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Contributions of various feed components to feed availability in integrated barley/livestock systems in the north-western coastal zone of Egypt: a simulation study

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Contributions of various feed components to animal husbandry in the north-western coastal zone of Egypt were quantified using systems analysis and simulation. Rangeland forage meets only 58% of the annual feed requirements of the present animal population, consequently barley products, subsidized concentrates and other supplements are required to maintain the animal population. Without buying non-subsidized supplements, the present sheep and goat population exceeds the potential by about 16%. Apparently, economic conditions are favourable for the Bedouin to maintain their present flock size.

Introduction

The north-western coastal zone of Egypt (480 km long and 25–60 km wide) extends from Alexandria to the Libyan border as far as the 75-mm isohyet. For the present study it is divided into four regions; the Burg el-Arab, the Dabaa, the Matruh and the Barrani regions (Fig. 1). The climate is arid-mediterranean with an average annual rainfall of about 125 mm. In the most eastern part, irrigation is possible. The main agricultural activities of the Bedouin settled in stone houses, are animal husbandry based on sheep and goats, rainfed barley, fig and olive cultivation.

Barley cultivation and animal husbandry are practised as an integrated production system. Barley, based on runoff/runon water supply, is grown for both human and animal consumption. The grain is either sold at market if of good quality, fed to the animals or sold to other herdsmen. In years with about average rainfall, barley and weed stubble are grazed by the animals during the summer. Most of the barley is harvested by sickle, if however pulled up by hand little stubble is left for the animals. If rainfall is unfavourable, e.g. too low to expect satisfactory grain yields, animals are allowed to graze the complete crop of barley and weeds.

In the animal husbandry system the lambs and kids are born predominantly in March and November. Donkeys are kept for transport; camels are reared to a limited extent. Cattle are kept mainly in the irrigated part of the zone, their number being negligible in the other areas. Poultry and game have been excluded from the present study.

Rangeland, the major feed resource, occupies an estimated 90% of the total area of the

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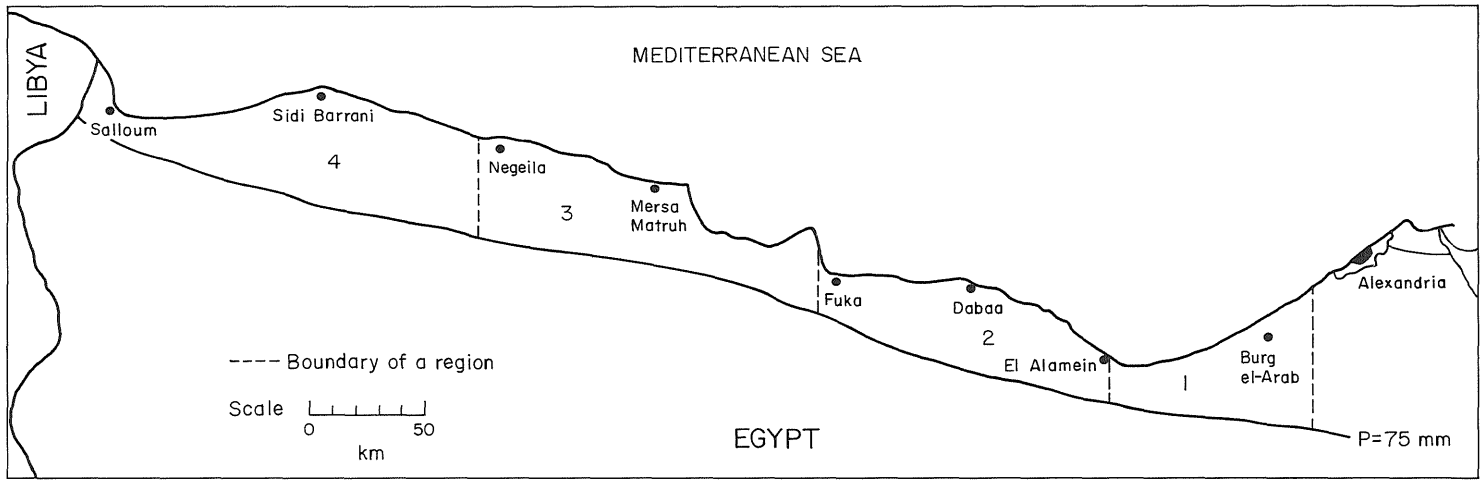

