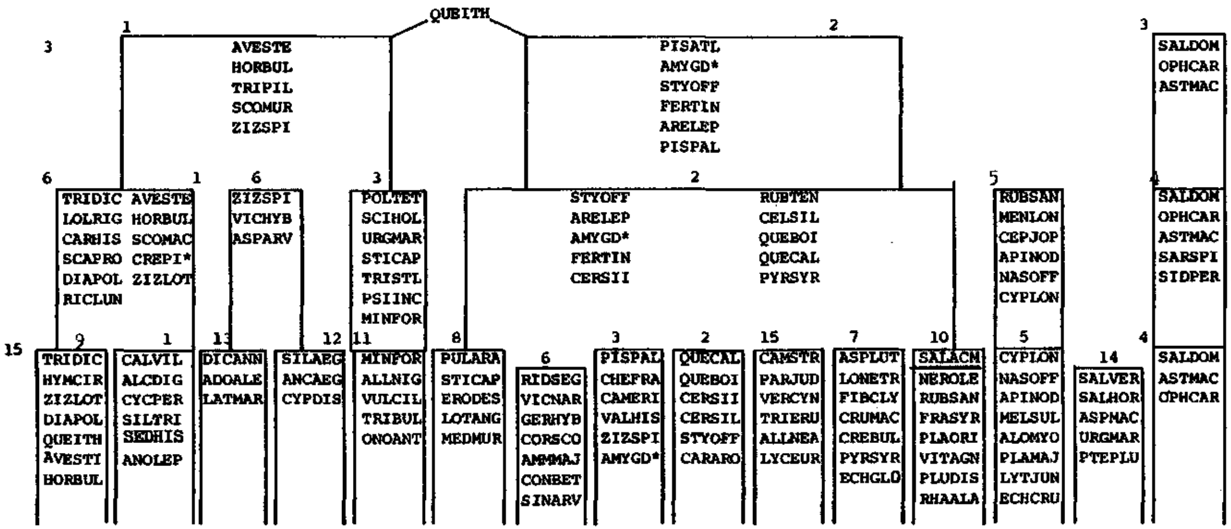


Table 5.2 ORDIN 1 DOMINANCE

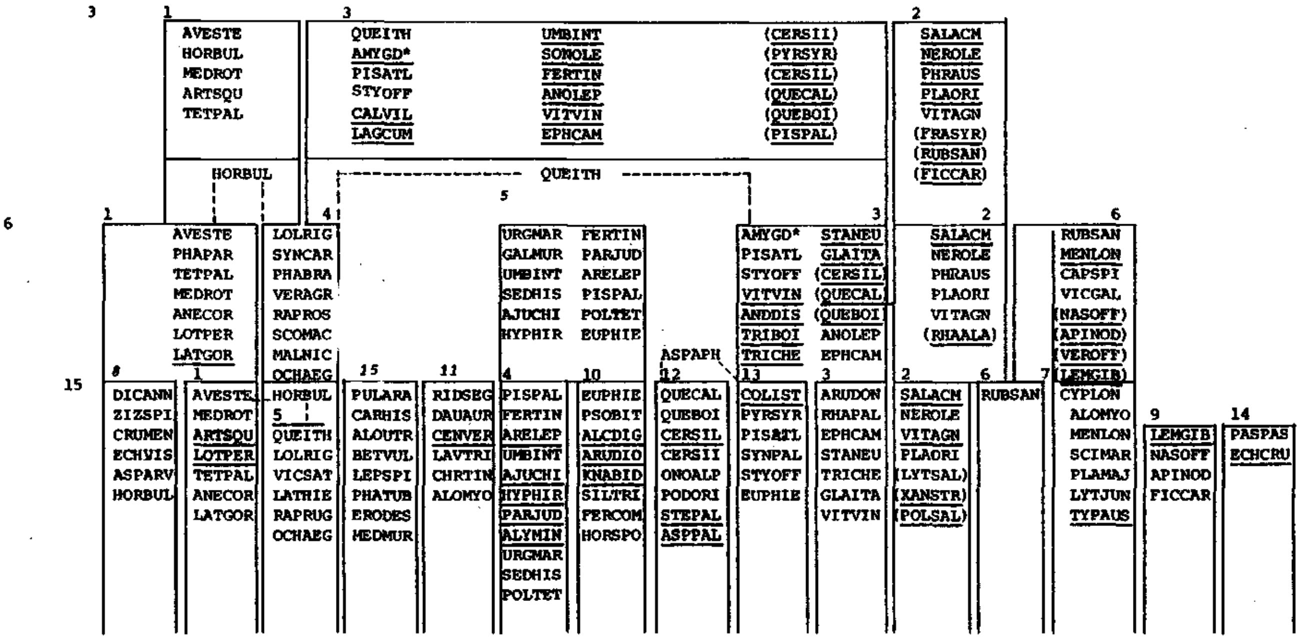


Table 5.3: ORDIN 8 OCCURRENCE

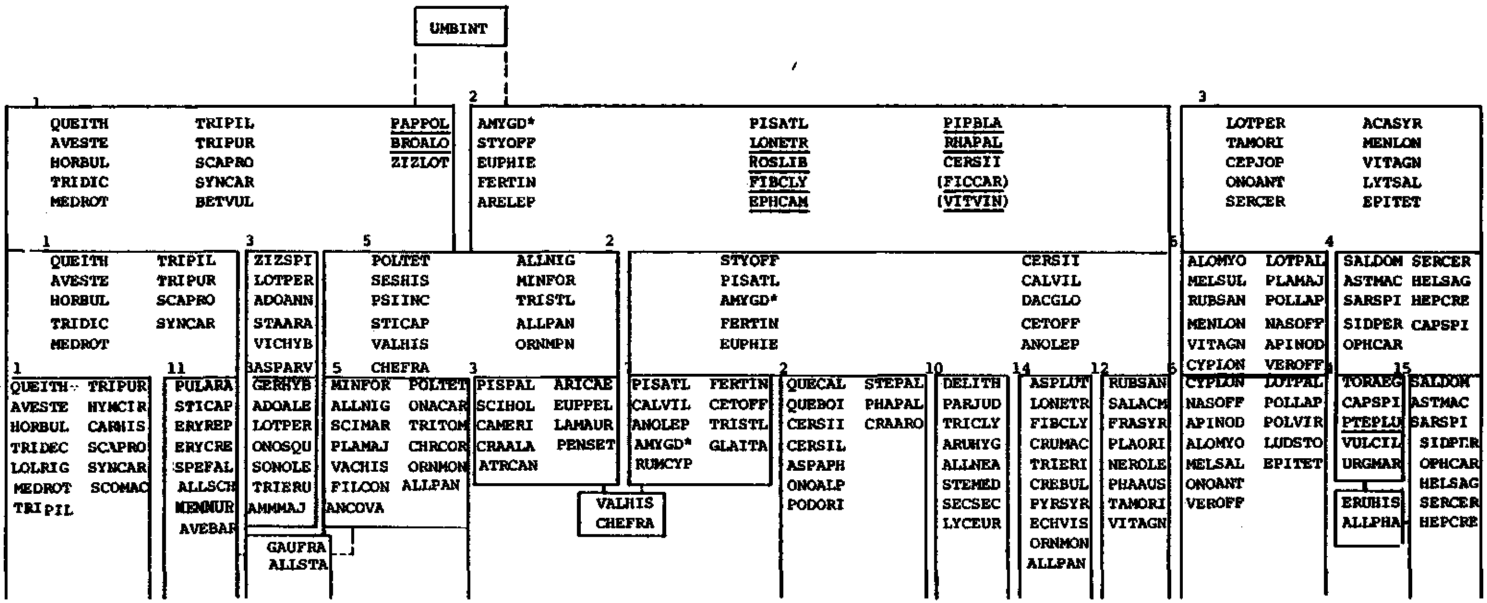


Table 5.4: ORDIN 8 - Dominance

1		3			2
AVESTE	SCOMAC	AMYGD*	SYNCAR	(CRAARO)	SALACM
FERCOM	LINPUB	BROMAD	LATHIE	(COLIST)	NEROLE
HORSPO	VICNAR	CREPAL	CAMRET	(CERSIL)	PHRAUS
TRIDIC	(ONOANT)	TRIPIL	(CERSII)		PLAORI
		HYMCIR	(PYRSYR)		AITAGN
					(FRASYR)
					(LYTSAL)
					(FICCAR)
					(TAMJOR)
					(RHAALA)

