

Studies on breeding shorebirds at Medusa Bay, Taimyr, in summer 2000

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**Studies on breeding shorebirds at Medusa Bay, Taimyr, in
summer 2000**

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ABSTRACT

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In the summer of 2000 a combined Dutch-Russian expedition took place to the Willem Barentz field station at Medusa Bay near Dikson in north-western Taimyr. The expedition was organised by Alterra, the Working Group for International Waterbird and Wetland Research (WIWO) and the Dutch Agricultural Department of the Dutch Embassy in Moscow. As a background document containing all basic information collected during the 2000 season, the results obtained by the Alterra and part of the results obtained by the WIWO team will be presented in this report. Its purpose is not to discuss data thoroughly but merely to summarise the research questions addressed and present the basic data. More elaborate analyses and discussion of the data will be made in the form of papers in international refereed journals, in combination with results from the 2001 season. Subjects of study generally concerned breeding biology of arctic breeding shorebirds and were all related to the timing of breeding.

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1 Introduction

1.1 Organisation and participants

In the summer of 2000 a combined Dutch-Russian expedition took place to the Willem Barentz field station at Medusa Bay near Dikson in north-western Taimyr. The expedition was organised by Alterra, the Working Group for International Waterbird and Wetland Research (WIWO) and the Dutch Agricultural Department of the Dutch Embassy in Moscow that enabled participation of one Ukrainian and five Russian biologists, working at different institutes.

The findings of this expedition will be reported in several publications. Apart from short reports to the WIWO and the Dutch Embassy, a combined report will be prepared including all subjects addressed by the different researchers. The aim is to finish this combined report before next field season. As a background document containing all basic information collected during the 2000 season, the results obtained by the Alterra and part of the results obtained by the WIWO team will be presented in this report. Its purpose is not to discuss data thoroughly but merely to summarise the research questions addressed and present the basic data. More elaborate analyses and discussion of the data will be made in the form of papers in international refereed journals, in combination with results from the 2001 season.

Participants of the expedition were: Hans Schekkerman (researcher Alterra), Ingrid Tulp (volunteer researcher Alterra), Raymond Klaassen (WIWO and student, Wageningen University), Sergei Kharitonov (senior research biologist, Bird Ringing Centre Moscow), Mikhail Berezin (entomologist, Moscow Zoo), Andrei Bublichenko (curator of mammalogy, Zoological Museum, St. Petersburg, Yulia Bublichenko, biologist Zoological Museum St. Petersburg), Sofia Rosenfeld (student, Moscow State University) and Sergei Khomenko (biologist, Azov-Black Sea Ornithological station, Ukraine).

The main research topics addressed by the different expedition members were:

Shorebird breeding ecology	Ingrid Tulp, Hans Schekkerman, Raymond Klaassen
Monitoring of breeding birds	Raymond Klaassen, Sergei Khomenko
Monitoring of lemming population	Andrei Bublichenko
Gulls and Geese breeding colonies	Sergei Kharitonov
Monitoring of arthropod abundance	Mikhail Berezin, Hans Schekkerman, Ingrid Tulp
Breeding ecology passerines	Yulia Bublichenko
Geese feeding ecology	Sofia Rosenfeld

As the Alterra and WIWO team combined their efforts in the field, results of topics addressed by both teams will be presented in this report.

1.2 Background and research topics

A short introduction to topics studied will be given here. The first part deals with breeding ecology and was the main responsibility of the Alterra team, while the monitoring was the main topic of the WITWO team.

1.2.1 Breeding ecology

The long-term population size of migratory shorebirds is determined by the equilibrium between reproductive success on the breeding grounds and mortality on breeding, staging and wintering sites. Many studies have focused on the feeding ecology of shorebirds while present in the European coastal wetlands. Much less is known on the arctic breeding grounds. Yet, it is there that new generations of birds are born to replace the birds that died on migration or during winter. The arctic summer is short and time available for finding a mate, laying eggs, raise chicks and prepare for migration is little over two months. Therefore arriving in time and in a condition that allows a quick start of breeding seems paramount for successful reproduction. This is the basic assumption of models of optimal bird migration (Weber *et al.* 1998, 1999). Yet, in contrast to the situation in arctic waterfowl, to date there is no published evidence of a relationship between timing and arrival condition and breeding success in shorebirds.

The main aim of the Alterra team was to study the effect of arrival time and arrival mass on reproductive success for selected long-distance migrants. Both these parameters may be influenced by factors operating in the wintering areas and at migration stopovers (site quality) or during migratory flights (weather), and they may determine whether there is enough time to raise chicks before the end of the short summer, or the number and quality of eggs being produced. This process might thus create a link between events (including effects of human interference) occurring along the migratory route and reproductive output which directly affects population dynamics.

1.2.2 Research topics addressed

The effects of arrival time and condition on the breeding performance can be studied in a direct approach in which shorebirds should be caught upon arrival to determine arrival condition and timing and follow consecutive breeding performance. For this approach the research topics needed to address are:

1. Describe (variation in) arrival date and arrival condition of arctic-breeding shorebirds
2. Study correlations between these variables and (a) probability of obtaining a mate and producing a clutch, (b) laying date, (c) clutch size, (d) egg size, (e) hatching success, (f) chick growth rate and survival, and (g) overall reproductive success.

As this required a totally new catching method we knew beforehand that difficulties might arise if it would fail. Also reproductive output might be difficult to measure in a year with an expected high predation rate as 2000. Therefore a more indirect

approach aiming to describe how the breeding schedule is fitted into the seasonal pattern of resources (temperature, snow melt, food for adults, food for chicks) could be applied in case difficulties would arise in the direct approach.

Because of the uncertainty of the nature of the breeding season a variety of other projects was prepared and carried out as well:

3. Build up an individually colour-marked population of a shorebird species with breeding site fidelity (Dunlin *Calidris alpina*, Pacific Golden Plover *Pluvialis fulva*), for study in the following years.
4. Study seasonal and habitat-related variation in the abundance of invertebrates as food for breeding shorebirds.
5. Study nest attendance in little Stints *Calidris minuta* and Curlew Sandpipers *Calidris ferruginea* to investigate trade-offs in time between incubation and feeding.
6. Measure energy expenditure of chick-rearing Little Stints (for comparison with earlier measurements on incubating adults).
7. Study (variation in) condition parameters of shorebirds upon departure from the arctic breeding grounds in late summer.
8. Study sexual selection for condition/plumage characters and its consequences in arctic shorebirds

The year 2000 was expected to be a year of low lemming abundance and high predation on shorebird nests by arctic foxes and other predators, which might severely limit possibilities to study open-nesting species such as shorebirds. Therefore we prepared and addressed a few alternative topics on Snow Bunting *Plectrophenax nivalis*, a hole-nesting species, which was supposed to suffer less from predation. This should yield comparative data on the ecological consequences of precocial (shorebirds) versus altricial (passerine) development in the tundra environment.

9. Study foraging and provisioning and growth of young in a (hole-nesting) insectivorous passerine (Snow Bunting).
10. Measure energy expenditure of growing chicks of Snow Buntings

1.2.3 Monitoring of breeding birds

A breeding bird monitoring program was started in 1998 by WIWO (van Turnhout *et al.*). The aim of this program is to monitor numbers of all breeding birds. To enable explanations for trends in numbers also several other biotic and abiotic factors are studied. This monitoring program was evaluated in 1999 and the final program was carried out in 2000.

The program consists of the monitoring of:

- a. Migration and arrival using transect counts and point counts.
- b. Numbers of breeding bird numbers using territory mapping, nest searching and transect counts.
- c. Nest success of breeding shorebirds
- d. Adult survival in Pacific Golden Plover

- e. Environmental variables
- f. Lemming density
- g. Arthropod availability
- h. Phenology of plant flowering

The full report of the monitoring program will be published in a combined Dutch-Russian report, and here only numbers of breeding birds will be presented

1.3 Results achieved

We used a new method for catching shorebirds upon arrival to measure arrival condition, which needed some trial and error and fine-tuning before it actually worked. Still it remained difficult to catch reasonable numbers of shorebirds, therefore the first of the research topics mentioned above did not yield satisfying results. As expected 2000 was a year with high predation caused by the large number of Arctic Foxes that visited the area daily, resulting in a large amount of nests being lost to predation. As a result study topics 2e and 2f were hampered to a great extent.

Field conditions allowed to study all other research topics described above. The direct approach to investigate effects of timing of arrival and arrival condition was not successful in several parts. On the other hand the indirect approach yielded very useful results.

1.4 Data analysis

Statistical analyses in this report were all calculated using Genstat 5 (Genstat 5 Committee 1993). Data presented in chapter 10 should be considered preliminary. These data will be published in detail in scientific papers combined with data from previous studies.

1.5 Itinerary

The Dutch part of the expedition departed from Amsterdam on 1 June. Together with the Russian expedition leader, Dr. Sergei Kharitonov, and Dr. Andre Bublichenko, we left for Norilsk on 3 June. After a visit to the office of the Great Arctic Reserve to receive the proper documents and permission to enter the reserve, the journey was continued to Dikson. Two more researchers, Sofia Rosenfeld and Sergei Khomenko joined the expedition in Norilsk. Logistics were all organised by our Russian colleagues. On 6 June the expedition arrived at Medusa Bay field station, situated 18 km south of Dikson (73°13'N, 80°19'E). This field station was built in 1994, with financial help from the Dutch Ministry of Agriculture, Nature Management and Fisheries. By the end of June the last two members of the expedition, Mikhail Berezin, Yulia Bublichenko also arrived in Medusa Bay. Most of the Russian researchers left the station by the end of July, only the Dutch team and the expedition leader stayed until 4 August. On 6 August we boarded on a ship taking

us from Dikson to Dudinka/Norilsk, where we paid another visit to the office of the Great Arctic Reserve to report on the expedition. We finally arrived in Moscow on 10 August and flew to the Netherlands on 11 August.

2 Study area

The study area is situated 18 km south of Dikson in the west of the Taimyr peninsula at 73°04'N 80°30'E (fig. 2.1). At the mouth of the river Yenissei Medusa Bay, measuring 1.2 km in diameter, is situated (fig. 2.2). At the north side of Medusa Bay a field station was established in 1994 (fig. 2.2). The station consists of a large building and a few small sheds, providing housing for 30 people. The study area in the monitoring program consists of three parts: an intensive plot measuring 4 km² (fig. 2.3) used for monitoring of shorebirds and passerines, a larger area measuring 12 km² used for the larger, more wide-spread shorebird species. Snowy Owls, Rough-legged Buzzards and Brent Geese were censused in a bigger area of 30 km² (fig. 2.3). Shorebird breeding biology studies were undertaken mainly in the 4 km² area. Teams that visited the area in 1998 and 1999 placed sticks along an west-east transect at distances of 250 m apart. A beacon on the highest hill in the centre of the area further facilitates orientation. The intensive study area is defined by natural borders: the Medusa river in the south, the bay in the north and west and another small river in the north-east.

Figure 2.1. Location of the study area (circle just South of Dikson) on the Taimyr Peninsula.

Figure 2.2 Location of Medusa Bay and the Efremova, Maximovka and Lemberova Rivers.

According to the classification given in Chernov (1985) the study area can be classified as arctic tundra, with some characteristics of typical tundra. The landscape is characterised by a rolling relief. The highest hills in the intensively studied area measured 39 m above sea level (a.s.l.). In the 30 km study area the highest hill reached 61 m. a.s.l. Since the study area bordered the mouth of the Yenisei river, the lowest point in the area was as high as sea level. No lakes or small ponds were present. To the east of the study area the relief became more distinct, with hilltops reaching as high as 160 m a.s.l.. Big rocks formations were present throughout the area and rocky outcrops were often found on steep slopes. Gravel occurred along rivers, at river mouths and on beaches.

The vegetation consists of lichens, mosses, sedges, grasses, Dwarf Willows *Salix polaris*, Dwarf Birch *Betula nana* and various herbs on the slopes and plateau's on top of hills. In the marshy areas found in valleys, on the lower parts of slopes and sometimes on top of hills, Cotton Grass *Eriophorum* sp. and extensive stands of sedges *Carex* sp. were predominant. In the east of the intensive plot, north of the plot and south-east of the plot large polygonal bogs are found. In most of the area well-vegetated tundra predominates, with few areas of frost-boiled tundra with clay-medallions

Caterpillar vehicles (*vezdekbods*) are used for transportation in the area. As long as the area is snow-covered this causes no harm to the tundra surface. Because transportation by helicopters has become increasingly expensive, *vezdekbods* are used throughout summer now and leave tracks that remain several decades. The number of *vezdekbod* tracks is increasing every year. Because of the poor state of the vehicles, preference is given to create new tracks instead of using the old tracks, thereby increasing the area that is affected by tracks. In these tracks vegetation cover increases through proliferation of grasses and sedges (Kevan *et al.* 1995). Also tracks cause drainage and creation of micro-relief and new puddles. A large part of the study area changes at a fast rate due to these tracks. Especially for the monitoring purposes, where changes in breeding bird numbers are the subject of study, such a quick evolving change in environment is not desirable.

Figure 2.3 The 30 km² study area surveyed for the monitoring scheme, with the 4km² intensive area (hatched).

3 Weather and season

Weather data were partly collected in the camp, and partly obtained from the meteorological station on Dikson Island, c. 18 km north of Medusa Bay. Long-term data (1994-2000) were taken from internet (www.ncdc.noaa.gov/ol/climate/climateresources.html) and purchased (1973-1993) from the US National Climate Data Centre in Ashville, North Carolina. Air temperature and operative temperature were automatically recorded every 30 minutes in the camp using TinyTalk data loggers and a black metal sphere (operative temperature). Air temperature was measured near the station in a shady place at 2m above the ground, operative temperature was measured at ground level. Data on wind speed, cloud cover and precipitation were obtained from the meteorological station at Dikson

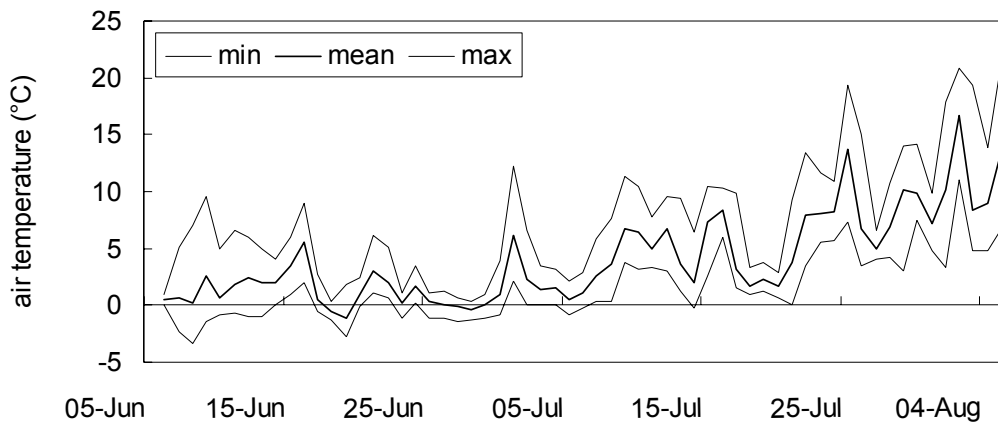


Figure 3.1. Mean, minimum and maximum temperature in the camp in the field period

June was cold with mean temperatures hardly rising above freezing point and lots of snow showers and mist (fig. 3.1). In contrast July was very warm compared to other years, with maximum temperatures of 21°C. Operative temperature follows mean temperature closely, but peaks in temperature, are even higher in operative temperature caused by the warming effect of solar radiation (fig. 3.2). Upon our arrival at 6 June an unexpectedly large part of the area was already free of snow (50%). This was probably caused by a relatively warm period mid May with temperatures rising above the freezing point (fig. 3.3). Snow cover declined during the first half of June to 20% on 17 June. Mean temperatures increased even further in August after the end of the expedition. Mean temperatures as measured in Dikson were on average 1.2°C colder than those measured in the camp (fig. 3.4). This temperature difference did not vary with temperature levels (fig. 3.4). The more exposed situation of the weather station on Dikson Island, surrounded by sea-ice and later by the open sea, is probably the cause of this temperature difference.

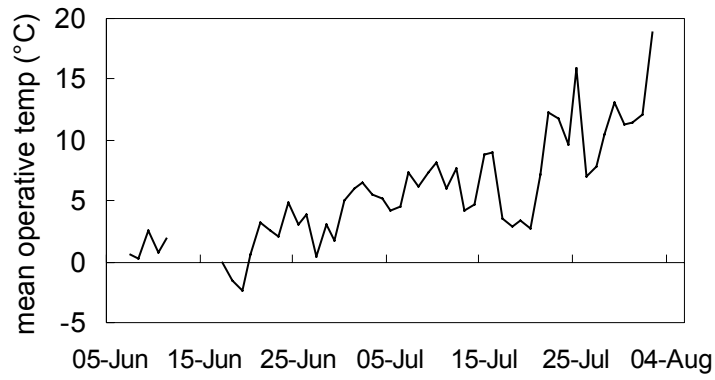


Figure 3.2. Mean operative temperature in the camp.