Figure 1. Map of the north-western coastal zone showing the four pilot regions (1) The Burg el-Arab region; (2) The Dabaa region; (3) The Matruh region; (4) The Barrani region.

coastal zone, including the runoff areas between the barley fields. The vegetation is dominated by shrubs, bushes and sub-shrubs, the latter forming the major group in many areas. Annuals occur only to a limited extent. Because of the increasing high animal density, currently almost 1·5 million head, the rangeland vegetation is insufficient throughout the year and therefore supplementary feed is necessary. Supplementation usually only occurs during the dry season, except in very dry years when it is also necessary in spring. The main supplement consists of concentrates (manufactured and/or barley grains) and roughage (straw, vegetable residues and/or clover). Feed resources to manufacture concentrates are not available locally and must be imported, but this constitutes a burden on the national economy since a large proportion of the concentrates are subsidized. Nevertheless, the availability of subsidized concentrates in the region has tripled in the last 6 years to about 45 million kg a^{-1}, as a result of the increasing number of sheep and goats and the supportive government policy.

In this paper the potential of small ruminant systems is evaluated against feed availability. The contribution of the feed components is quantified and the management options discussed. A model was developed to simulate the difference between feed availability and feed requirements. The feed balance per average animal for a specific area, taking the present flock composition into account, is used as an indication for viability of animal husbandry systems. The model and results are discussed.

The model ARID ANIMAL

Short description

The model ARID ANIMAL describes the feed requirements of the various animal species in a target-oriented way, i.e. requirements are a function of the production level aimed at. As insufficient data were available to characterize both feed requirements and feed quality in terms of energy and protein contents, only the energy aspect, expressed in Scandinavian Feed Units (FU), was taken into account. Availability of rangeland forage, barley products and subsidized concentrates are introduced as forcing functions, i.e. they are not influenced by the behaviour of the system. The model is written in CSMP (Continuous System Modelling Program) and is described in detail (available on request) by van Duivenbooden (1987).

ARID ANIMAL calculates for each region the feed balance based on its specific barley area, rangeland area and animal population, for each month starting from October. The feed balance per 'average animal of the flock (EE)' per month is defined in the model as:

$$\text{FEBAL} = (\text{RLFAV} + \text{BSAV} + \text{BGAV} + \text{CONAV}) - \text{FUTRQ} \qquad (1)$$

where,

RLFAV	= Rangeland forage availability	(FU EE–1 mth–1)
BSAV	= Barley straw availability	(FU EE–1 mth–1)
BGAV	= Barley grain availability	(FU EE–1 mth–1)
CONAV	= Subsidized concentrate availability	(FU EE–1 mth–1)
FUTRQ	= Total feed requirements	(FU EE–1 mth–1)

If the feed balance is negative, the amount of additional (non-subsidized) supplements required to compensate that deficiency is calculated. The term 'additional supplements' is used because barley straw, barley grains and subsidized manufactured concentrates as used at present are already taken into account in the feed balance.

Main input data

The animal population
The small ruminant (sheep and goats) population is estimated at 1·46 million head, a doubling compared with 10 years ago (Aboul-Naga, 1987). In addition, there are about 21,000 donkeys and 200 camels. Based on data and present developments, the fractional distribution of the small ruminant population in the coastal zone among the four regions is estimated at 0·12, 0·24, 0·30 and 0·34 for the Burg el-Arab, the Dabaa, the Matruh and the Barrani regions, respectively. Camels are assumed to be distributed similarly and donkeys in proportion to the population density.

The structure of the flock
Flock structure is characterized by both age distribution and the ratio of sheep to goats, estimated at 2·7:1. At present there is a tendency to keep young lambs and kids for late fattening and/or for increase in the breeding stock.

Fertility characteristics
Fertility characteristics being species-specific include: conception rate, litter size, mortality rate, and the ratio of lambs (and kids) born in March to those born in October (0·4:0·6). However in the present version of the model the values of these characteristics are not modified when the feed balance is negative, due to lack of relevant data. It is assumed that the deficiency is compensated by additional supplements.

Productivity characteristics
Productivity characteristics also being species-specific include: weights at various ages, target fattening weight, culling rate and fraction of lambs and kids, sold before and after fattening.