6

1		4		3		5		2	6
AVESTE	LATGOR	HORBUL	RAPROS	AMYGD*	ANDDIS	CARHIS	URGMAR	SALACM	RUBSAN
FERCOM	LOTPER	LOLRIG	SCOMAC	PISATL	TRIBOI	UMBINT	ARELEP	NEROLE	MENLON
HORSPO	TETPAL	MEDROT	PAPPOL	CALCIL	STANEU	SEDHIS	POLTET	PHRAUS	CAPSPI
TRIDIC	PHAPAR	TRIPIL	PHABRA	STYOFF	GLAITA	POABUL	CRAARO	PLAORI	VICGAL
		TRIPUR	VICSAT	RHAPAL		ALYMIN	PISPAL	VITAGN	(VEROFF)
		OCHAEG	RANARV			AJUCHI		(LYTSAL)	(NASOFF)
						HYPHJR		(EPITET)	(APINOD)
								(RHAALA)	(EPIHIR)
								(POLSAL)	(POLLAP)
								(XANSTR)	

15

1	4	14	11	12	13	8	3	5	9	2	6	10	7	15
AVESTE	HORBUL	DICANN	RIDSEG	QUECAL	COLIST	LYCEUR	ARUDON	PISPAL	PSOBIT	SALACM	RUBSAN	MENLON	LEMGIB	PASPAS
FERCOM	LOLRIG	ZIZSPI	DAUAUR	QUEBOI	PYRSYR	VICHYB	RHAPAL	FERTIN	ALCDIG	NEROLE	CAPSPI	CYPLON	NASOFF	ECHCRU
TRIDIC	RANMAR	BUTUMB	CENVER	CERSII	PISATL	TORTEN	ANOLEP	ARELEP	KNABID	VITAGN		SCIMAR	APINOD	
SCAPRO	TRIPUR	BALUND	LAVTRI	MYRCOM	SYMPAL	TRICLY	STANEU	PARARG	ARUDIO	PLAORI		PLAMAJ	FICCAR	
LOTPER	OCHAEG	CRUMEM	MOLSPI	CERSIL	STYOFF	SOLLUT	TRICHE	POLTET	SILTRI	(LYTSAL)		MELSUL		
PHAPAR	RAPROS	ONOALO	CHRTIN	ONOALP	ONOCAR	SECSEC	GLAITA	TRISIL		(POLSAL)		LOTPAL		
AEGPER	PAPPOL	SORHAL	BRANIG	PODORI	LINSTR	VICGAI	ECHCAM	URGMAR		(XANSTR)		POLLAP		
LATGOR	PHABRA	LATMAR		TSEPAL		CYNCRE	VITVIN	HYPHIR				VEROFF		
	VICSAT			ASPPAL			POATRI	SEDHIS				VICGAL		
	RANARV			ANTLAM			CALVIL	CARHIS				EPIHIR		
				PIMMIL				UMBINT				POLVIR		
								ALYMIN				LUDSTO		
								ZIZLOT				LYTJUN		

APPENDIX 10.1.I MECHANICAL MEASURING OF CATTLE BEHAVIOUR ON PASTURE - A STATISTICAL ANALYSIS *)

Statistical analysis of bull activity on eight consecutive monthly days, during 33 months (see 10.2.2.1, 10.3.2.1) was carried out, in the following stages:

1. Graphical proposal of activity data according to 8 intervals of the 24 hour day, was carried out, from which the following can be concluded:
   a. bull activity changes in each day over all months and years;
   b. bull activity changes during the 24 hour day in each month;
   c. bull activity changes during the 24 hour day in each season.

   Data from 8 consecutive monthly days were drawn on one axis system of 3 hours intervals against activity level in each. Medians of activity were drawn for each month, for each season and for each year.

   Differences between intervals of the 24 hours day were conspicuous, but generally the same trend was identified in the 8 days, without any apparent order of days. In some months, exceptional days showed a different trend and by excluding them a consistent activity pattern could be noticed.

2. Statistical tests were carried out to check the hypothesis that the 8 consecutive monthly observation days are independent replicates representing the month.

   The statistics "RAD", measuring the sum of deviations from the mean of X_{ij} - the activity level of the bull in time interval i at day j, was defined as follows:

$$RAD = \frac{1}{8} \sum_{j=1}^{n} \frac{|X_{ij} - \bar{X}_i|}{\bar{X}_i}$$

   The small value of RAD which was obtained (ca. 0.3) shows minimal variability and thus, relatively slight differences in bull activity time in the same interval at the various monthly observation days.

---

*) Statistical analysis was prepared by Miss A. Keisar as a part of her Master's degree in statistics at the Hebrew University of Jerusalem.