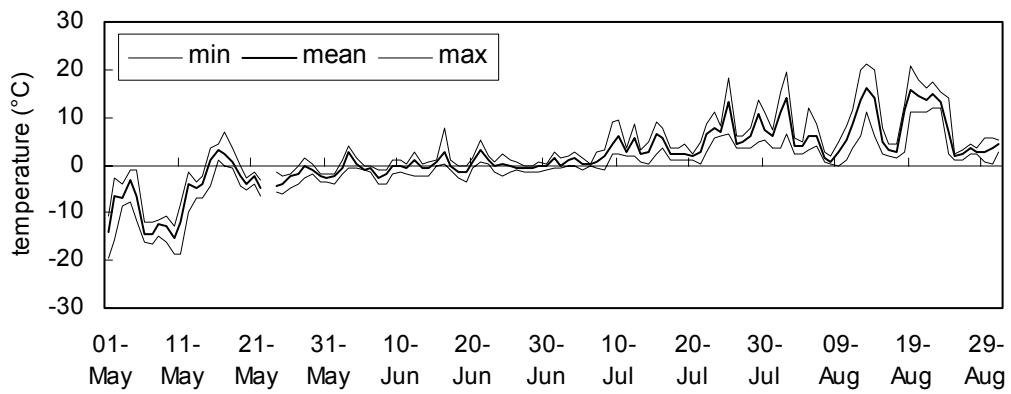


Figure 3.3. Mean, minimum and maximum temperature as measured in Dikson meteorological station in May-August 2000.

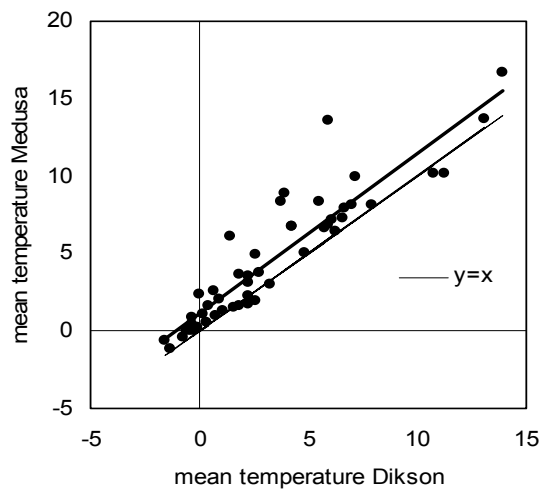


Figure 3.4. Comparison of mean temperature in Medusa Bay and in Dikson. The thick black line is a linear regression line.

Medusa River started flowing on 12 June, which is early compared to 1994 (21 June, Hertzler & Günther 1994), 1996 (25 June, Tulp *et al.* 1997), 1997 (17 June, Khomenko *et al.* 1999), 1998 (21 June) and 1999 (21 June, F. Willems, pers. comm.). In June as a whole it snowed and/or rained on 25 days. Thick mist occurred on (parts of) five days (out of 24 days, we arrived at 6 June). Except for the second week, most of July was dry, with short rain showers or drizzle on 13 days and mist on six days (fig. 3.5). Wind speeds varied between 2 and 12 m/s (fig. 3.6). In June winds were moderate to strong with predominating northerly directions. Winds were less strong in July, but still coming from the north most of the time, while on several days southerly winds brought in relatively warm air.

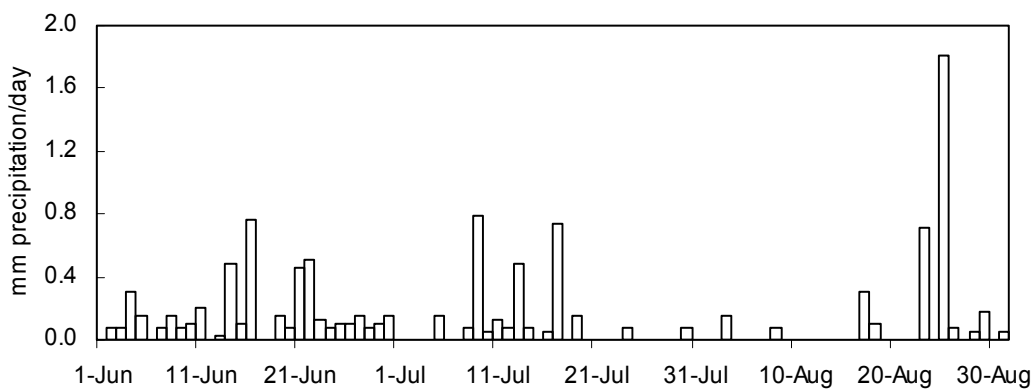


Figure 3.5. Daily precipitation as measured in Dikson.

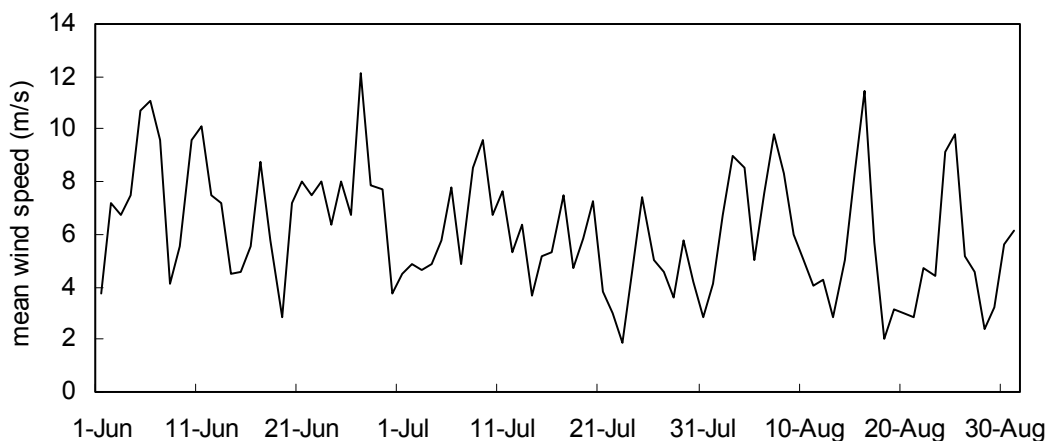


Figure 3.6. Mean wind speed as measured in Dikson.

The availability of long-term temperature data enables a comparison between this season and previous years (fig. 3.7). The temperature pattern in 2000 was very similar to that in 1999. Maximum temperatures were relatively high compared to other years, but the date at which mean temperature stayed above the freezing point was late. The high temperatures in August 2000 are not normal for this time of year and only occurred in 1995 before. In most years the warmest period occurs late July and early August. Long term temperature sums from June to August show an increase over the past 28 years (fig. 3.8) with an increase of 0.6 °C in mean temperature.

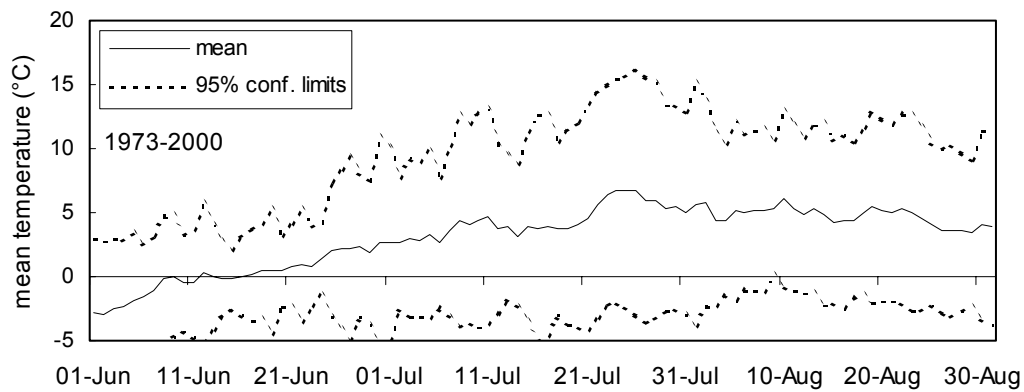


Figure 3.7. Mean daily temperature in June-August 1973-2000.

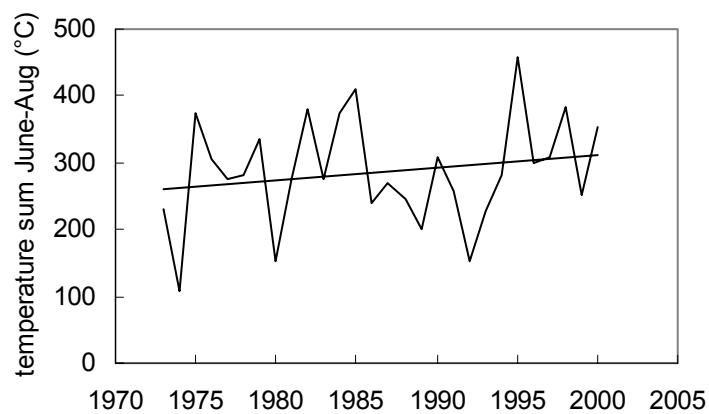


Figure 3.8. Temperature sums (June-August) in 1973-2000.

4 Lemmings and predators

Detailed studies on lemming densities were carried out by Andrei Bublichenko and results will be presented in the combined report. Here we will only give a short characterisation of the situation regarding lemmings and predators.

Lemming numbers were very low: during 8-10 hours in the field per day we did not see a single lemming on most days, and one at the most. The few lemmings seen were mainly Siberian Lemmings *Lemmus sibericus*, with occasional Collared Lemmings *Dicrostonyx torquatus*. In July several young lemmings were encountered (see photo). At least three different (non-reproducing) Arctic Foxes *Alopex lagopus* frequented the 4 km² intensive study area. Shorebird nests were predated by arctic foxes mainly, judging from droppings or smell. Snow Buntings, breeding between rocks, were also predated by Arctic Foxes and Stoats *Mustela erminea*. As is usual in a year with low lemming numbers (Underhill *et al.* 1993), Snowy Owls *Nyctea scandiaca*, skuas and Brent Geese *Branta bernicla* did not attempt breeding. However, Long-tailed Skuas *Stercorarius longicaudus* were territorial. Pomarine skuas *Stercorarius pomarinus* were only on passage. A few breeding attempts of White-fronted Geese *Anser albifrons* were observed in the 30km² area. Predated nests of Taimyr Gulls *Larus taimyrensis*, Glaucous Gulls *Larus hypoerboreus* and Arctic Terns *Sterna paradisaea* were found on nearby islands. Several Rough-legged Buzzard *Buteo lagopus* pairs started breeding but either abandoned their clutch or their nests were predated. At the nearby rivers Efremova, Maximovka and Lemberova Peregrine Falcons *Falco peregrinus* were breeding successfully and a few pairs of Red-breasted Geese *Branta ruficollis* and White-fronted Geese bred in their vicinity.

5 Shorebird breeding parameters

In this chapter an overview will be given of different breeding parameters. Nest distribution and numbers will be given here, as well as preliminary breeding densities resulting from the monitoring program. The monitoring scheme was especially developed to assess breeding densities and can deviate from nest numbers actually found. For final breeding densities we refer to the combined Dutch-Russian report. For shorebirds species phenology, number of eggs and float curves will be presented. nest success will be discussed in chapter 9. Other species such as passerines, Ptarmigan *Lagopus mutus* and Rough-legged Buzzard were no specific subjects of study, but the limited data collected will be presented here as well.

5.1 Territories

Breeding densities were in most species determined by territory mapping. Here only data for the 4 km² plot will be given to provide a comparison with nests actually found (table 5.1). Only for Little Stints more nests than territories were found, which is not surprising as the territory mapping was found to be not useful for this species. An elaborate analysis of the monitoring, with a discussion of usefulness for the different species will be presented in the combined Dutch-Russian report.

Table 5.1. Results of the monitoring in the 4 km² plot. For Shore Lark and Lapland Bunting only a 0.75 km² sub-part was counted.

Species	n territories in 4 km ² plot	n territories/km ²
Pacific Golden Plover <i>Pluvialis fulva</i>	40	10.0
Ringed Plover <i>Charadrius hiaticula</i>	7	1.8
Turnstone <i>Arenaria interpres</i>	7	1.8
Little Stint <i>Calidris minuta</i>	80	20.0
Temminck's Stint <i>Calidris temminkii</i>	4	1.0
Dunlin <i>Calidris alpina</i>	28	7.0
Curlew Sandpiper <i>Calidris ferruginea</i>	17	4.3
Shore Lark <i>Eremophila alpestris</i> *	21	28.0
Red throated Pipit <i>Anthus cervinus</i>	6	1.5
Pied Wagtail <i>Motacilla alba</i>	1	0.3
Wheatear <i>Oenanthe oenanthe</i>	1	0.3
Snow Bunting <i>Plectrophenax nivalis</i>	47	11.8
Lapland Bunting <i>Calcarus lapponicus</i> *	36	48.0
Ptarmigan <i>Lagopus mutus</i>	15	3.8

5.2 Nests

Nests were searched for making use of nest indicative behaviour. Depending on the species, the incubating bird alarms (Turnstone, Dunlin, Ringed Plover, Pacific Golden Plover), walks or flies off the nest at a great distance (Pacific Golden Plover, Curlew Sandpiper, Ringed Plover) or flushes off when it is approached (Little Stint, Temminck's Stint, Dunlin). The nest positions were recorded in a Global Positioning System (GPS) with an accurateness of 3 m and most nests were marked inconspicuously with a stone or a small stick 10 m north of the nest. Pacific Golden Plover nests were not marked, only the co-ordinates were registered. Of each nest found, eggs were measured and floated to determine incubation stage. Nests were checked at two to five days intervals. At each visit the status of the nest was recorded. If a nest was found empty after the potential hatching date, it was considered as hatched only if small egg fragments were found in the nest cup, otherwise considered predated. In many nests this was confirmed because they held fox droppings or were urine-marked.

Table 5.2. Numbers of shorebird nests found, predated, hatched and deserted. Numbers of families of which nests were not found but which should have bred in the study area are also given. The majority of the total number of nests were found inside the 4km² plot.

species	total nests	predated	hatched	deserted	families	total nests+ families	outside 4km ² plot families
Pacific Golden Plover	30	19	8	2	0	30	3
Grey Plover	1	1	0	0	0	1	1
Ringed Plover	10	8	2	0	0	10	1
Turnstone	3	3	0	0	2	5	0+ 2 fam
Little Stint	108	93	12	3	30	138	20+ 8 fam
Temminck's Stint	3	2	1	0	0	3	2
Dunlin	29	25	4	0	5	34	0+ 3 fam
Curlew Sandpiper	10	10	0	0	4	14	1

Table 5.3. Numbers of nests of passerines and other birds found, predated, hatched and deserted. The majority of the total number of nests were found inside the 4km² plot.

species	total nests	n found with eggs	with chicks	n predated	n hatched	n desert.	outside 4km ² plot
Lapland Bunting	18	15	3	13	3	0	3
Red-throated Pipit	2	2	0	0	1	0	0
Snow Bunting	23	14	9	7	14	0	4
Shore Lark	6	6	0	5	1	0	0
White Wagtail	1	1	0	0	1	0	0
Ptarmigan	4	4	0	3	1	0	0
Rough-legged Buzzard	1	1	0	1	0	0	0

5.3 Float curves

For all eggs the developmental stage of the eggs was determined by floating the eggs in water. An undeveloped egg sinks to the bottom at once. With progressing development the embryo grows and the air sac increases, resulting in a reduction of egg mass, while the egg volume stays constant. At first the angle of the longitudinal axis of the egg with the water surface increases until the egg balances on its tip. Then the egg starts floating and eventually the blunt end is lifted out of the water. Using angle measurements and measurements of the distance between the tip of the egg and the water surface of eggs with a known laying or hatching date, a relation to developmental phase can be derived if total incubation duration is known (van Paassen *et al* 1984). For Pacific Golden Plover, Ringed Plover, Little Stint, Dunlin and Curlew Sandpipers data were combined with data obtained in 1996 in the same area and float curves were constructed (fig. 5.1).

Float curves were used to estimate the start of incubation. Total incubation period was taken as: Pacific Golden Plover 25 days, Ringed Plover 23 days, Turnstone 22 days, Little Stint 20 days, Dunlin/Curlew Sandpiper 21 days (Cramp & Simmons 1983). In addition to the nest data, families with chicks found were also used to estimate nesting phenology (fig. 5.2). Chicks encountered were caught and measured and their age was estimated using growth curves from Schekkerman *et al.* 1998b (Curlew Sandpiper/Dunlin), Schekkerman *et al.* 1998a (Little Stint), Tulp *et al.* 1998 (Turnstone). The combination of these methods introduce potential estimation errors of a few days. These errors were taken into account in the composition of distributions of starting dates. Instead of assigning a single date per nest, the probability of starting on a certain date was spread over five days, with the presumed date given a weight of 0.3, the neighbouring dates given a weight of 0.25 and the first and fifth date a weight of 0.1.