Feed requirements
Feed requirements include: maintenance, walking, flushing before the breeding season, steaming up before lambing, lactation till weaning, and lamb or kid fattening after weaning. Differences in animal characteristics mean that the feed requirements of each species differ from month to month therefore they were calculated per head for each of the species separately. However in the present study the interest is not in the dynamics of feed requirements of individual species, but in that of the flock as a whole. Due to differences in size between the animals, their monthly needs cannot be added indiscriminately. Therefore the 'average animal of the flock' is defined. The monthly requirements (FU/head) are multiplied by a conversion factor (EE/head). This is quantified on the basis of the relationship between the various animal species as given by Le Houérou & Hoste (1977) and subsequently by a factor that takes into account the present flock composition, i.e. the contribution of each animal species to the total animal population. This is expressed as the fraction of the total animal population (EE/EE).

Availability and quality of rangeland forage
Production of natural vegetation is low and the inter-annual variability high due to the variable precipitation. Accurate determination of the standing biomass on the rangeland is very difficult because of its heterogeneity. Generally, peak biomass is recorded at the end of winter or in early spring. However, spatial variability in biomass production is high. Because of the problems associated with measuring biomass production, primary production of the vegetation in the Burg el-Arab region was calculated using a simulation model. Generally, primary production in semi-arid regions is determined by soil moisture availability and/or soil fertility. As soil fertility data of the rangeland area are very scarce, only variation in precipitation could be taken into account. Four rainfall regimes were

Table 1. *Rangeland area (ha) of the four regions and the corresponding weighted average of simulated available rangeland forage dry matter (kg ha^{-1} a^{-1}) under four rainfall regimes*

	Rangeland area				Forage availability			
	Region				Region			
Rainfall	BeA	Dabaa	Matruh	Barrani	BeA	D	M	B
$p > 150$ mm	9080	0	0	70	360	0	0	175
$125 < p < 150$ mm	8420	31380	28400	71820	345	520	355	460
$100 < p < 125$ mm	26710	98000	137390	135990	370	390	305	305
$75 < p < 100$ mm	68910	92900	156510	186030	360	340	300	300

BeA, the Burg el-Arab region.

distinguished: 75–100, 100–125, 125–150 and exceeding 150 mm a^{-1}. As a first approximation, biomass production of the sub-shrubs was simulated as a function of precipitation and standing biomass using the model ARID SHRUB developed by van Duivenbooden (1985). Subsequently, the results were modified taking into account the carrying capacity at the end of the 1960s (FAO, 1970*b*), and the reconnaissance soil maps of FAO (1970*a*) (Table 1). Using these maps and taking into account the isohyetes, we estimated the rangeland area per precipitation regime.

Forage quality is as important for animal productivity as forage availability (Ketelaars, 1983). The quality of a feed resource is determined mainly by its crude protein content and to a lesser extent by its energy content and digestibility. As green and dry pasture differ considerably in nutritive value, both components of the feed resource are treated separately in constructing the feed balance. Moreover, feed availability during the dry season is influenced largely by pasture use during the green season. In a schematized set-up the annual pasture cycle can be divided into three phases: (1) Green grazing period (Dec.–Feb.), (2) Early dry grazing period (March–April) and (3) Main dry grazing period (May–Nov.). The nutritional value of rangeland forage dry matter for these periods is estimated at 0·75, 0·55 and 0·45 FU kg^{-1}, respectively.

Availability and quality of subsidized concentrates

For a total small ruminant population of 1·46 million head, the amount of subsidized concentrates available per year is 32·9 kg head^{-1} based on 1985 figures. Averaged over the main dry period, that is equivalent to 5·4 kg head^{-1} month^{-1}, which is in close agreement with the amount of 5 kg head^{-1} month^{-1} reported by Aboul-Naga (1987). Although the amount of concentrate actually supplied daily to the animals varies from place to place in the coastal zone, the average value is applied. The importance of the subsidized concentrates is further substantiated by the increase in supply. In 1975 the ration was only 2·6 kg head^{-1} month^{-1} in the main dry period. The nutritional value of concentrate dry matter is about 1 FU kg^{-1}.

Availability and quality of barley products

Crop yields of barley were estimated with a simulation model, developed and evaluated by van de Ven (1987). Areas and average yields for each region, when 250 mm infiltration is realized, are given in Table 2, excluding the irrigated area in the Burg el-Arab region. The rangeland area needed to collect sufficient runoff water for realization of that infiltration regime is also grazed. It is assumed that all barley products are available for the animals and that total supplement availability is evenly distributed over the period from May to Nov. The nutritional value of dry matter of grains and straw is estimated at 1·0 and 0·4 FU kg^{-1}, respectively.