The statistics "SLOPE", checking the consistency of the direction taken by the change during transition from one interval to the next. "SLOPE" checks the occurrence of exceptional incidents and was defined as follows:

$$\text{"SLOPE"} = \frac{1}{L}\left[\sum_{i=1}^{L}\frac{1}{K}\sum_{j=1}^{k}\frac{|\mu_i - \alpha_{ij}|}{G}\right]$$

α_{ij} is the j exceptional observation slope at the i interval (i = 1....8)
μ_i is the median of the unexceptional observations slopes.
L is the number of intervals in the month having exceptional observations
K is the number of exceptional observations in each interval (K = 0....4)

In case of equality, when in 4 intervals a decline and in 4 intervals an increase were observed, the group in which greater variability occurs is considered exceptional. In other cases, the smaller group is considered exceptional.

"SLOPE" median value was found to be slight (0.105), which means that regularity exists in transition from one interval to the next in the 8 monthly observation days.

The Run-Test*), a test checking the random order of similar consecutive data, showed also that the 8 consecutive observation days were independent (significance level 0.05).

The conclusion drawn from these three tests is that the observation days of the month are autonomous replicates representative of that month.

In the graphical analysis no significant differences were observed as regards months of the same season, but characteristic seasonal graphs differing significantly from one season to another were drawn, as shown in figures 10.1.I and discussed above (see 10.3.2.1).

Relative uniformity was found between observation years. Changes within each season, in the various years, tend to be similar, regarding winter and summer in particular (see fig. 10.2.I).

3. Analysis of variance of monthly activity level is represented by activity median changes in each time interval.

A three-way analysis of variance was carried out for each season separately using SPSS ANOVA programme (Nie *et al.*, 1975).

---

*) Sigel S. (1956): Non-parametric statistics. McGraw Hill: 52-60.

FIG 10,11 :