Figure 5.1. Development of incubated eggs in Pacific Golden Plover (PGP), Little Stint (LS), Dunlin (DU) and Curlew Sandpiper (CS). Left panels: the angles of eggs during the first week of incubation in relation to hatching date (logistic regression equations: PGP: $\text{angle} = 90 \times (0.25 + (0.75 / (1 + \exp(-1.5dth - 30))))$), LS: $\text{angle} = 90 \times (0.25 + (0.75 / (1 + \exp(-1.5dth - 25.5))))$), DU + CS: $\text{angle} = 90 \times (0.25 + (0.75 / (1 + \exp(-1.5dth - 24))))$). Right panels: the distance from the water surface to the top of the egg during the last two weeks of incubation in relation to hatching date (regression equations: PGP: $\text{distance} = 8.4 + 0.5dth$, LS: $\text{distance} = 5.1 + 0.4dth$, DU + CS: $\text{distance} = 7.6 + 0.6dth$).

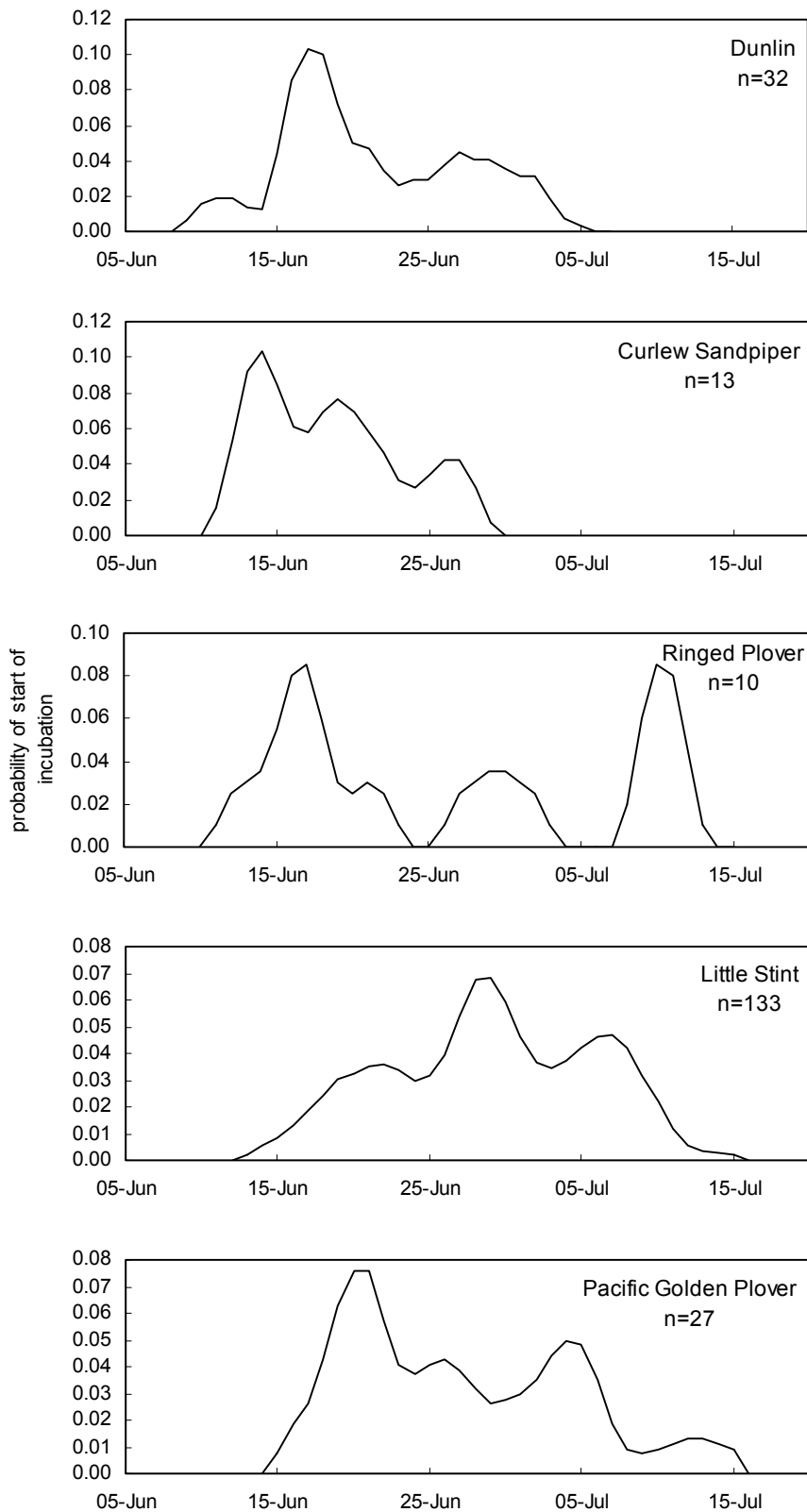


Figure 5.2. Distribution of dates on which incubation started (after completion of clutch). Dates were observed directly (finding incomplete nests), deduced from floating of eggs or chick measurements. The distributions appear smoothed because 1-2 day errors in estimation of the hatching date were taken into account. Numbers between brackets indicate the number of nests and/or broods on which the distribution is based.

Figure 5.3. Distribution of nests of Pacific Golden Plover and Ringed Plover.

Figure 5.4. Distribution of nests of Curlew Sandpiper and Turnstone.

Figure 5.5. Distribution of nests of Little Stint and Temminck's Stint

Figure 5.6. Distribution of nests of Dunlin.

Figure 5.7 Distribution of nests of Snow Bunting, Lapland Bunting, Shore Lark and Red-throated Pipit. This map is not complete as passerine nests were not actively searched for.

Figure 5.8. Distribution of nests of Ptarmigan and Ring-billed Gull.

5.4 Species accounts

For each species short information is given on breeding phenology, egg size measurements, nest distribution and additional information related to breeding. The distribution of nests is given in figures 5.3-5.8. For most species the median start of incubation was a few days later than in 1996. Data on phenology in 1998/1999 are not yet published and cannot be used for comparison here. The earliest clutches were produced earlier than in 1996, probably due to the early availability of snow-free area but the occurrence of replacement clutches resulted in a long breeding season, shifting the median date backwards.

5.4.1 Grey Plover

Only one nest was found which was situated outside the study area in polygonal tundra. The actual nest was no more than a depression on the edge of a moss polygon. Incubation started on 28 June (table 5.4). When the nest was revisited it was predated, probably not by a fox, but by a skua or gull, judging from the shell remains.

Table 5.4. Egg size measurements and estimated start of incubation of Grey Plover clutch (volume is calculated as $0.5 \times \text{length} \times \text{width}^2$).

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	start of incubation
rk49zi	4	51.10	35.85	32.8	28-Jun

5.4.2 Ringed Plover

Of the ten nests found (fig. 5.3) at least two were replacement clutches. The median date of start of incubation was 25/26 June (table 5.5, three days later than in 1996, which is due to replacement clutches. The breeding season was long with the first nest starting on 13 June and the last one on 11 July. Nests were all situated in river valleys or on shingles close to the seashore. All but one of the complete clutches found contained four eggs.

Table 5.5. Egg size measurements and estimated start of incubation of Ringed Plover clutches (volume is calculated as $0.5 \times \text{length} \times \text{width}^2$). Incomplete nests that were preyed upon before nest completion are indicated (inc).

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	start of incubation	replacement of nest
hs12rp	4	33.40	24.68	10.2	13-Jun	
hs13rp	4	34.63	25.10	10.9	17-Jun	
hs28rp	4	33.93	24.70	10.4	21-Jun	
hs40rp	4				28-Jun	hs13rp
hs43rp	4				1-Jul	
hs58rp	4	35.00	25.30	11.2	28-Jun	
it2rp	3 inc	34.93	24.33	10.3	16-Jun	
it4rp	4	33.08	24.83	10.2	17-Jun	
it72rp	2 inc				10-Jul	hs12rp
rk61rp	3				11-Jul	

5.4.3 Pacific Golden Plover

In total 30 nests and 40 territories (table 5.1, 5.2, fig. 5.3) were found of which at least two were replacement clutches (table 5.6). Numbers of territories are rather constant over the last years: 23 (1996), 34 (1998), 43 (1999) and 40 (2000), Median start of incubation was 25/26 June, which is similar to 1996. The first pair started on 17 June and the last one on 14 July. Although it can not be confirmed by visual observations on colour-marked birds, most of the nests that were started in July probably concerned replacement clutches. The majority of nests contained four eggs. Only three late nests contained three or two eggs and one first clutch contained three eggs (rk8gp).

Table 5.6. Egg size measurements and estimated start of incubation of Pacific Golden Plover clutches (volume is calculated as $0.5 \times \text{length} \times \text{width}^2$).

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	start of incubation	replacement of nest
hs41gp	4	47.78	32.30	24.9	26-Jun	
hs42gp	4	47.95	33.58	27.0	17-Jun	
hs52gp	4	48.83	32.20	25.3	25-Jun	
hs65gp	2				14-Jul	
hs68gp	4	45.50	32.95	24.7	11-Jul	
it18gp	4	44.68	32.38	23.4	21-Jun	
it27gp	4	49.50	32.80	26.6	20-Jun	
it28gp	4	47.58	32.03	24.4	20-Jun	
it29gp	4	47.65	32.98	25.9	23-Jun	
it30gp	4	48.73	33.48	27.3	19-Jun	
it34gp	4	46.03	31.38	22.6	27-Jun	
it37gp	4				<30-Jun	
it42gp	4				<30-Jun	
it55gp	4	46.28	31.70	23.2	1-Jul	
it56gp	4	49.33	33.40	27.5	5-Jul	
it59gp	4	45.75	32.53	24.2	24-Jun	
it63gp	4	45.43	32.03	23.3	5-Jul	
it66gp	4	47.28	32.35	24.7	4-Jul	it37gp
it71gp	4	48.65	32.63	25.9	1-Jul	
it76gp	4	47.80	34.05	27.7	4-Jul	
it77gp	4	46.78	34.18	27.3	1-Jul	
it78gp	4	48.70	33.00	26.5	17-Jun	
it83gp	2				<14-Jul	
it97gp	4	46.60	31.50	23.1	29-Jun	
it98gp	3	47.80	31.30	23.4	7-Jul	it27gp
rk33gp	4	47.18	34.23	27.6	21-Jun	
rk36gp	4	47.85	33.00	26.1	22-Jun	
rk6gp	4	49.15	31.73	24.8	20-Jun	
rk70gp	4				27-Jun	
rk8gp	3	47.50	33.47	26.6	20-Jun	

Many nests of Pacific Golden Plover were located near some conspicuous object such as a vezdekhod track, a stone or driftwood. To find out whether this was a coincident or these nest positions occurred more often than would be expected if it would be only randomly, we compared the surroundings of the nests to those of 47 points randomly chosen inside the 4km² study area. The co-ordinates for these points were entered into the GPS and checked in the field. For each nest and random point

the distance to the nearest marked object was noted. We tested whether the median distances between nests and a marked object was smaller than between random points and a marked object using a Mann-Whitney U-test. Despite the large number of random points that was located near a track, the median distance between nests and marked objects was significantly smaller ($z=-3.8$, $P<0.01$).

5.4.4 Turnstone

Turnstones tend to nest in the wetter low-lying areas near rivers or in valleys (fig. 5.4). A total of three nests were found (table 5.7). Apart from the nests two families were found with young chicks.

Table 5.7. Egg size measurements and estimated start of incubation of Turnstone clutches (volume is calculated as $0.5 \times \text{length} \times \text{width}^2$).

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	start of incubation
rk16tu	4	39.98	27.78	15.4	21-Jun
rk7tu	4	39.78	27.45	15.0	16-Jun
hs59tu	4				<11-Jul

5.4.5 Little Stint and Temminck's Stint

In total 108 nests of Little Stint and three Temminck's Stint nests were found. Preferred nesting habitat were marshy areas, both in valleys and higher on hills, polygonal tundra and sedge meadows (fig. 5.5). Little Stints had a very long breeding season. None of the nests found were replacement clutches of colour-marked birds that started an earlier nest inside the study area. As many had been marked, this indicates that many of the birds starting later in the season probably arrived from other areas. Both species have a double-clutch breeding system: the female produces two clutches, of which one is incubated by the male and the other one by herself (which can be fathered by a different male than the first nest) Only one bird (one of the few that was caught and colour-marked prior to nesting) was found incubating two nests: hs17ls and it35ls. Hs17ls was predated 24 June and the same bird was seen on a new nest, containing 4 eggs on 28 June. Because on average one egg per day is laid, it seems unlikely that this was a replacement clutch rather than the second clutch produced by the same female. The median start date of incubation was 29 June (fig. 5.2) which is two days later than in 1996. Earliest nests were started 15 June, while the latest birds started incubation on 14 July (table 5.8). Most nests contained four eggs. One nest, which was incubated by a male, contained one egg only. Nest rk3ls was partly (one egg) preyed upon when it contained two eggs, but the next day another egg was laid. This nest was preyed upon before we could establish if the full clutch size of four would be reached.

Table 5.8. Egg size measurements and estimated start of incubation of Little Stint clutches (volume is calculated as $0.5 \times \text{length} \times \text{width}^2$). Incomplete nests that were preyed upon before nest completion are indicated (inc).

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	start of incubation
<i>Little Stint</i>					
hs15ls	4	27.85	20.70	6.0	18-Jun
hs16ls	4	28.80	19.87	5.7	22-Jun
hs17ls	1 inc	26.70	20.40	5.6	24-Jun (same female as it35ls)
hs22ls	4	29.68	20.50	6.2	23-Jun
hs24ls	4	28.85	20.40	6.0	18-Jun
hs30ls	4				<28-Jun
hs31ls	4	29.35	20.70	6.3	30-Jun
hs34ls	4	30.08	20.30	6.2	29-Jun
hs37ls	4	29.58	20.93	6.5	2-Jul
hs38ls	4	28.15	20.58	6.0	30-Jun
hs44ls	4	27.78	21.15	6.2	24-Jun
hs45ls	4				2-Jul
hs46ls	1				6-Jul
hs47ls	4				4-Jul
hs48ls	4	29.68	20.20	6.1	28-Jun
hs49ls	4	28.65	20.65	6.1	27-Jun
hs53ls	3	27.43	20.70	5.9	30-Jun
hs54ls	4	27.73	19.73	5.4	27-Jun
hs56ls	4	28.55	20.50	6.0	7-Jul
hs57ls	4	28.93	20.45	6.0	6-Jul
hs5ls	4	27.85	20.33	5.8	19-Jun
hs62ls	4	30.55	21.50	7.1	26-Jun
hs63ls	4	28.73	20.35	5.9	30-Jun
hs66ls	4	28.55	21.15	6.4	4-Jul
hs67ls	2	29.55	20.25	6.1	7-Jul
hs69ls	4	27.45	20.03	5.5	12-Jul
hs70ls	4	28.38	20.95	6.2	6-Jul
hs71ls	4	28.50	20.73	6.1	7-Jul
hs73ls	3	29.50	21.37	6.7	10-Jul
hs74ls	4	28.58	20.18	5.8	9-Jul
hs75ls	4				6-Jul
hs76ls	4	29.23	20.90	6.4	9-Jul
hs9ls	4	28.30	20.83	6.1	18-Jun
it00ls	4				7-Jul
it11ls	4	28.38	19.63	5.5	19-Jun
it12ls	4	28.57	20.07	5.8	20-Jun
it16ls	4	28.18	20.53	5.9	21-Jun
it23ls	4	29.98	20.58	6.3	23-Jun
it25ls	4	28.33	19.53	5.4	24-Jun
it32ls	4	27.88	20.43	5.8	27-Jun
it33ls	4	28.23	20.33	5.8	27-Jun
it35ls	4	26.95	20.83	5.8	28-Jun
it36ls	4	27.78	19.85	5.5	26-Jun
it38ls	4	28.70	20.28	5.9	30-Jun
it39ls	4	28.50	20.10	5.8	26-Jun
it40ls	4	28.33	20.55	6.0	28-Jun
it44ls	4	27.58	20.38	5.7	29-Jun
it46ls	3 inc				2-Jul
it47ls	4	28.08	19.73	5.5	27-Jun
it48ls	4	27.98	20.63	6.0	26-Jun