Table 2. *Weighted average of simulated barley grain (BGWAP) and straw (BSWAP) production (kg DM ha^{-1} a^{-1}) on the barley fields (ABF, ha) in the four regions without irrigation, weeding and fertilizer, receiving 250 mm infiltration, and corresponding area of rangeland between the barley fields (ARLBBF, ha) (van de Ven, 1987)*

Region	BGWAP	BSWAP	ABF	ARLBBF
Burg el-Arab non-irrigated	480	2640	6840	16020
Dabaa	534	2676	9010	32360
Matruh	654	2956	12710	33600
Barrani	688	2983	11330	17730
Total coastal zone	597	2831	40830	99710

Simulation results

To evaluate the feed balance, two components must be considered, the feed requirements and the feed availability. The magnitude of feed requirements varies during the year, being a function of the production level and the composition of the average animal. As insufficient information is available to describe the feed requirements of camels and donkeys in detail, emphasis is on sheep and goats. Where in addition to donkeys and camels, only sheep or only goats would be present (for instance in the Matruh region) these data are presented in Fig. 2. That figure shows that a change in flock composition in favour of sheep leads to an optimum pasture exploitation in winter. Without sheep less forage is used in winter and more supplements may be required in the main dry period due to loss of forage quality.

Next, feed availability is considered. As rangeland forage availability determines the potential for animal husbandry in winter, that characteristic is discussed first in detail.

It is clear from Fig. 3, showing availability of rangeland forage during the year in the four regions, that the present stocking rate exceeds the animals' maintenance requirements in the main dry period. Due to the low quality of rangeland forage, high quality supplements are then indispensable. Distribution of rangeland forage during the year and differences in peak forage availability among the four regions are crucial factors.

As the Bedouin, according to what they say, are forced to move to the inland area, the contribution of that area to the total feed availability is examined. Figure 4 shows the

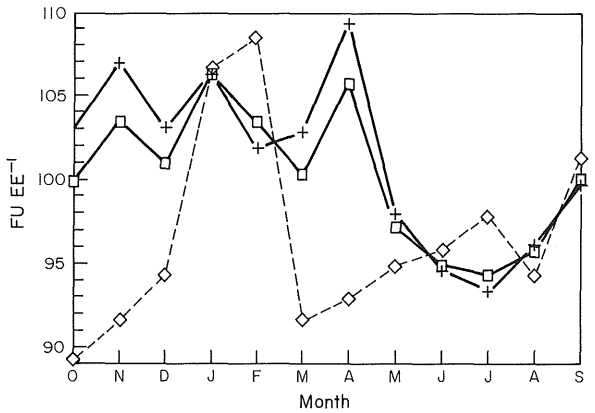

Figure 2. Simulated feed requirements of an 'average' animal of the flock comprising camels, donkeys, sheep and goats (ratio sheep to goats 2·7:1) (□), sheep only (+) and goats only (◇).

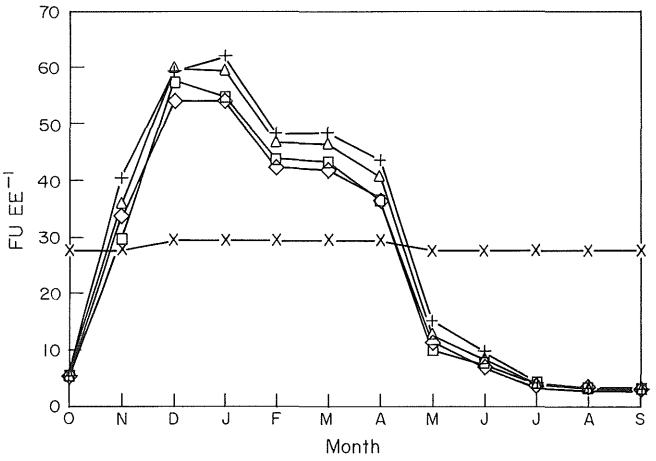

Figure 3. Simulated feed availability of rangeland forage in the course of the year in the Burg el-Arab (□), the Dabaa (+), the Matruh (◇) and the Barrani regions (△). x, maintenance requirements.