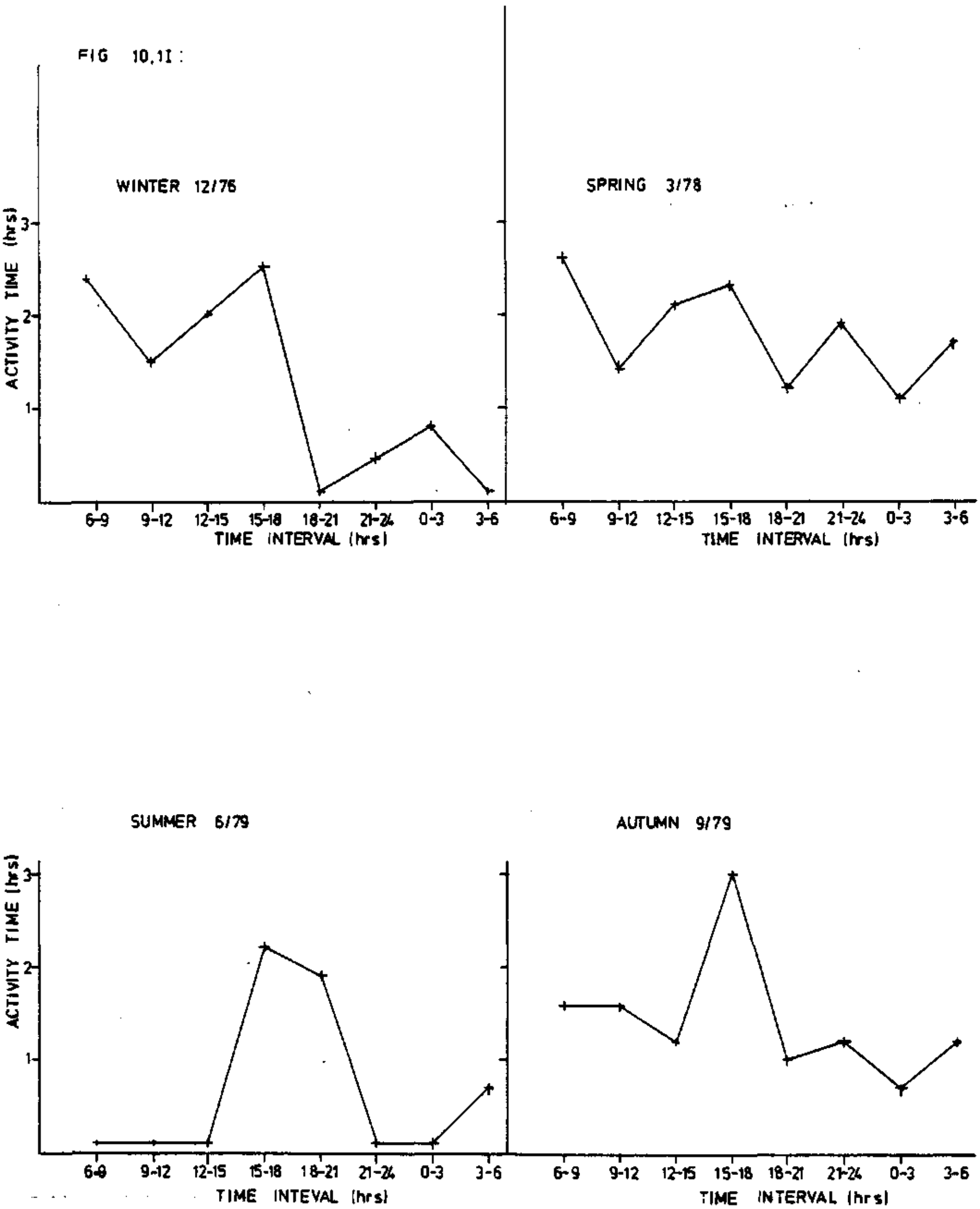

WINTER 12/76
SPRING 3/78
SUMMER 6/79
AUTUMN 9/79
ACTIVITY TIME (hrs)
1
2
3
6-9
9-12
12-15
15-18
18-21
21-24
0-3
3-6
TIME INTERVAL (hrs)
TIME INTEVAL (hrs)