Table 5.8. Continued

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	start of incubation
<i>Little Stint</i>					
it51ls	4	28.38	20.33	5.9	1-Jul
it54ls	4				30-Jun
it61ls	4	29.55	21.45	6.8	29-Jun
it67ls	4	30.43	20.00	6.1	8-Jul
it68ls	4	28.78	20.10	5.8	17-Jun
it69ls	4	28.13	20.65	6.0	29-Jun
it70ls	4	29.88	21.35	6.8	19-Jun
it73ls	4	30.13	20.53	6.3	20-Jun
it74ls	4	28.53	20.65	6.1	29-Jun
it75ls	4	29.03	20.38	6.0	5-Jul
it80ls	4	28.65	21.00	6.3	4-Jul
it81ls	4	28.60	21.90	6.9	3-Jul
it82ls	4	27.95	20.83	6.1	9-Jul
it85ls	4	29.20	20.05	5.9	7-Jul
it87ls	4	28.55	20.90	6.2	2-Jul
it8ls	1 inc				20-Jun
it92ls	4	29.25	21.03	6.5	6-Jul
it93ls	3 inc				<19-Jul
it96ls	4	28.28	20.58	6.0	10-Jul
it99ls	3	31.33	20.60	6.6	8-Jul
rk11ls	4	27.18	19.65	5.2	23-Jun
rk14ls	4	29.65	20.53	6.2	24-Jun
rk18ls	4	29.50	21.35	6.7	29-Jun
rk19ls	4	29.50	21.15	6.6	29-Jun
rk20ls	4	28.33	20.10	5.7	20-Jun
rk23ls	4	28.75	21.35	6.6	26-Jun
rk24ls	4				<30-Jun
rk29ls	4	28.88	20.18	5.9	20-Jun
rk2ls	1 inc	30.50	21.10	6.8	18-Jun
rk31ls	3	28.17	20.00	5.6	30-Jun
rk37ls	4				26-Jun
rk39ls	4				5-Jul
rk3ls	2 inc	28.05	20.10	5.7	18-Jun
rk40ls	4				6-Jul
rk41ls	4	29.58	20.55	6.2	3-Jul
rk42ls	4	28.18	20.05	5.7	27-Jun
rk43ls	4	28.53	20.75	6.1	17-Jun
rk44ls	4	27.93	20.65	6.0	22-Jun
rk45ls	4	29.13	21.35	6.6	22-Jun
rk4ls	3 inc	30.10	20.45	6.3	21-Jun
rk50ls	4	29.83	20.70	6.4	7-Jul
rk51ls	4	28.90	20.15	5.9	3-Jul
rk52ls	4				20-Jun
rk54ls	4	28.73	20.70	6.2	9-Jul
rk55ls	4	27.25	20.93	6.0	27-Jun
rk56ls	4	28.90	20.18	5.9	29-Jun
rk58ls	4	28.50	20.53	6.0	2-Jul
rk59ls	4	27.83	20.28	5.7	27-Jun
rk60ls	3	28.13	20.57	5.9	10-Jul
rk64ls	4	28.43	20.33	5.9	4-Jul
rk65ls	4	28.63	20.48	6.0	14-Jul

Table 5.8. Continued

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	start of incubation
<i>Little Stint</i>					
rk66ls	4	29.43	21.38	6.7	03-Jul
rk67ls	3inc	28.33	20.53	6.0	09-Jul
rk68ls	4	27.65	20.13	5.6	05-Jul
<i>Temminck's Stint</i>					
it88ts	4				9-Jul
rk30ts	4	29.25	20.68	6.2	2-Jul
rk69ts	?				<20-Jul

5.4.6 Dunlin

Median start of incubation was 20 June. The long tail to the right of the distribution of start of incubation is caused by replacement clutches (fig. 5.2). The first nest was started on 11 June (table 5.9), which is five days earlier than the earliest Dunlin nest found in 1996. Replacement clutches were produced as late as early July. As far as we know there were at least seven replacement clutches, of which one was only discovered in the chick stage. For an analysis of replacement clutches see chapter 8. Apart from the nests found five broods were encountered. Old *vezdekobod* tracks were favourite nesting habitat for Dunlins. The effect of the tracks is that the original vegetation of moss and herbs is taken over by grass and sedges. Most nests were found in areas that were severely effected by these tracks (fig. 5.6). Out of 27 nests for which the actual nest site was recorded, 11 were found on one of the elevated sides right next to the track. Only in the eastern part of the study area Dunlin nests were found in more natural area. This relatively low lying area with a polygonal structure and sedge and grass in between the mossy polygons probably represent their natural breeding habitat. Since 1996, the number of *vezdekobod* tracks had probably doubled. The fact that Dunlin numbers seem to increase over the last couple of years may be related to this development. In 1996, 13 territories were found, 20 in 1998 (van Turnhout & Felix pers. comm) and 31 in 1999 (Willems & van Kleef pers. comm).

5.4.7 Curlew Sandpiper

In total ten nests were found (fig. 5.4, table 5.2). Median start of incubation was 19 June (table 5.10), three to four days earlier than in 1996. Curlew Sandpipers did not produce replacement clutches and therefore the start of incubation took place in a period of only two weeks, with the first nest starting on 13 June and the last one on 27 June (as compared to 15 and 29 June in 1996). Although none of the nests that we found hatched we encountered four broods, that were probably born in the study area. All but one completed clutches contained four eggs. Numbers of breeding Curlew Sandpipers vary greatly between years and seem to decline. Numbers of nests/territories found in consecutive years were: 71 (1996), 43 (1998), 24 (1999, Willems *et al.* pers. comm.), 17 (2000).

Table 5.9. Egg size measurements and estimated start of incubation of Dunlin clutches (volume is calculated as $0.5 \times \text{length} \times \text{width}^2$). Numbers in superscript indicate first and replacement clutches of the same female. Incomplete nests that were preyed upon before nest completion are indicated (inc). If a nest was located in or near a *vezdekbod* track it is indicated in the last column.

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	start of incubation	replacement of	in track?
hs10du	2 inc	35.45	24.45	10.6	20-Jun		-
hs11du	4	34.55	25.13	10.9	17-Jun		-
hs14du	4	37.65	26.45	13.2 ¹	17-Jun		+
hs20du	4	33.85	24.48	10.1	17-Jun		-
hs23du	4	34.63	25.48	11.2	19-Jun		-
hs32du	4	33.98	24.63	10.3	25-Jun		+
hs33du	4	33.73	23.98	9.7 ⁵	27-Jun	it7du	-
hs36du	4	35.23	24.33	10.4	25-Jun		-
hs50du	4	33.73	24.15	9.8	28-Jun		-
hs51du	4	37.50	25.38	12.1	17-Jun		-
hs55du	4	33.83	24.18	9.9	20-Jun		-
hs64du	4	36.78	25.83	12.3 ¹	1-Jul	hs14du	-
hs6du	4	36.60	25.93	12.3 ²	14-Jun		+
hs7du	4	35.35	24.63	10.7 ³	11-Jun		+
it13du	4	35.25	24.53	10.6	16-Jun		-
it45du	4	35.68	24.05	10.4 ⁴	1-Jul	it9du/hs11du	+
it6du	4	35.05	25.80	11.7	17-Jun		-
it7du	4	33.20	24.20	9.7 ⁵	17-Jun		+
it9du	4	34.83	24.78	10.7 ⁴	11-Jun		-
rk10du	4	35.50	24.58	10.7	17-Jun		-
rk13du	4	35.93	26.25	12.4	20-Jun		+
rk15du	4	35.10	24.18	10.3	21-Jun		-
rk17du	4	34.93	25.93	11.7	22-Jun		+
rk21du	4	36.25	25.00	11.3	20-Jun		?
rk22du	4	37.10	25.40	12.0	26-Jun		+
rk25du	4	34.93	25.65	11.5	24-Jun	it9du	+
rk34du	4	37.38	25.75	12.4 ²	1-Jul	hs6du	?
rk35du	4	35.80	25.18	11.3 ³	28-Jun	hs7du	-
sk1du	4				<24-Jun		+

Table 5.10. Egg size measurements and estimated start of incubation of Curlew sandpiper clutches (volume is calculated as $0.5 \times \text{length} \times \text{width}^2$). Incomplete nests that were preyed upon before nest completion are indicated (inc).

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	start of incubation
hs21cs	4	37.00	26.00	12.5	20-Jun
hs26cs	4	37.70	26.33	13.1	15-Jun
hs35cs	4	35.63	25.93	12.0	27-Jun
hs3cs	4	37.15	26.05	12.6	14-Jun
hs8cs	3 inc	35.50	26.03	12.0	19-Jun
it17cs	4	37.35	26.30	12.9	17-Jun
it1cs	4	37.18	25.95	12.5	14-Jun
it22cs	4	37.10	26.18	12.7	13-Jun
it50cs	3	36.40	24.90	11.3	21-Jun
rk12cs	4	35.83	26.05	12.2	18-Jun

5.4.8 Passerines

No specific effort was made to find nests of passerines, but data on nests that were found accidentally are given below (table 5.11) and in the distribution map (fig. 5.7). The earliest Snow Bunting nest (on the attic of the station) was started on 9 June and the latest on 29 June. Clutches consisted of four to seven eggs. Shore Lark nests that were found were started between 14 and 30 June and contained five eggs in most cases. Nests of Lapland Bunting contained three to seven eggs and were started between 12 June and 6 July. Two Red-throated Pipit nests were found, with four and five eggs.

Table 5.11. Egg size measurements and estimated start of incubation of passerine clutches (volume is calculated as $0.5 \times \text{length} \times \text{width}^2$). No number of eggs is given for nests found with chicks. Start of incubation includes egg-laying since passerines start incubation after the first few eggs are laid. Total incubation was taken as Snow Bunting 12 days, Lapland Bunting 11 days and Shore Lark 10 days (Cramp 1988, Cramp & Perrins 1994), presuming that each day one egg is laid.

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	start of incubation
<i>Shore Lark</i>					
hs19sl	?				22-Jun
hs1sl	?				14-Jun
it14sl	5	24.00	16.30	3.2	<20-Jun
it43sl	5	23.20	17.32	3.5	<30-Jun
rk1sl	5	22.94	15.26	2.7	<14-Jun
rk38sl	4				3-Jul
<i>Snow Bunting</i>					
hs27sb	7	21.39	16.31	2.8	19-Jun
hs60sb	?				18-Jun
it15sb	6	23.05	16.95	3.3	16-Jun
it19sb	5	21.90	16.54	3.0	18-Jun
it21sb	5				< 22 Jun
it26sb	6	22.98	16.75	3.2	23-Jun
it52sb	5	21.30	15.76	2.6	12-Jun
it58sb	?				< 5 Jul
it5sb	5	23.16	16.62	3.2	17-Jun
it65sb	5	23.42	16.82	3.3	24-Jun
it79sb	?				23-Jun
it84sb	3				25-Jun
it86sb	4				29-Jun
it91sb	?				27-Jun
it94sb	?				24-Jun
it95sb	4				29-Jun
jb1sb	?				25-Jun
rk26sb	6				< 28 Jun
rk46sb	6				16-Jun
rk47sb	?				< 8 Jul
rk5sb	6	22.72	15.88	2.9	12-Jun
rk63sb	?				25-Jun
rk9sb	6				<21 June

Table 5.11. *Continued*

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	start of incubation
<i>Lapland Bunting</i>					
hs25lb	?				8-Jun
hs29lb	6				< 28 Jun
hs4lb	3				<16 Jun
it10lb	5				<18 Jun
it20lb	5				< 22 Jun
it31lb	7	20.84	14.77	2.3	<19-Jun
it41lb	?	20.97	15.38	2.5	< 24 Jun
it53lb	6				< 27 July
it57lb	5				23-Jun
it60lb	4				2-Jul
it64lb	6				< 6 july
it89lb	5				27-Jun
it90lb	?				<18 July
rk28lb	6				< 1 July
rk32lb	4				<28-Jun
rk48lb	4				30-Jun
rk57lb	6				< 25 Jun
rk62lb	4				6-Jul
<i>Red-throated Pipit</i>					
rk53rt	4				7-Jul
hs73rt	5				<15-Jul

5.4.9 Other species

Besides shorebirds and passerines two more bird species were breeding in the area: Ptarmigan and Rough-legged Buzzard (fig. 5.8, table 5.12). Four Ptarmigan nests were found of which hs61pt could have been a replacement for hs18pt, which was preyed upon on 26 June. In the study area one nest of Rough-legged Buzzard was already present on the day of our arrival (6 June), with three eggs. The parents managed to care for the nest until 18 June. Thereafter the nest was deserted and eventually also predated. Another pair was hanging around in the 4 km² study area for several days in June alarming faintly, but no nest could be found. In the larger plot (12 km²) one more nest containing four eggs was found, but this was also deserted early in the season. Being migratory as they are, Rough-legged Buzzards apparently cannot estimate the local food situation upon arrival. Since they have to start egg laying early, due to their long development period, they might best start egg laying right away, before they can assess if there will be enough food to raise the young. In this respect they differ from Snowy Owls, that are present in the arctic throughout the year and probably have a better idea of the local food situation. In a year with low lemming numbers, Snowy Owls do not even start egg laying, probably because they can assess probability of successful reproduction better than migratory birds of prey can. Both Long-tailed and Pomarine Skuas were completely absent as breeding birds. Snowy Owls and Pomarine Skuas did not even start to occupy territories.

Table 5.12. Egg size measurements and estimated start of incubation of Ptarmigan (pt) and Rough-legged Buzzard (rb) clutches (volume is calculated as $0.5 \times \text{length} \times \text{width}^2$). Incomplete nest that were preyed upon before clutch completion are indicated (inc).

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	start of incubation
<i>Ptarmigan</i>					
hs18pt	10				23-Jun
hs2pt	8 inc	42.77	30.69	20.1	16-Jun
hs61pt	7				4-Jul
it49pt	8 inc				<1-Jul
<i>Rough-legged Buzzard</i>					
it3rb	3	54.80	44.53	54.3	<6-Jun

6 Biometrics of adult shorebirds

6.1 Methods

During the first ten days of our stay (6-16 June) we tried to catch shorebirds that had just arrived to the breeding grounds. A clap net measuring 10x2 m and operated through a line at a distance of c. 20 m was used. The net was released through an elastic mechanism. Birds were lured to the net by means of decoys and sound recordings of displaying and calling birds. Once a bird was inside the trapping area the net was released. The same method was used to capture birds on autumn migration between 4 July and 4 August. We also tried using mist nets both on spring and autumn migration. In spring we put up mist nets close to the ground in wet areas near melting snow edges and carefully tried to push Little Stints towards the nets. Unfortunately they escaped at the last moment when they were very close to the net. On autumn migration we put up a section of mist nets across the Medusa River and played Little Stints tape near it. By walking up and down the river it was possible to chase Little Stints in the nest, although birds caught were mainly juveniles. Red-necked Phalarope that were swimming in the Medusa River were caught by gently approaching them with a mist net held horizontally in between two people, that was quickly turned vertically when the bird flew up.

Nesting birds were caught using small clap nets that were set up over the nest and released by the bird itself when it returned to the nest. Birds with chicks were either captured with the same clap net and using a small cage to keep the chicks. The sound of the chicks led the parents to the net immediately. Also a mist net could be held down between two people close to the chicks and either their sound or an imitation of it by the catcher would lure the parent bird close to the net that was then put on top of the bird. With older chicks that do not need brooding and are more silent the parent tend not to approach the chicks directly but fly over them. In this case the net was held between two people and put up quickly in a vertical motion, capturing the adult in flight. As nests were predated at a great rate birds were caught throughout their incubation cycle. But after we found out that this caused some desertions (chapter 9) we resumed to catch them only later in the incubation period.

Captured birds were ringed with metal rings and Little Stints, Curlew Sandpipers, Dunlins and Pacific Golden Plovers were fitted with an individual colour code. The scheme marker for all species was pink over metal on the right tarsus, two colour rings on the left tarsus and one ring each on the left and right tibia. Bill length, total head length and tarsus length were measured to the nearest 0.1 mm using callipers. Wing length (maximum chord, 1 mm) and tarsus + toe (1 mm) were measured with a stopped ruler. Pesola spring balances were used to measure body mass (1g Pacific Golden Plover, 0.1 g other species). Fat was scored on the belly, breast, abdomen and furculum using a three point scale (0= no fat, 1=little to moderate fat, 2= much fat). Contour feather moult was scored separately on the belly (including breast), back and head. In Dunlin the size of the black ventral area was measured. Dunlins, Little Stints and Curlew Sandpipers were photographed in a standardised way to register variation in plumage brightness. To enable sex

determination by DNA analysis we took two feathers from the ventral area in Little Stints and in some Dunlins for which the sex was not clear. Primary moult was scored using the five-point scale system (Ginn & Melville 1983). Contour feather moult was described using a four point system: 0= no moult, 1= light moult, 2= moderate moult, 3= heavy moult.

The aim of a co-operative project with Dr. Marcel Klaassen (Netherlands Institute for Ecology) was to determine whether arctic breeding birds are capital or income breeders by means of isotope analysis of feather samples. Therefore we collected a small feather sample (1-2 contour feathers) of birds that had a combination of feathers grown in the wintering areas, stopover areas or breeding areas (e.g. Pacific Golden Plovers). A small sample of natal down was taken from chicks and from older chicks also one new growing contour feather.

6.2 Results

6.2.1 general

The trapping early in the season was not as successful as hoped for. During ten catching days only seven birds were caught. This was partly due to the fact that we had to go through some trial and error before the net worked satisfactorily. Opportunities to catch birds were many more than the ones that were eventually successful. We had expected that so early in the season very little of the surface area would have been snow free, leaving only limited area for the newly arriving birds to feed. However, upon our arrival already more than half of the area was cleared of snow. Furthermore most species (Pacific Golden Plover, Dunlin, Curlew Sandpiper) seemed to respond well to the soundings. They were actually attracted to the net, although most of the time it concerned the birds that already had their territory in the area (Pacific Golden Plover, Dunlin). The decoys worked well in the sense that they helped attracting the birds to the catching area, but the displaying birds clearly expected more of a reaction from our static plastic decoys. The decoys were mostly not convincing enough to bridge the last meters to get the birds within reach of the net. Little Stints did not respond to the sound at all during spring, while on autumn migration they were easily attracted using sound.