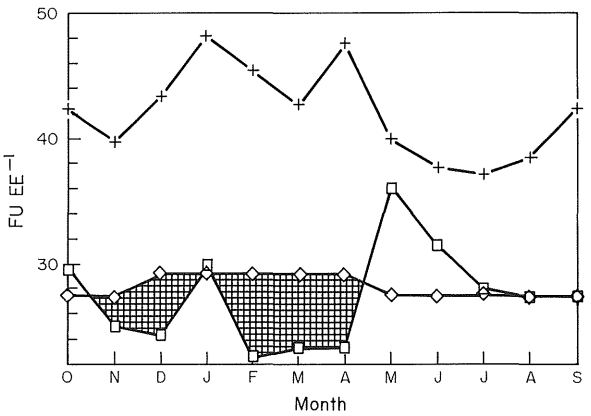

Figure 4. Simulated total feed requirements (+), feed availability (□) and maintenance requirements (◇) in the course of the year in the Matruh region, when the area with precipitation below 100 mm is not used as rangeland. Hatched area represents minimum supplement requirement.

importance of the inland area, where annual rainfall is between 75 and 100 mm, in maintaining the present level of animal production. Without that feed resource, additional supplements would already be indispensable to meet the maintenance requirements of the animal population. This contrasts with the current situation, where winter rangeland forage is sufficient (Fig. 3) while summer supplies are inadequate.

Barley products and subsidized concentrates increase the total feed availability (Fig. 5*a*), so that they are sufficient for maintenance throughout the year (Fig. 5*b*). The feed balances for the pre-defined production levels for the Burg el-Arab, the Dabaa, the Matruh and the Barrani region separately, are presented graphically in Fig. 6*a*, and the average for the total coastal zone in Fig. 6*b*. These figures show that under the present circumstances feed deficiencies exist. Beside the need for supplements during the early

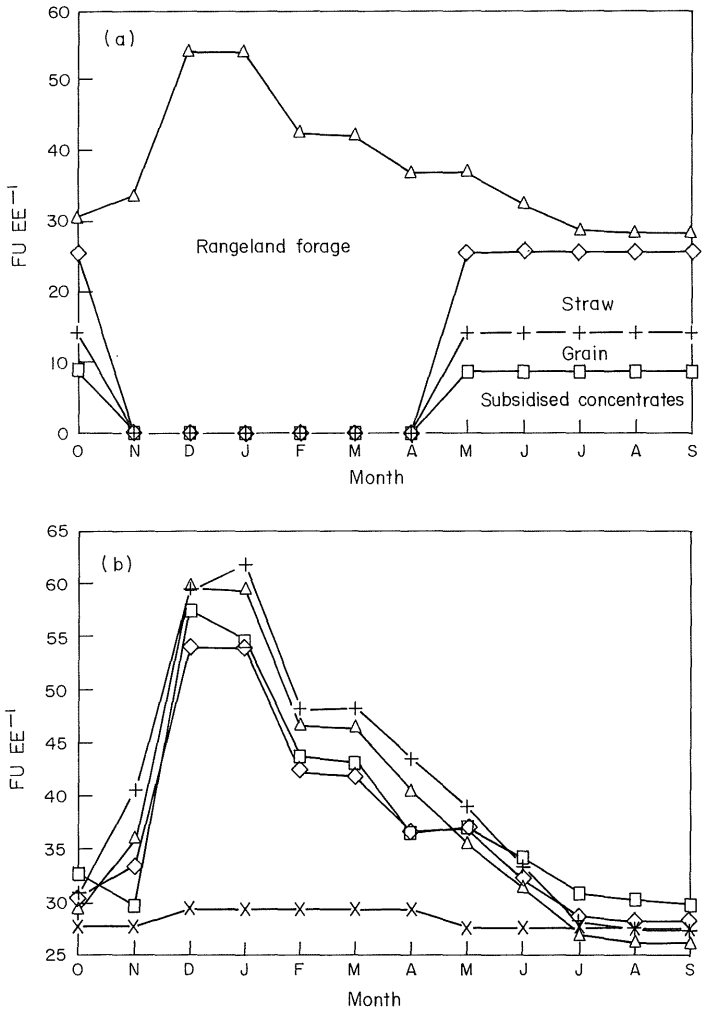

Figure 5. Simulated components of feed availability in the course of the year in the Matruh region (*a*); and total feed availability in the Burg el-Arab (□), the Dabaa (+), the Matruh (◇) and the Barrani region (△), respectively (*b*). x, maintenance requirements.

dry and the main dry periods, relatively high additions are needed for Nov. and April. Hence, saving straw and grain until Nov. and the next April would be sound practice, but storehouses are not always available. Furthermore, rangeland forage contributes on average 58% of the total annual feed requirements (Table 3) and in all regions additional supplements are required, ranging from 12 to 16% of the total, to feed the present animal population.