FIG. 10,2I

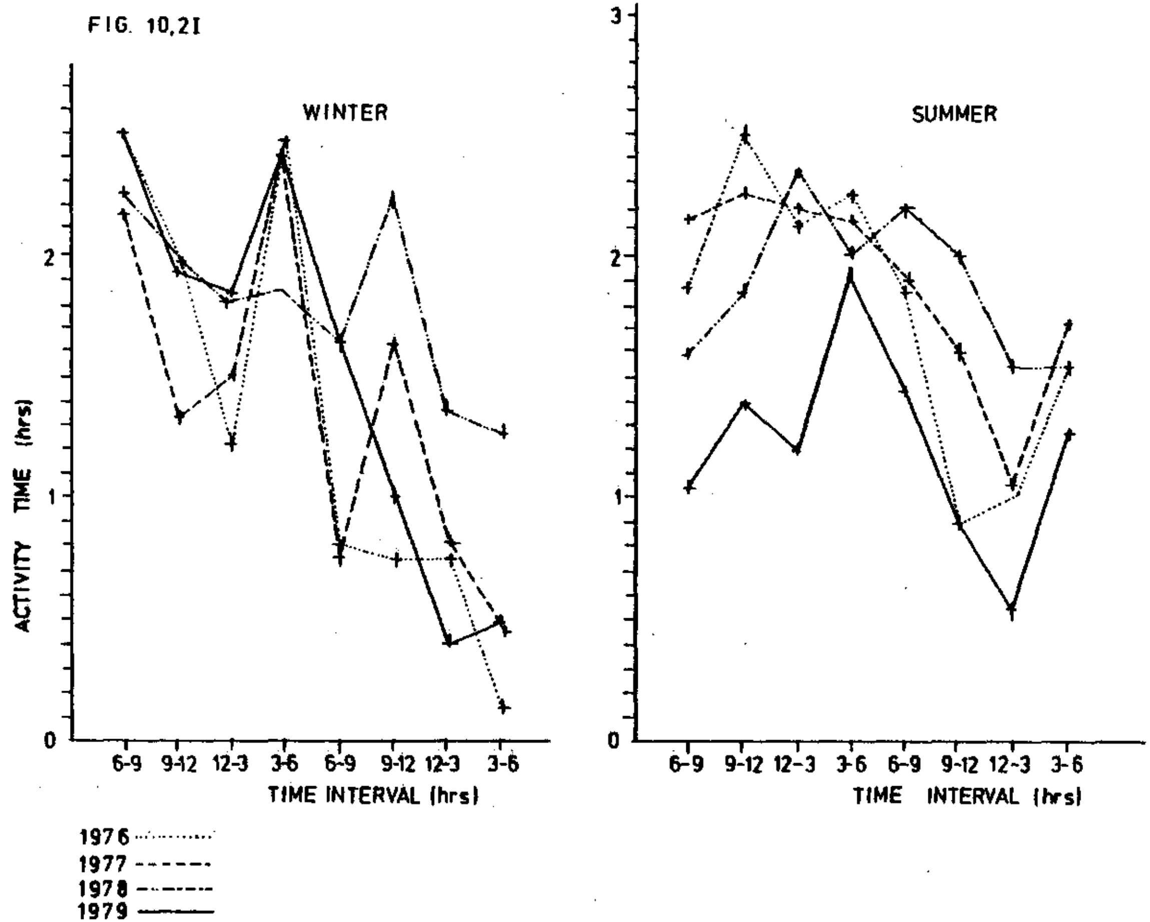


Figure 10.2.I: Winter and summer activity of a bull in the pasture graphs, given in median values of activity in 3 hours interval during 8 intervals of the 8 monthly days. In various years.

Table 10.1.I - 1: Winter activity - analysis of variance.
Grand Mean of winter activity per interval = 1.43 hrs.
Cases : 328; Missing : 9.

Analysis of Variance : hours by month, interval, year.

Source	sum of squares	df	mean squares	F	Sig. of F
Main effects	183.318	11	16.683	40.967	0.001
Month	1.117	2	0.559	1.372	0.255
Interval	174.138	7	24.877	61.086	0.001
Year	7.709	2	3.855	9.465	0.001
2-way interactions	35.483	30	1.183	2.904	0.001
Month interval	16.475	14	1.177	2.890	0.001
Month year	4.024	2	2.012	4.941	0.008
Interval year	12.544	14	0.900	2.209	0.008
Explained	219.001	41	5.341	13.116	0.001
Residual	112.806	277	0.407		
Total	331.807	318	1.043		

Multiple classification analysis (MCA) : hours by month, interval, year.

Variable + Category		N	Unadjusted Dev. ≠ N	ETA	Adjusted for independents Dev. ≠ N	BETA
Month	Nov.	143	-0.04		-0.02	
	Dec.	96	0.10		0.08	
	Jan.	80	-0.05		-0.07	
				0.07		0.06
Interval	6- 9	39	0.95		0.95	
	9-12	40	0.24		0.24	
	12-15	40	0.26		0.26	
	15-18	40	1.05		1.06	
	18-21	40	-0.46		-0.46	
	21-24	40	-0.07		-0.07	
	0- 3	40	-0.73		-0.73	
	3- 6	40	-1.22		-1.22	
				0.72		0.72
Year	1976	136	-0.14		-0.15	
	1977	136	0.19		0.18	
	1979	47	-0.13		-0.10	
				0.16		0.15

Multiple R squared = 0.0553

Multiple R = 0.744

Table 10.1.I - 2: Spring activity - analysis of variance.
Grand mean of spring activity per interval = 1.41 hrs.
Cases : 160; Missing : 1.

Analysis of Variance : hours by month, interval, year.

Source	sum of squares	df	mean squares	F	Sig. of F
Main effects	35.795	10	3.580	7.023	0.001
Month	0.354	1	0.354	0.695	0.406
Interval	24.400	7	3.486	6.839	0.001
Year	3.723	2	1.861	3.652	0.029
2-way interactions	26.123	21	1.244	2.441	0.001
Month interval	6.299	7	0.900	1.765	0.100
Interval year	18.209	14	1.301	2.552	0.003
Explained	61.918	31	1.997	3.919	0.001
Residual	64.729	127	0.510		
Total	126.648	158	0.802		

Multiple classification analysis (MCA) : hours by month, interval, year.

Variable + Category		N	Unadjusted Dev. ≠ N	ETA	Adjusted for independents Dev. ≠ N	BETA
Month	Feb.	79	-0.22		-0.07	
	Mar.	80	0.22		0.07	
				0.25		0.08
Interval	6- 9	19	0.55		0.55	
	9-12	20	0.08		0.08	
	12-15	20	0.08		0.08	
	15-18	20	0.64		0.64	
	18-21	20	-0.26		-0.26	
	21-24	20	-0.17		-0.17	
	0- 3	20	-0.54		-0.54	
	3- 6	20	-0.36		-0.36	
				0.44		0.44
Year	1977	40	-0.39		-0.33	
	1978	79	0.02		0.03	
	1979	40	0.34		0.27	
				0.29		0.24

Multiple R squared = 0.283
Multiple R = 0.532