Table 6.1. Number of shorebirds ringed at Medusa Bay in 2000. The number of recoveries only refers to birds caught at the same site in earlier seasons.

species	females	males	unknown sex	juv	total	recovered	colour marked	chicks
Pacific Golden Plover	8	7	0	0	15	2	16	8
Ringed Plover	3	1	0	0	4	1	0	4
Little Stint	46	32	25	19	123	0	79	18
Dunlin	14	25	3	1	42	2	35	18
Curlew Sandpiper	19	3	0	4	26	0	12	0
Turnstone	1	2	0	2	5	0	3	6
Red-necked Phalarope	0	4	1	0	5	0	0	0
total	91	74	29	26	220	5	145	54

In total 220 adult shorebirds were newly ringed, five birds were recovered (table 6.1). The recoveries were two Pacific Golden Plovers, one which was ringed and colour-marked in 1996, but which had lost all colour-rings. The other was ringed and colour-marked in 1999. One Ringed Plover was recaptured that was ringed in 1997 and two Dunlins that were ringed in 1998. We only ringed chicks that were at least one week old or of species that are site faithful, (Pacific Golden Plover, Ringed Plover, Dunlin Tomkovich & Soloviev 1994) total numbers ringed are not high. All Little Stints that are now still classified as 'sex unknown' will be sexed using DNA analysis of feather samples.

Table 6.2. Mean (and sd) biometrics (in mm, mass in g) of shorebirds captured in the prebreeding period, during incubation, chick-rearing or after breeding on migration. In Little Stints no distinction between sexes is made in the chick-rearing and postbreeding period.

species	sex/age	n	bill	total head	tarsus	tarsus + toe	wing	mass
Pacific Golden Plover								
<i>incubating</i>	ad females	8	22.2	55.9	43.0	72.1	168.9	135.7
			1.2	2.2	1.0	2.6	1.6	9.8
	ad males	9	21.9	57.0	43.5	73.1	167.7	130.5
			1.2	1.3	1.3	1.5	1.8	4.5
Ringed Plover								
<i>incubating</i>	ad female	4	13.3	39.9	26.7	46.5	133.0	62.4
			0.4	0.3	2.6	1.7	3.9	6.7
Little Stint								
<i>incubating</i>	females	33	18.7	39.7	21.8	40.4	99.8	29.2
			0.8	1.0	0.6	1.9	2.4	2.0
	males	26	18.1	38.8	21.6	40.1	97.6	28.5
			0.9	0.7	1.3	1.6	2.0	1.5
<i>chick-rearing</i>	sex unknown	15	18.4	39.2	21.7	39.8	98.5	27.0
			1.4	1.4	1.1	1.6	2.5	2.8
<i>postbreeding</i>	sex unknown	16	18.7	39.2	21.7	39.6	98.4	26.5
			0.8	1.1	1.2	1.3	2.5	2.1
	juveniles	19	18.7	39.6	22.2	39.5	99.4	25.2
			0.9	1.1	2.6	1.0	2.8	2.5
Dunlin								
<i>incubating</i>	females	12	37.0	61.3	25.8	48.5	121.0	55.8
			1.8	1.8	0.9	1.7	1.9	3.6
	males	19	32.6	57.1	24.7	47.1	117.2	51.9
			1.3	1.5	1.1	1.2	2.0	3.1
<i>postbreeding</i>	females	3	37.2	61.4	25.6	48.2		52.9
			1.8	1.7	1.6	1.0		3.8
	males	6	32.8	57.0	25.0	46.7	112.8	49.3
			2.5	2.5	1.6	2.8	1.8	6.1
Curlew Sandpiper								
<i>prebreeding</i>	ad males	3	35.6	60.2	29.8	51.0	134.3	57.0
			2.8	2.7	2.0	1.0	1.5	3.5
<i>incubating</i>	ad females	8	39.5	64.0	31.4	54.4	133.5	64.3
			1.4	2.1	1.2	2.1	3.8	4.0
<i>postbreeding</i>	ad females	10	39.7	64.9	31.8	54.4	131.7	58.5
			2.5	4.2	1.4	2.2	2.8	4.6
	juveniles	4	38.4	61.1	31.2	53.8	133.0	58.6
			2.7	1.8	1.5	1.8	5.5	5.8

6.2.2 Biometrics

Mean biometric data for prebreeding, incubating, chick-rearing and postbreeding shorebirds are given in table 6.2. Only for groups that consisted of at least three individuals means are given. In general postbreeding birds weighed less than incubating birds. In Little Stints the provisional distinction between sexes is made based on plumage characteristics, since DNA analyses are not yet carried out.

6.2.3 Pacific Golden Plover

Seventeen Pacific Golden Plovers were caught, of which 17 were newly ringed, and one was retrapped and given a new colour-ring combination. Several ringed birds without colour rings were seen breeding in the area but these were very difficult to catch. Apart from the two retrapped birds (one ringed in 1996, the other in 1999), four more colour-ringed individuals were seen. One male bird with a blue ring on the right tibia and one metal ring on the right tarsus had a nest close to the camp. This bird also wore a yellow ring on its left tibia early in the season but lost the ring. We saw it pulling at the ring repeatedly. Another bird with code *-/lm;-/yl* (*l*= light green) was ringed in 1999. One male with code *y/--;-/-m* was observed several times in the area. A male with code *p/--;p/-m* (*p*= pale blue) held a territory just south of the Medusa together with an unringed female. Three birds showed primary moult. Apart from the two birds ringed on 24 July, all trapped birds showed body moult on the back. All plovers caught from 8 July onwards and one bird caught on 23 June were moulting feathers in the breast area, replacing black feathers with light yellow/greyish feathers. On average females were slightly heavier than males.

Table 6.3. Biometrics of incubating (I) Pacific Golden Plovers. Bill length. total head length. tarsus length. tarsus + toe length and wing are all in mm. mass is in g. Recoveries of birds ringed in previous years are printed in bold. Colour codes: *m*= metal, *r*= red, *w*= white, *k*= pink, *b*= blue, *y*= yellow.

ring	date	colour code (l/r)	age	sex	nest	status	bill	total head	tarsus	tars +toe	wing	mass	primary moult
HS004602	23-Jun	<i>r/ww;k/km</i>	>2kj	F	IT18GP	I	23.7	57.6	43.1	73.0	167	142.0	
HS004601	23-Jun	<i>y/yr;w/km</i>	>2kj	F	RK8GP	I	23.3	58.1	41.5	67.0	170	151.0	
HS004652	3-Jul	<i>w/ww;k/km</i>	>2kj	F	HS41GP	I	20.6	54.7	43.4	71.0	168	137.0	
HS004605	3-Jul	<i>r/wb;r/km</i>	>2kj	F	IT29GP	I	21.4	55.9	43.4	74.5	168	131.0	
HS004662	15-Jul	<i>r/wb;r/km</i>	>2kj	F	RK33GP	I	21.5	51.4	43.4	74.0	171	145.0	
HS004666	24-Jul	<i>w/rk;b/km</i>	>2kj	F	RK70GP	I	22.7	57.6	42.7	72.0	170	124.5	
HS004669	26-Jul	<i>w/rw;w/km</i>	>2kj	F	IT97GP	I	21.0	54.9	41.7	70.5	167	124.0	
HS004674	30-Jul	<i>r/wr;w/km</i>	>2kj	F	IT76GP	I	23.2	56.6	44.8	75.0	170	131.0	
HS004603	26-Jun	<i>r/yy;r/km</i>	>2kj	M	IT27GP	I	20.6	54.4	40.7	70.0	166	124.0	
HS004606	4-Jul	<i>k/kk;k/km</i>	>2kj	M	IT28GP	I	22.4	57.0	43.2	72.0	168	129.0	
HS004656	8-Jul	<i>y/wr;r/km</i>	>2kj	M	HS42GP	I	22.1	57.0	43.3	74.0	166	133.0	
HS004661	12-Jul	<i>y/ky;y/km</i>	>2kj	M	IT55GP	I	20.4	57.0	45.3	74.0	167	134.0	2110000000
HS003651	12-Jul	<i>-/lm;-/wl</i>	>2kj	M	IT76GP	I	22.1	56.8	45.0	75.0	168	125.0	
HS003111	13-Jul	<i>y/yy;y/km</i>	>2kj	M	IT78GP	I	23.0	58.3	43.0	73.5	170	132.0	
HS004665	24-Jul	<i>b/yk;y/km</i>	>2kj	M	RK70GP	I	21.7	57.1	44.2	73.5	171	138.5	5540000000
HS004668	26-Jul	<i>r/rr;k/km</i>	>2kj	M	IT97GP	I	21.1	56.0	43.6	74.0	166	129.0	
HS004676	2-Aug	<i>y/ry;y/km</i>	>2kj	M	IT98GP	I	24.1	59.2	42.9	72.0	167	130.0	5500000000

6.2.4 Ringed Plover

Ringed Plovers were only caught during incubation. None of the birds caught was moulting. As catching of on Ringed Plover nests seemed to increase the risk of predation of the nest only a small number of birds was caught.

Table 6.4. Biometrics of incubating (I) Ringed Plovers. Bill length, total head length, tarsus length, tarsus + toe length and wing are all in mm, mass is in g. The bold record refers to a recovered bird, ringed in an earlier season

ring	date	colour code	age	sex	nest	status	bill	total head	tarsus	tarsus +toe	wing	mass
KS04001	18-Jun	-	>2kj	F	IT4RP	I	13.3	39.7	25.1	46.0	128	53.5
KS06107	20-Jun	-	>2kj	F	HS12RP	I	13.0	39.5	25.0	44.5	137	61.5
KS06109	20-Jun	-	>2kj	F	HS13RP	I	13.0	40.1	26.1	47.0	132	69.0
KS06117	28-Jun	-	>2kj	F	HS28RP	I	13.8	40.2	30.6	48.5	135	65.5
KS06108	20-Jun	-	>2kj	M	HS13RP	I	13.7	40.8	26.4	48.0	132	58.0

6.2.5 Little Stint

Only one bird was caught in the prebreeding period by chasing it into a mist net. This bird was seen sitting on a nest containing one egg and retrapped 13 days later on yet another nest containing four eggs. During incubation 70 birds were caught, and another 15 during the chick-rearing period. A total of 36 birds was caught on autumn migration. Little Stints were heavier during incubation than during chick-rearing (fig 6.1). Amongst post-breeding birds body mass varied between 22 and 32 g, indicating that the sample consisted of birds that were fattening and of birds that were very lean and presumably just arrived from more northerly areas.

One Little Stint (FS10068), ringed and colour-marked on 30 June and last seen on 18 July after having lost her clutch, was observed in the Huleh Valley, northern Israel, on 7 September 2000. This was only the third foreign recovery resulting from a few thousand Little Stints ringed in Taimyr over the last decade.

Table 6.4. Biometrics of prebreeding (pre), incubating (I), chick-rearing and postbreeding (post) Little Stints. Bill length, total head length, tarsus length, tarsus + toe length and wing are all in mm, mass is in g. Birds ringed and recaptured in 2000 are printed in italics. Colour codes: m= metal, r= red, w= white, k =pink, b= blue, y= yellow.

ring	date	colour code (l/r)	age	sex	nest	status	bill	total head	tarsus	tarsus +toe	wing	mass
FS10001	15-Jun	r/wb;y/km	>1kj	F?		pre	19.8	39.3	22.6	41.0	101	36.2
<i>FS10001</i>	<i>28-Jun</i>	<i>r/wb;y/km</i>	<i>>1kj</i>	<i>F?</i>	<i>IT35LS</i>	<i>I</i>						<i>31.0</i>
FS10054	20-Jun	y/rw:w/km	>1kj	F?	HS5LS	I	18.4	39.7	21.2	39.5	100	29.0
FS10060	24-Jun	r/wy;k/km	>1kj	F?	IT25LS	I	17.3	38.7	21.8	41.5	99	29.0
FS10061	24-Jun	w/wk;r/km	>1kj	F?	RK14LS	I	18.7	39.7	21.5	39.5	100	29.5
FS10063	28-Jun	y/by;y/km	>1kj	F?	IT33LS	I	17.7	37.9	21.9	40.0	94	28.2
FS10006	29-Jun	w/yy;w/km	>1kj	F?	RK19LS	I	19.4	39.9	21.2	39.5	99	34.2
FS10068	30-Jun	k/kk;k/km	>1kj	F?	HS34LS	I	18.2	39.5	21.9	41.0	103	33.3
FS10065	30-Jun	w/ww;k/km	>1kj	F?	IT36LS	I	19.6	40.9	21.5	40.5	101	29.4
FS10066	30-Jun	r/kk;k/km	>1kj	F?	IT39LS	I	19.5	40.7	21.1	38.5	100	32.5
FS10069	1-Jul	y/ky;y/km	>1kj	F?	IT47LS	I	17.7	38.2	22.5	41.0	98	30.0
FS10010	1-Jul	r/kb;r/km	>1kj	F?	IT48LS	I	19.5	41.0	22.0	40.0	101	31.2
FS10009	1-Jul	y/rr;r/km	>1kj	F?	RK23LS	I	19.4	40.7	21.8	41.0	100	29.8
FS10011	2-Jul	y/ww;w/km	>1kj	F?	HS37LS	I	19.0	40.7	21.8	40.5	101	29.3
FS10012	2-Jul	r/yk;r/km	>1kj	F?	HS38LS	I	18.8	39.3	21.6	40.0	97	26.7
FS10072	2-Jul	w/ww;w/km	>1kj	F?	IT51LS	I	18.0	38.5	20.8	40.0	99	30.0
FS10013	5-Jul	y/rb;k/km	>1kj	F?	HS44LS	I	19.4	38.6	21.9	41.0	97	27.7
FS10014	6-Jul	y/rk;k/km	>1kj	F?	HS48LS	I	18.3	39.9	20.7	39.0	96	26.0
FS10015	6-Jul	y/kk;y/km	>1kj	F?	HS49LS	I	18.2	39.8	22.4	42.0	102	31.7
FS10016	6-Jul	r/kr;r/km	>1kj	F?	RK42LS	I	17.0	38.6	21.4	39.5	97	28.5
FS10019	7-Jul	w/rb;y/km	>1kj	F?	HS53LS	I	18.1	38.8	22.1	39.0	98	25.8

Table 6.4. Continued.