In the months with a negative feed balance, the quality of additional supplements determines the total intake and that in turn determines the possibilities for exploitation of the rangeland. For instance, part of the required supplement could be met by rangeland forage left from the months with a positive feed balance. That is, however, only possible on a limited scale, as the quality of the rangeland forage declines rapidly with age. High quality supplements are still necessary then, to ensure adequate intake to meet the maintenance levels. On the other hand abundant concentrate availability reduces the need for rangeland forage. The total amount of required supplement is thus a function of

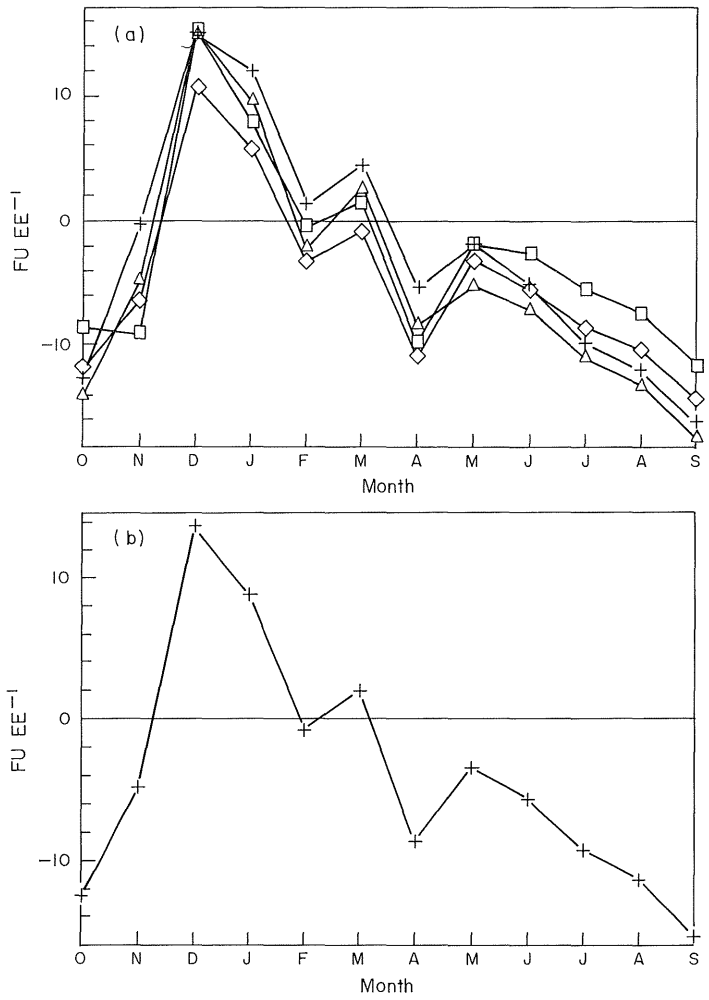

Figure 6. Simulated feed balance in the course of the year in the Burg el-Arab (□), the Dabaa (+), the Matruh (◇) and the Barrani regions (△) (*a*); and in the coastal zone (*b*).

Table 3. *Simulated contribution of the various feed components (per centage of annual feed requirements), taking into account decrease in rangeland forage quality in months with positive feed balance, and existing feed shortage with the present number of sheep, goats, donkeys and camels*

	Feed component					
Region	Rangeland forage	Barley straw	Barley grain	Subsidised concentrates	Shortage	Total
Burg el-Arab	56·3	15·4	6·2	10·2	11·9	100
Dabaa	61·2	11·8	5·2	9·6	12·2	100
Matruh	55·0	13·1	6·4	10·0	15·8	100
Barrani	58·2	10·7	5·5	9·7	15·9	100
Total coastal zone	57·7	12·2	5·7	9·8	14·6	100

management, i.e. stocking rate and the production level aimed at. For the Matruh region, the simulations show that for the present systems in addition to rangeland (1·94 ha EE^{-1}), supplementary dry matter of concentrates and straw are needed at a rate of 140 and 91 kg EE^{-1} a^{-1}, respectively. Multiplying the required rangeland area with the present animal population, leads to the conclusion that available rangeland is a constraint. Consequently, if migration of animals to other areas is not possible, it can be seen that the present animal population exceeds the potential.