ring	date	colour code (l/r)	age	sex	nest	status	bill	total head	tarsus	tarsus +toe	wing	mass
FS10020	8-Jul	w/rk;y/km	>1kj	F?	HS54LS	I	18.0	38.6	21.6	49.5	99	27.6
FS10075	8-Jul	-	>1kj	F?	IT70LS	I	16.9	38.5	22.7	41.0	97	29.3
FS10021	10-Jul	r/kw;w/km	>1kj	F?	IT74LS	I	19.2	40.7	21.9	40.0	101	31.2
FS10035	10-Jul	k/ry;y/km	>1kj	F?	IT75LS	I	19.6	40.5	22.2	40.5	99	27.2
FS10080	12-Jul	k/yw;r/km	>1kj	F?	RK55LS	I	19.2	39.9	22.6	41.0	100	28.2
FS10082	13-Jul	r/yw;k/km	>1kj	F?	RK58LS	I	19.2	40.8	22.4	40.0	102	26.6
FS10023	14-Jul	k/bk;k/km	>1kj	F?	IT81LS	I	20.0	41.1	22.8	40.0	104	29.1
FS10084	14-Jul	w/by;w/km	>1kj	F?	RK54LS	I	19.4	40.6	21.9	38.5	101	27.4
FS10085	14-Jul	b/kb;k/km	>1kj	F?	RK60LS	I	18.6	40.7	21.7	41.0	104	30.2
FS10026	15-Jul	k/rw;y/km	>1kj	F?	IT85LS	I	18.6	40.0	20.8	40.0	104	30.3
FS10030	16-Jul	k/ww;w/km	>1kj	F?	IT87LS	I	18.2	37.8	20.9	39.0	97	28.0
FS10086	16-Jul	b/yr;y/km	>1kj	F?	RK56LS	I	18.5	39.6	21.2	39.5	99	27.4
FS10032	19-Jul	y/wb;k/km	2kj	F?	HS70LS	I	18.4	39.4	21.8	39.0	99	28.3
KS06153	30-Jul	-	>1kj	F?	HS76LS	I	18.8	39.6	23.5	41.5	104	30.2
KS06151	30-Jul	-	>1kj	F?	IT67LS	I	19.4	39.7	22.4	42.5	101	29.9
FS10055	20-Jun	b/wr;r/km	>1kj	M?	IT12LS	I	16.8	36.6	19.6	37.5	97	25.5
FS10053	20-Jun	r/yb;k/km	>1kj	M?	RK3LS	I	17.4	38.3	21.6	40.5	97	28.7
FS10056	21-Jun	r/yr;w/km	>1kj	M?	HS15LS	I	18.7	38.8	22.1	40.0	98	27.3
FS10003	21-Jun	y/yy;y/km	>1kj	M?	IT16LS	I	17.0	38.3	22.0	44.0	96	27.4
FS10057	23-Jun	b/bb;b/km	>1kj	M?	IT23LS	I	19.8	40.1	22.4	42.0	97	28.5
FS10059	24-Jun	r/wr;r/km	>1kj	M?	HS22LS	I	18.6	39.3	22.7	42.0	97	30.0
FS10058	24-Jun	b/yy;y/km	>1kj	M?	RK11LS	I	17.6	39.4	26.1	40.5	95	28.5
FS10004	26-Jun	r/wr;y/km	>1kj	M?	HS24LS	I	17.8	38.7	20.4	38.0	96	27.3
FS10005	29-Jun	r/yr;b/km	>1kj	M?	RK18LS	I	17.5	38.3	21.2	40.5	100	32.5
FS10067	30-Jun	y/wy;y/km	>1kj	M?	IT40LS	I	18.6	39.1	21.7	40.0	97	29.6
FS10008	30-Jun	r/wr;w/km	>1kj	M?	IT44LS	I	18.1	39.0	21.3	39.5	99	29.0
FS10018	7-Jul	y/bb;w/km	>1kj	M?	IT68LS	I	17.4	37.9	20.2	37.0	97	28.5
FS10073	7-Jul	y/yr;r/km	>1kj	M?	RK44LS	I	17.9	39.3	21.2	40.0	98	28.6
FS10017	7-Jul	y/kr;r/km	>1kj	M?	RK45LS	I	17.9	38.5	21.8	39.5	99	28.7
FS10079	10-Jul	w/yw;y/km	>1kj	M?	HS57LS	I	20.3	39.5	21.8	40.5	95	29.5
FS10037	10-Jul	y/wk;w/km	>1kj	M?	RK37LS	I	18.3	38.9	20.1	39.5	95	27.5
FS10037	13-Jul	y/wk;w/km	>1kj?		RK37LS	I						24.6
FS10036	10-Jul	y/ry;k/km	>1kj	M?	RK39LS	I	17.4	37.8	19.1	37.0	94	25.1
FS10077	10-Jul	k/wy;w/km	>1kj	M?	RK51LS	I	18.5	38.8	21.4	39.5	98	27.7
FS10078	10-Jul	r/ww;w/km	>1kj	M?	RK52LS	I	18.4	39.1	22.3	40.0	101	29.4
FS10083	13-Jul	w/ry;w/km	>1kj	M?	RK59LS	I	19.1	40.2	23.1	41.0	101	30.1
FS10024	14-Jul	b/kr;k/km	>1kj	M?	HS67LS	I	18.7	39.7	22.0	41.0	98	27.9
FS10022	14-Jul	k/wr;w/km	>1kj	M?	IT80LS	I	18.4	39.2	21.6	40.0	99	28.8
FS10025	14-Jul	w/yw;k/km	>1kj	M?	IT82LS	I	19.0	38.9	22.8	42.0	98	28.7
FS10027	15-Jul	w/ky;r/km	>1kj	M?	IT73LS	I	18.0	39.0	20.4	39.0	102	27.4
FS10031	16-Jul	r/rr;w/km	>1kj	M?	HS46LS	I	17.5	38.7	20.5	39.0	95	27.5
FS10087	16-Jul	r/kk;y/km	>1kj	M?	RK66LS	I	18.3	39.5	22.6	40.5	99	31.6
FS10050	27-Jul	w/rw;k/km	2kj	M?	HS75LS	I	16.3	37.1	22.1	42.5	98	28.6
FS10002	16-Jun	y/yy;k/km	>1kj?		RK3LS	I	19.0	38.9	22.8	42.0	97	31.0
FS10051	18-Jun	r/yr;y/km	>1kj?		HS9LS	I	17.5	38.3	22.1	40.0	95	31.5
FS10052	19-Jun	w/kw;w/km	>1kj?		IT11LS	I	17.8	38.5	21.6	40.0	92	28.5
FS10062	28-Jun	k/bk;b/km	>1kj?		IT32LS	I	18.5	39.7	21.6	39.5	98	24.2
FS10064	29-Jun	b/wk;w/km	>1kj?		RK20LS	I	17.0	37.6	21.6	39.5	97	26.5
FS10007	30-Jun	r/wr;b/km	>1kj?		HS31LS	I	18.9	40.0	21.4	41.0	100	29.6
FS10070	1-Jul	k/yk;y/km	>1kj?		RK29LS	I	19.1	39.1	21.5	40.4	98	28.0
FS10071	2-Jul	y/yk;k/km	>1kj?		RK31LS	I	19.1	39.6	21.4	40.0	99	29.4
FS10028	15-Jul	k/rk;w/km	>1kj?		RK64LS	I	19.5	40.5	22.3	40.0	102	29.5
KS06242	1-Aug	-	>1kj?		IT00LS	c	18.9	39.8	22.2	40.5	102	31.5

Table 6.4. Continued.

ring	date	colour code (l/r)	age	sex	nest	status	bill	total head	tarsus	tarsus +toe	wing	mass
FS10029	16-Jul	r/yw;w/km	>1kj	F?	fam12	c	18.5	39.6	22.4	40.5	-	26.6
FS10033	19-Jul	r/yy;r/km	2kj	?	fam15	c	16.8	37.7	21.1	38.5	97	28.0
FS10034	19-Jul	b/wr;k/km	>1kj	?	fam16	c	17.6	38.8	21.3	38.5	97	25.1
FS10088	20-Jul	y/wr;b/km	>1kj	F?	fam19	c	17.2	36.8	20.4	37.5	95	21.8
FS10074	8-Jul	-	>1kj	F?	fam2	c	16.8	37.7	21.9	39.5	97	23.3
FS10089	22-Jul	b/rk;w/km	>1kj	F?	fam25	c	20.1	40.2	22.5	40.0	102	30.8
FS10076	10-Jul	k/yr;r/km	>1kj	F?	fam3	c	17.7	38.5	20.5	39.0	96	24.8
FS10090	24-Jul	-	>1kj	?	fam38	c	19.4	40.4	21.1	39.0	99	26.8
FS10039	25-Jul	k/yb;r/km	>1kj	F?	fam40	c	20.0	41.3	22.1	41.5	99	30.9
FS10047	25-Jul	y/yk;y/km	>1kj	F?	fam41	c	20.8	41.6	23.5	43.0	101	28.5
FS10096	28-Jul	r/ky;y/km	>1kj	F?	fam47	c	19.5	40.1	23.5	42.5	98	28.2
FS10097	28-Jul	y/yw;w/km	>1kj	F?	fam48	c	18.2	38.5	20.6	38.5	99	26.0
KS06152	31-Jul	-	>1kj	?	fam51	c	18.7	39.9	22.3	40.5	102	27.3
FS10081	12-Jul	r/yy;y/km	>1kj	M?	fam6	c	16.3	37.6	20.1	38.0	95	25.7
KS06255	29-Jul	-	>1kj	F?	-	post	19.1	40.0	22.4	40.5	101	30.0
KS06166	3-Aug	-	>1kj	F?	-	post	19.1	38.9	22.4	41.8	99	27.7
FS10092	21-Jul	-	>1kj	M?	-	post	19.5	39.8	19.9	39.0	101	26.6
KS06256	29-Jul	-	>1kj	M?	-	post	17.7	38.2	22.1	38.5	97	25.8
KS06139	29-Jul	-	>1kj	M?	-	post	19.2	40.8	24.1	41.5	100	25.2
KS06140	29-Jul	-	>1kj	M?	-	post	18.2	39.2	22.0	40.0	97	24.0
FS10091	21-Jul	-	>1kj	?	-	post	19.3	40.1	22.5	40.0	97	26.3
FS10100	29-Jul	-	>1kj	?	-	post	18.0	37.9	19.8	39.5	96	23.7
KS06134	29-Jul	-	>1kj	?	-	post	17.9	38.0	23.6	41.0	96	28.0
KS06135	29-Jul	-	>1kj	?	-	post	19.2	40.3	20.7	37.5	101	26.0
KS06234	30-Jul	-	>1kj	?	-	post	18.5	37.9	20.6	38.0	98	28.8
KS06234	31-Jul	-	>1kj	?	-	post	-	-	-	-	-	28.0
KS06259	31-Jul	-	>1kj	?	-	post	18.1	38.2	21.5	38.5	96	28.7
KS06261	31-Jul	-	>1kj	?	-	post	19.4	39.3	22.3	40.5	97	29.1
KS06238	1-Aug	-	>1kj	?	-	post	17.5	37.8	20.5	38.0	95	23.0
KS06241	1-Aug	-	>1kj	?	-	post	17.2	38.5	21.2	38.5	-	24.0
KS06159	1-Aug	-	>1kj	?	-	post	20.1	40.4	20.9	40.0	100	24.6
KS06245	3-Aug	-	>1kj	?	-	post	19.6	40.6	22.4	41.0	104	28.1
KS06233	30-Jul	-	1kj	?	-	post	16.2	37.3	20.3	38.5	100	23.7
KS06235	30-Jul	-	1kj	?	-	post	18.1	39.2	32.2	40.5	99	24.0
KS06236	30-Jul	-	1kj	?	-	post	18.6	39.5	22.3	41.0	100	26.7
KS06260	31-Jul	-	1kj	?	-	post	18.5	38.6	22.3	40.0	96.5	24.3
KS06239	1-Aug	-	1kj	?	-	post	19.2	40.2	22.5	-	101	23.5
KS06240	1-Aug	-	1kj	?	-	post	19.1	41.8	21.1	38.0	93	22.5
KS06154	1-Aug	-	1kj	?	-	post	19.8	40.3	21.7	39.5	101	21.5
KS06161	1-Aug	-	1kj	?	-	post	18.1	38.7	20.7	38.0	98	27.4
KS06155	1-Aug	-	1kj	?	-	post	18.5	38.4	20.2	38.0	97	23.3
KS06156	1-Aug	-	1kj	?	-	post	19.0	39.7	22.2	41.0	99	24.3
KS06157	1-Aug	-	1kj	?	-	post	19.8	40.7	21.3	39.5	100	25.4
KS06266	3-Aug	-	1kj	?	-	post	19.0	39.7	22.2	39.5	96	23.8
KS06264	3-Aug	-	1kj	?	-	post	19.0	40.2	22.9	40.0	104	28.7
KS06244	3-Aug	-	1kj	?	-	post	19.2	40.5	20.5	40.0	104	32.0
KS06246	3-Aug	-	1kj	?	-	post	19.7	39.8	22.9	40.5	102	27.3
KS06247	3-Aug	-	1kj	?	-	post	18.7	39.4	22.3	39.5	98	25.5
KS06248	3-Aug	-	1kj	?	-	post	19.6	40.7	22.1	40.0	103	26.6
KS06249	3-Aug	-	1kj	?	-	post	18.4	38.7	20.0	38.0	98	25.8
KS06250	4-Aug	-	1kj	?	-	post	17.5	38.2	22.4	40.0	99	22.9

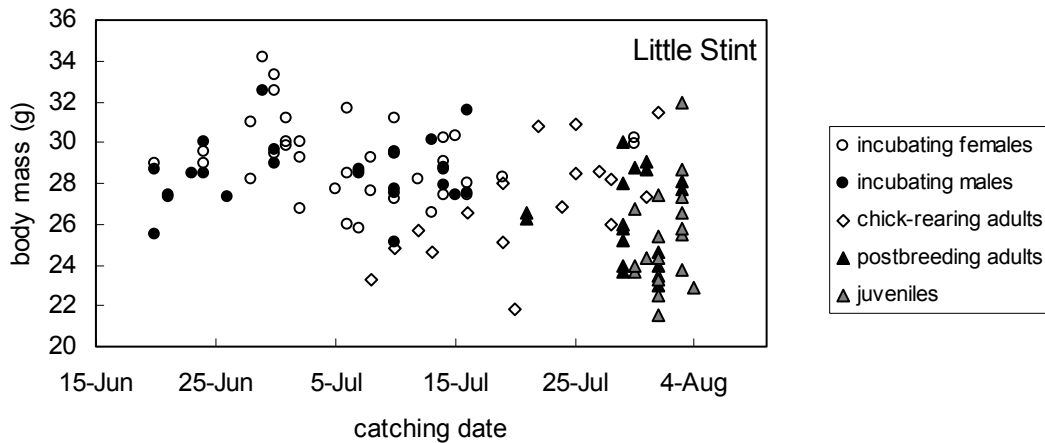


Figure 6.1. Body mass of incubating, chick-rearing and postbreeding Little Stints relative to catching date. Sex determination is based on plumage characteristics and can deviate from actual sex. Because of fading of plumage no distinction between sexes was made in chick-rearing and postbreeding individuals.

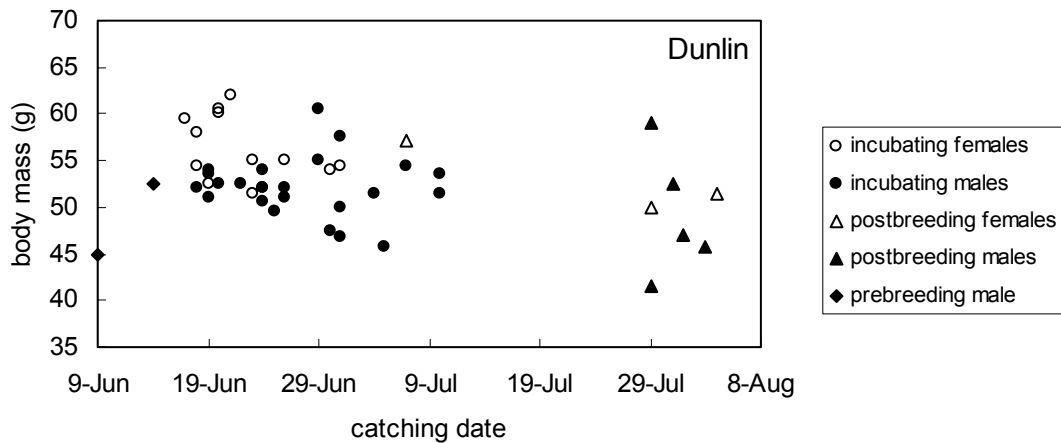


Figure 6.2. Body mass of incubating and postbreeding male and female Dunlins relative to catching date.

6.2.6 Dunlin

In the arrival period only two males were caught, one weighed approximately the same as incubating males (52.5 respectively 51.9, table 6.5), the earliest bird caught on 9 June was very light. We tried to catch as many complete pairs as possible to analyse possible preferences in partner choice. This succeeded for 12 pairs. Analysis of biometrics in Dunlin pairs will be presented in chapter 8. The larger females are on average heavier than males. Seven out of eight birds caught on autumn migration had very little fat and had lower body mass than on average during incubation (fig. 6.2). Compared to incubating females and males, females weighed on average 2.9 g and males 2.6 g less. Only one juvenile Dunlin was caught which was one of the lightest birds. Of all birds caught 23 were moulting their primaries, the earliest moulting bird was caught on 22 June. None of the birds caught on the nest were in contour feather moult, while seven out of eight adult birds on autumn migration were moulting their body feathers. Only the bird caught on 7 July, the earliest was not in body moult yet.

Table 6.5. Biometrics of prebreeding (pre), incubating (i) and postbreeding (post) Dunlins. Bill length, total head length, tarsus length, tarsus + toe length and wing are all in mm, mass is in g. Bold records are recoveries of birds ringed in earlier seasons, records in italics refer to birds recaptured in 2000. Birds ringed and recaptured in 2000 are printed in italics. Colour codes: m= metal, r= red, w= white, k=pink, b= blue, y= yellow.

ring	date	colour code (l/r)	age	sex	nest	status	bill	total head	tarsus	tars + toe	wing	mass	prim. moult
KS06300	14-Jun	b/ww:k/km	>2kj	M		pre	32.4	57.4	24.8	49.5	118	52.5	
KS06202	9-Jun	b/wr:w/km	2kj	M		pre	34.1	58.3	26.8	48	117	45.0	
KS06203	17-Jun	b/yb:w/km	>2kj	?	IT7DU	I	37.3	62.7	27.6	49.0	121	59.5	
KS06106	18-Jun	r/yb:w/km	>2kj	F	HS7DU	I	36.1	61.1	25.6	48.5	122	54.5	
KS06205	18-Jun	r/ww:w/km	>2kj	F	IT9DU	I	36.6	61.5	26.7	50.0	118	58.0	
<i>KS06205</i>	<i>1-Jul</i>	<i>r/wm:w/km</i>			<i>IT45DU</i>	<i>I</i>						<i>57.6</i>	
KS06206	19-Jun	r/wk:y/km	>2kj	F	IT13DU	I	35.8	60.2	24.9	46.0	121	52.5	
KS06110	20-Jun	r/rw;k/km	>2kj	F	HS14DU	I	37.3	62.4	25.3	49.0	124	60.5	
KS06210	20-Jun	b/rb:w/km	>2kj	F	HS6DU	I	37.6	62.1	25.7	47.0	121	60.0	
KS06111	21-Jun	r/wr:w/km	>2kj	F	IT6DU	I	38.9	63.6	26.6	50.5	123	62.0	
KS06113	23-Jun	y/br;b/km	>2kj	F	HS11DU	I	37.3	61.3	24.2	46.5	119	51.5	
KS06213	23-Jun	b/bb;k/km	>2kj	?	HS20DU	I	34.8	59.0	25.0	46.5	119	50.0	
KS06214	23-Jun	y/kk;r/km	>2kj	F	RK10DU	I	40.6	65.1	27.0		124	55.0	
KS06217	24-Jun	y/yy:y/km	>2kj	F	RK15DU	I	36.4	60.4	25.2	47.0	121	52.0	
KS04801	26-Jun	y/ww;k/km	>2kj	F	RK13DU	I	34.0	58.3	26.6	50.0	121	55.0	
KS06118	30-Jun	y/by:y/km	>2kj	F	HS32DU	I	36.0	60.9	25.9	49.5	119	54.0	4333210000
KS06120	1-Jul	k/kw:w/km	>2kj	F	RK25DU	I	39.1	60.2	24.7	50.5	121	54.5	1111000000
KS06204	18-Jun	w/yr:k/km	>2kj	M	HS6DU	I	33.9	58.8	24.7	45.0	118	52.0	
<i>KS06204</i>	<i>4-Jul</i>	<i>w/yr;k/km</i>	<i>>2kj</i>	<i>M</i>	<i>RK34DU</i>	<i>I</i>						<i>51.5</i>	<i>1100000000</i>
KS04806	19-Jun	k/km:w/bw	>2kj	M	IT6DU	I	32.0	56.6	25.9	48.5	120	53.5	
KS06207	19-Jun	w/yk:y/km	>2kj	M	IT9DU	I	30.3	54.2	25.2	46.0	116	54.0	
KS06208	19-Jun	r/yr:r/km	>2kj	M	HS7DU	I	32.0	57.1	25.6	48.0	117	51.0	
KS06209	20-Jun	w/yw:w/km	>2kj	M	IT13DU	I	30.4	55.5	24.1	45.0	119	52.5	
<i>KS06209</i>	<i>10-Jul</i>	<i>w/yw:w/km</i>	<i>>2kj</i>	<i>M</i>	<i>IT13DU</i>	<i>I</i>						<i>53.5</i>	
KS06212	22-Jun	r/yy;k/km	>2kj	M	HS14DU	I	32.8	55.5	25.2	47.0	116	52.5	1100000000
KS06114	24-Jun	y/yb;r/km	>2kj	M	HS20DU	I	32.9	58.8	25.3	49.0	120	54.0	
KS06218	24-Jun	w/yr:w/km	>2kj	M	HS11DU	I	31.6	56.0	23.6	46.0	114.5	50.5	2222100000
KS06219	24-Jun	y/rr:w/km	>2kj	M	RK13DU	I	31.5	54.9	25.3	47.0	118	52.0	1110000000
KS06220	25-Jun	w/rw:w/km	>2kj	M	RK17DU	I	32.6	57.4	25.3	48.0	115	49.5	1111000000
<i>KS06220</i>	<i>1-Jul</i>	<i>w/rw:w/km</i>		<i>M</i>	<i>RK17DU</i>	<i>I</i>						<i>50.0</i>	<i>4432100000</i>
KS06115	26-Jun	r/rr;k/km	>2kj	M	RK15DU	I	32.2	57.0	25.2	47.5	119	51.0	
KS06116	26-Jun	r/bk;r/km	>2kj	M	HS23DU	I	32.5	57.2	25.0	47.5	117	52.0	
KS06222	29-Jun	k/bb;k/km	>2kj	M	RK21DU	I	34.5	59.5	25.2	48.0	121	60.5	2210000000
KS06223	29-Jun	k/ww:w/km	>2kj	M	RK22DU	I	32.7	58.2	25.4	48.0	116	55.0	2210000000
KS06119	30-Jun	k/ky:y/km	>2kj	M	HS33DU	I	33.1	56.8	25.1	46.5	115	47.5	
KS06121	1-Jul	y/yw:y/km	>2kj	M	HS36DU	I	31.2	55.7	24.0	45.5	117	46.8	5544320000
KS06122	5-Jul	r/by;k/km	>2kj	M	RK25DU	I	33.5	58.0	24.1	46.0	114	45.7	3321000000
KS06123	7-Jul	k/rk;k/km	>2kj	M	HS51DU	I	34.4	58.3	20.8	48.0	118	54.5	5555411000
KS06141	10-Jul	b/yk:y/km	>2kj	M	HS55DU	I	34.7	59.5	24.9	47.5	117	51.5	5554421000
KS06124	7-Jul	b/yy;k/km	>2kj	F		post	35.1	59.4	23.7	47.0	121	57.2	
KS06137	29-Jul	-	>1kj	F		post	38.6	62.6	26.4	48.5		50.0	555555543
KS06172	4-Aug	-	>1kj	F		post	37.8	62.1	26.6	49.0		51.5	5555555431
KS06138	29-Jul	-	>1kj	M		post	33.1	56.8	25.6	46.5	114	59.0	555555554
KS06254	29-Jul	-	2kj	M		post	30.2	54.6	22.9	42.5	114	41.5	5555554100
KS06258	31-Jul	-	>1kj	M		post	37.5	61.8	27.3	51.0	115	52.6	5555555543
KS06237	1-Aug	-	>1kj	M		post	32.0	56.8	24.9	46.5	112	47.0	555555554
KS06267	3-Aug	-	>1kj	M		post	31.3	55.7	23.5	45.5	110	45.8	5555555543
KS06251	4-Aug	-	>2kj	M		post	32.4	56.2	25.6	48.0	112	49.9	555555554
KS06268	3-Aug	-	1kj	?		post				25.6	118	44.0	
KS06232	29-Jul	-	>2kj	?		post	34.9	59.9	25.8	48.5	117	43.3	5555555410

6.2.7 Curlew Sandpiper

Of the total of seven birds caught during spring migration/arrival four were Curlew Sandpipers. Together with Dunlins Curlew Sandpipers seemed to respond the most effective to the sound recordings, both in spring and on autumn migration. On average incubating birds were heavier than postbreeding birds (table 6.6, fig. 6.3). Postbreeding birds may consist of birds that have just landed to make a stopover, or are at the end of a stopover and preparing for the next lap. In the sample of postbreeding birds we found both very light and very heavy ones (fig 6.3). None of the birds was moulting its primaries and body moult was only observed in migrating birds.

Table 6.6. Biometrics of prebreeding (pre), incubating (I) and postbreeding (post) Curlew Sandpipers. Bill length, total head length, tarsus length, tarsus + toe length and wing are all in mm. mass is in g. Colour codes: m= metal, r= red, w= white, k =pink, b= blue, y= yellow.

ring	date	colour code (l/r)	age	sex	nest	status	bill	total head	tarsus	tarsus +toe	wing	mass
KS06201	9-Jun	y/yw;k/km	>2kj	M		pre	38.8	63.3	31.9	50.0	133	53.5
KS06101	11-Jun	w/ww:w/km	>2kj	M		pre	34.3	59.1	29.5	52.0	134	60.5
KS06103	15-Jun	y/by;y/km	>2kj	M		pre	33.7	58.2	28.0	51.0	136	57.0
KS06102	15-Jun	y/wy;k/km	>2kj	F		pre	35.7	61.0	29.8	57.0	136	57.0
KS06104	16-Jun	w/rw;k/km	>2kj	F	HS3CS	I	39.5	62.5	31.8	55.0	135	66.5
KS06105	16-Jun	y/yr:w/km	>2kj	F	IT1CS	I	40.2	64.4	31.2	54.0	135	69.5
KS06112	23-Jun	b/ww:w/km	>2kj	F	IT22CS	I	38.2	63.6	31.4	55.0	137	64.0
KS06211	21-Jun	b/yy;k/km	>2kj	F	IT17CS	I	36.8	59.9	30.6	53.0	127	66.5
KS06215	23-Jun	r/wr:w/km	>2kj	F	HS21CS	I	41.4	67.0	33.7	58.5	138	68.0
KS06216	24-Jun	y/by:w/km	>2kj	F	RK12CS	I	39.7	64.2	30.0	51.0	129	60.0
KS06221	29-Jun	w/rb;y/km	>2kj	F	HS26CS	I	40.0	65.0	30.6	54.5	133	60.5
KS06224	6-Jul	y/yw;y/km	>2kj	F	IT50CS	I	40.5	65.3	32.2	54.5	134	59.0
KS06225	19-Jul	-	>2kj	F		post	41.3	65.6	30.8	54.5	130	60.9
KS06226	21-Jul	-	>2kj	F		post	40.1	64.8	30.6	52.5	133	57.5
KS06227	21-Jul	-	>2kj	F		post	45.1	69.7	34.4	59.5	127	58.5
KS06130	28-Jul	-	>2kj	F		post	37.0	60.6	31.2	54.0	131	54.0
KS06131	28-Jul	-	>2kj	F		post	39.4	63.3	32.3	54.5	134	57.0
KS06132	28-Jul	-	>2kj	F		post	38.8	63.5	32.7	55.0	131	62.4
KS06133	28-Jul	-	>2kj	F		post	41.1	74.4	30.0	52.0	129	54.0
KS06136	29-Jul	-	>2kj	F		post	37.6	61.6	32.0	52.5	137	54.0
KS06257	29-Jul	-	>2kj	F		post	36.4	61.4	30.5	53.5	133	57.8
KS06165	1-Aug	-	1kj	?		post	36.0	59.0	30.7	52.5	125	54.8
KS06265	3-Aug	-	1kj	?		post	40.4	63.5	30.7	54.5	134	54.8
KS06170	4-Aug	-	1kj	?		post	36.1	61.0	30.0	52.0	136	57.6
KS06171	4-Aug	-	>2kj	F		post	40.0	64.2	33.2	56.0	132	68.8
KS06252	4-Aug	-	1kj	?		post	41.1	61.0	33.4	56.0	137	67.0

6.2.8 Turnstone

Two males were caught during incubation, one female with chicks and two first year birds on autumn migration. The female with chicks was accompanied by two males. None of the birds caught showed body moult.

Table 6.7. Biometrics of incubating (I), chick-rearing and postbreeding (post) Turnstones. Bill length, total head length, tarsus length, tarsus + toe length and wing are all in mm, mass is in g. Colour codes: m= metal, r= red, w= white, k =pink, b= blue, y= yellow.

ring	date	colour code (l/r)	age	sex	nest	status	bill	total head	tarsus	tarsus +toe	wing	mass
HS004604	26-Jun	y/ry;w/km	>2kj	M	RK16TU	I	18.5	47.2	25.3	52.0	151	97.7
HS004651	23-Jun	y/wr;y/km	>2kj	M	RK7TU	I	20.4	48.9	25.8	51.0	152	98.5
HS004655	5-Jul	r/yy;k/km	>2kj	F	fam1	c	20.3	48.3	25.3	49.5	153	107.5
HS004677	3-Aug	-	1kj	?		post	20.1	47.0	24.8	47.0	143	87.0
HS004682	4-Aug	-	1kj	?		post	19.7	47.7	25.7	51.5	147	96.5

6.2.9 Red-necked Phalarope

A small sample of five birds was caught on autumn migration. These were all adult birds and none of them were moulting.

Table 6.8. Biometrics of postbreeding (post) Red-necked Phalaropes. Bill length, total head length, tarsus length, tarsus + toe length and wing are all in mm, mass is in g.

ring	date	colour code	age	sex	nest	status	bill	total head	tarsus	tarsus +toe	wing	mass
KS06158	1-Aug	-	>1kj	M		post	22.5	44.7	20.2	41.0	108	33.6
KS06162	1-Aug	-	>1kj	M		post	20.4	42.2	20.9	41.5	105	36.6
KS06163	1-Aug	-	>1kj	M		post	20.8	43.6	20.4	42.0	110	33.4
KS06164	1-Aug	-	>1kj	M		post	21.6	43.2	20.8	42.0	117	32.4
KS06160	1-Aug	-	>1kj	?		post	22.2	44.3	19.3	39.0	107	29.9

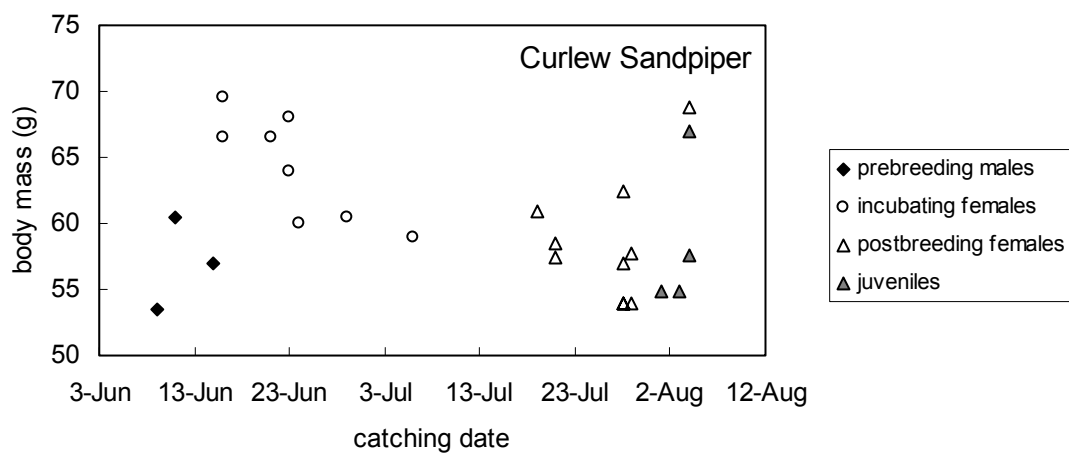


Figure 6.3. Body mass of prebreeding, incubating and postbreeding Curlew Sandpipers relative to catching date.

7 Condition and reproductive parameters

The main aim of the Alterra expedition was to describe (variation in) arrival date and arrival condition of arctic breeding shorebirds and to study correlations between these variables and (a) probability of obtaining a mate, (b) laying date, (c) clutch size, (d) egg size, (e) hatching success, (f) chick growth rate and survival, and (g) overall reproductive success. As catching of shorebirds upon arrival was not as successful as hoped for we focussed on the nest period instead and addressed the topics mentioned above in an indirect way. By catching birds on the nest we were able to collect data on their condition. The start of incubation (which was estimated using float curves, chapter 5) provided a measure of timing. Because nest success was greatly reduced through the high predation rate, hatching success, chick growth rate, survival and reproductive success could not be measured. The remaining variable indicative of fitness was egg size. In several shorebird species egg size is related to chick size and breeding success (Galbraith 1988, Grant 1991, Blomqvist *et al.* 1997), though not in all (Jager *et al.* 2000). Especially for Little Stint and Dunlin, and less so for Pacific Golden Plover and Curlew Sandpiper we collected a large enough data set to address questions on the relation between condition and reproductive effort.

7.1 Timing of breeding

For female Pacific Golden Plover a significant decline was found in body mass and in body mass corrected for structural size in relation to start of incubation: the birds that started later weighed less ($R^2=44.9$, $p=0.041$, fig. 7.1). Males did not show this pattern. None of the other body dimensions correlated with start of incubation, therefore the trend can not be explained by a trend in size. An unknown proportion of the nests that were started later in the season could have concerned replacement clutches. A reduction in body mass is then likely since these females have already produced a clutch and spent some time incubating. No relation between body mass or condition and start of incubation was found in Little Stints (fig. 7.1). Only wing and bill length correlated positively with the start of incubation ($R^2=12.1$, $p=0.002$ and $R^2=8.6$, $p=0.007$ respectively) suggesting that birds starting incubation later were larger. Because females have on average longer wings and bills we interpret this as an increase in the number of females incubating in the course of the season. In an analysis of data sets collected in a range of sites across the arctic, we found that the sex ratio of breeding birds is skewed with more females in the most northerly areas (Tulp *et al.* in press). Little Stint have a double clutch breeding system, in which females produce two clutches and male and female take care of their own clutch. Therefore an influx of females caught on the nest later in the season can be explained by females producing and incubating the second clutch. Since DNA samples to determine sex in the Little have not yet been analysed, we can not determine the sexes with certainty. However, if the sex as determined in the field