This large number of animals can thus only be maintained thanks to abundant availability of both subsidized and non-subsidized supplements. However, if meat export prices collapse, buying additional supplements immediately becomes unattractive and production decreases. The production system would be more stable if it were less dependent on high economic inputs, e.g. concentrates. It is suggested that such a system should have at least a positive annual feed balance, attainable by on the one hand rangeland improvement (fertilization, planting of highly nutritive shrubs etc.) and increasing barley production, and on the other by reduction of feed requirements. As results of improvements in barley and rangeland production could not be substantiated by data, possible reductions in feed requirements are examined. To maintain the present production system the animal population must be reduced. As the sheep and goat population is dominant, the required reduction in the small ruminant population under various management options is calculated. It is assumed that the total amount of subsidized concentrates decreases proportionally to the decrease in animal population and the reduced quality of the biomass of the rangeland when used outside the green grazing period has been taken into account.

The management options considered here, are: (1) The present practice of both barley cultivation and provision of subsidized concentrates. (2) The present practice of barley cultivation, but without subsidized concentrates. (3) The present practice of barley cultivation, but not as feed. Subsidized concentrates continue to be available and are required to compensate for the poor quality of forage in the main dry period. (4) The present practice of both barley cultivation and provision of subsidized concentrates, but the area between the barley fields cannot be grazed. (5) The present practice of both barley cultivation and provision of subsidized concentrates, but barley products not available as feed and the area between the barley fields cannot be grazed. (6) Instead of barley cultivation, local shrub species are planted on the barley fields. Simulated biomass dry matter production under these conditions is 1000 kg ha^{-1} a^{-1}. Subsidized concentrates continue to be available and are required to compensate for the poor quality of forage in the main dry period.

The consequences of realizing these management options for the size of the small ruminant population in the coastal zone are given in Table 4. From this it can again be deduced that the present animal population is about 16% higher than allowed by feed availability. This also means that in the present barley/small ruminant system no margins are left for years with below-average conditions. That conclusion corresponds with the observation that in dry years the Bedouin are on the move in the zone and partly to the Delta, and that they complain about the ration of subsidized concentrates.

To a large extent, availability of subsidized concentrates and barley products enables the Bedouin to maintain their present flock size. In the absence of barley cultivation the reduction in herd size can only be compensated to a limited extent by shrubs planted on the barley fields (management option 6). As subsidized concentrates are available in insufficient amounts, under the present price ratio of input/output, buying of non-subsidized concentrates (about 100 kg EE^{-1} a^{-1}) is still economically attractive. One should realize, however, that a substantial reduction in herd size would lead to a low stocking rate in winter, resulting in a more vigorous growth of the natural vegetation with its associated higher water use and a shorter growing season. The net result would be that availability of forage from natural rangeland in summer is reduced and more supplements are necessary. Eventually, the perennial vegetation may die completely and although some annual herbs may take over, the total availability of rangeland forage will be much lower (van

Table 4 *Availability of feed components under six management options (+, available; −, not available) and simulated reduction in small ruminant population (per centage of present number) under these management options to obtain a positive annual feed balance*

	Availability					
	Management option					
Feed component	1	2	3	4	5	6
Concentrates	+	−	+	+	+	+
Barley grains and straw	+	+	−	+	−	−
Rangeland between barley fields	+	+	+	−	−	+
Shrubs instead of barley	−	−	−	−	−	+
	Reduction					
	Management option					
Region	1	2	3	4	5	6
Burg el-Arab	13	24	43	25	55	35
Dabaa	13	23	35	25	47	29
Matruh	18	28	45	29	55	39
Barrani	18	27	39	22	44	34
Total coastal zone	16	26	41	25	49	33

Duivenbooden, 1985, 1988) with its associated consequences for the potentials of animal husbandry systems. Hence, reduction in flock size only is not sufficient. Further research (field experimentation and modelling) is required to improve rangeland production and to determine the optimum stocking rate at the rangeland (i.e. the rate that would extend the effective green grazing period while maintaining the vegetation in a continuously productive state), to ensure a stable barley/small ruminant system, that was also profitable under conditions below average.

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