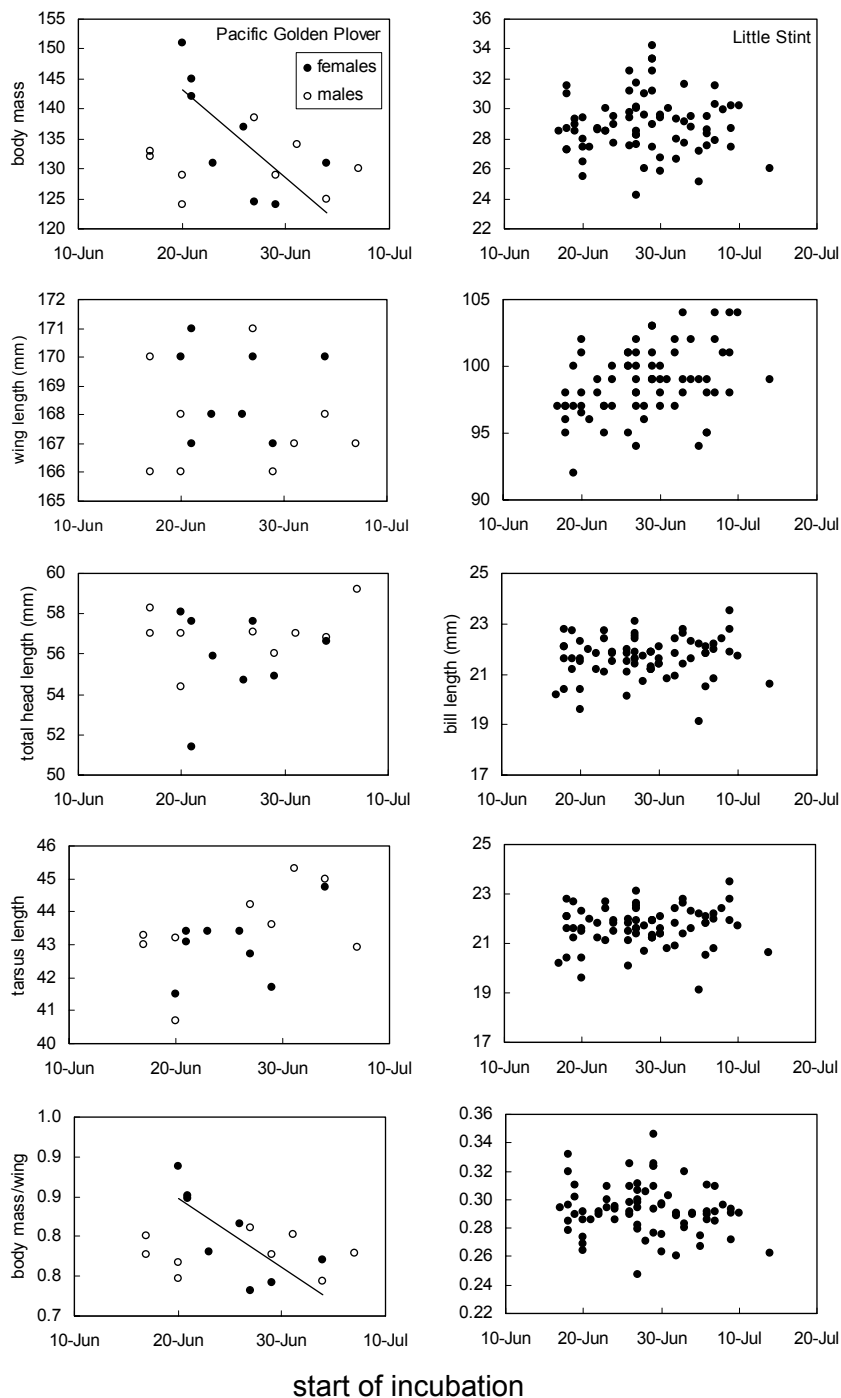
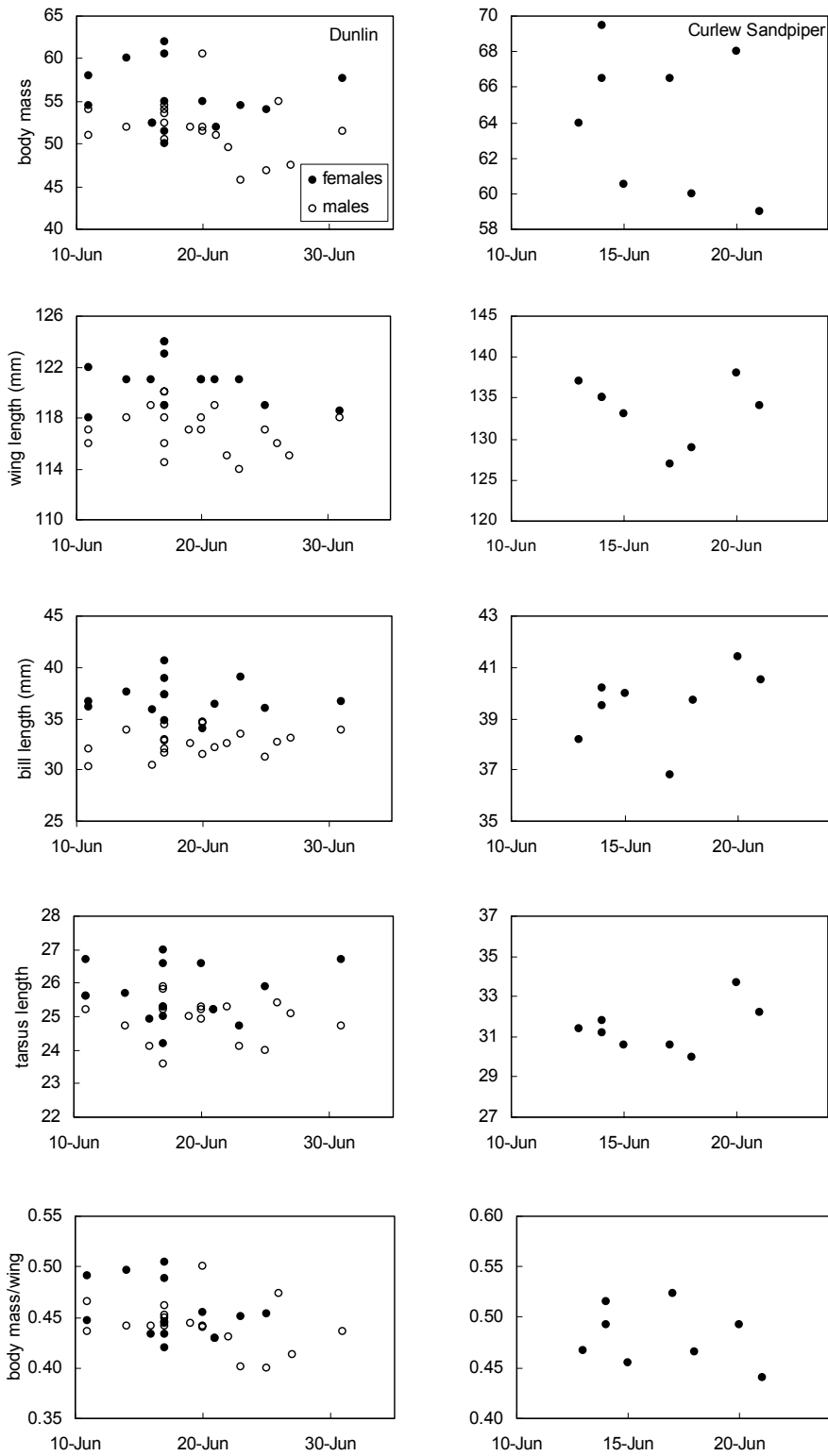


Figure 7.1. Biometric data in relation to the start of incubation (excluding egg laying) in Pacific Golden Plover and Little Stint. Note that none of the measurements were taken on the start of incubation. This is not a problem for constant data (wing length), but body mass values may vary throughout incubation. The linear regressions in PGP refer to females only.

from the coloration and measurements is used for the time being, in females the effect of wing length remained significant ($R^2=12.6$, $p=0.19$), but not in males. Neither for Dunlin, nor for Curlew Sandpipers a significant relationship was found between the timing of breeding and any of the body size dimensions (fig. 7.2)



start of incubation

Figure 7.2. Biometric data in relation to the start of incubation in Dunlin and Curlew Sandpiper. Note that none of the measurements were taken on the start of incubation. This is not a problem for constant data like wing length, but body mass values may vary throughout incubation.

7.2 Egg size

Numbers of eggs laid showed very little variation: more than 95% of the clutches contained four eggs (see chapter 5). A significant decline in egg size in relation to start of incubation was only found in Curlew Sandpipers (fig. 6.3, $R^2=33$, $p=0.048$). The other species showed no trend at all in egg size. Replacement clutches laid by the same female Dunlin were very similar in egg dimensions. In five known cases the difference in mean egg volume between the two clutches was: 0, 0.1, 0.3, 0.7 and 0.9 ml (0.3-7.4%, fig. 6.3).

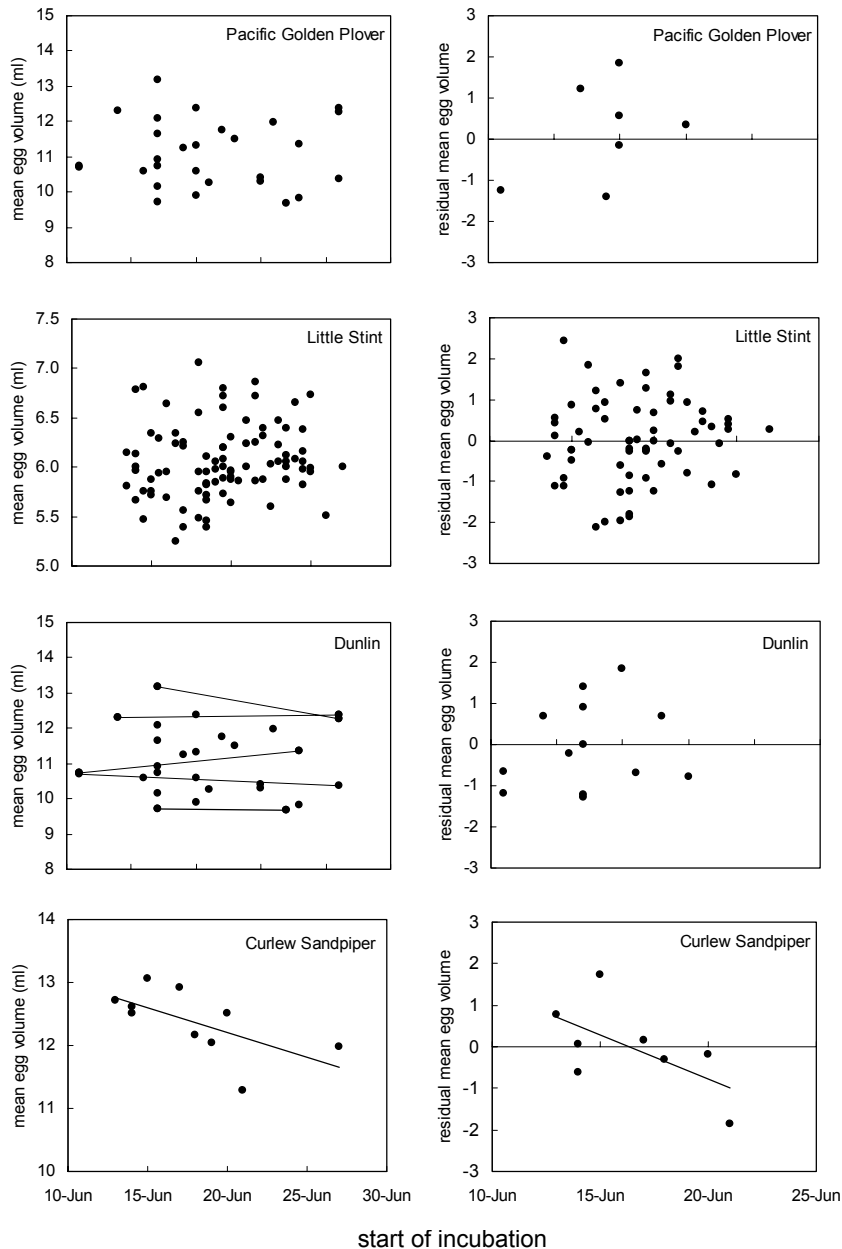


Figure 7.3. Egg size in relation to the start of incubation in Pacific Golden Plover, Little Stint, Dunlin and Curlew Sandpiper. Lines connect replacement clutches produced by the same female.

8 Dunlin: mating association, replacement clutches & resightings

We found 29 nests (including replacement clutches) for 28 territories. In total 31 adults were caught on the nest, and one before breeding. A description of catching, measuring and ringing procedures is given in chapter 6. For 14 of those 29 nests the identity of both parents was known. For the other nests only one of the parents was caught or identified (by means of resightings of colour ringed birds). Biometrical data allow an analysis of mating associations. Do large females mate with large males or do females with large black ventral areas mate with similarly coloured males? Another type of questions relates to replacement clutches: how often are they produced, how soon after clutch loss, how far from the first nest. Are replacement clutches produced by the same pairs or do Dunlins remate with a new partner?

8.1 Assortative mating

Amongst the 14 nests of which the identity of both parents was known, two nest were replacement clutches by the same pairs and one pair concerned a mix of parents of other nests. Therefore 12 pairs remain to investigate whether assortative mating took place. For these pairs all different biometric data taken were plotted (fig. 8.1) and it turned out that only tarsus length ($R=0.67$) and the number of parasites ($R=0.51$) yielded a significant correlation between male and female. Strikingly the one outlying point in the correlation between tarsus of the male and of the female, concerned the replacement clutch by a new combination of two birds that had their first nest with a different partner.

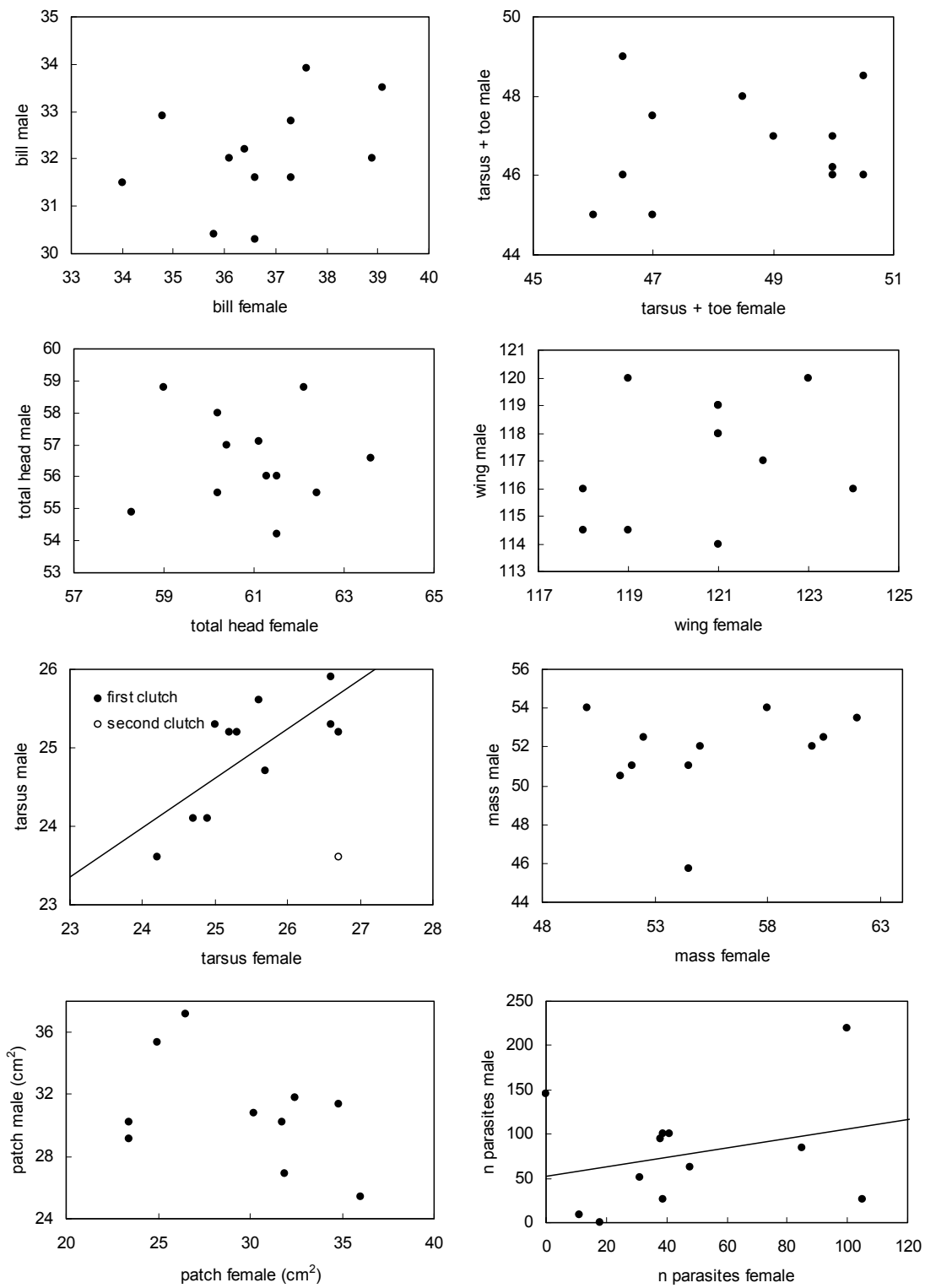


Figure 8.1. Relationships between body size measurements of Dunlin mates.

8.2 Replacement clutches

In total seven replacement clutches were discovered (table 8.1), of which one only after the eggs had hatched (called new). In five cases the parents of the second clutch were mated with the same birds, in two cases (it9du, hs11du) the couple split up and they both mated with another partner. In most cases the replacement clutch was laid in the same territory and distance between replacement clutches varied between 79 and 182 m (table 8.1). In the two cases where partners were changed for the replacement clutch the distance between the two clutches was larger.

Table 8.1. Replacement clutches and mating associations and distance between first and replacement nest.

bird	sex	nest1	partner1	sex	nest2	partner2	sex	distance between nests (m)
r/ww;w/km	f	it9du	w/yk;y/km	m	it45du	w/yr;w/km	m	145
w/yk;y/km	m	it9du	r/ww;w/km	f	rk25du	kk/w;w/km	f	293
y/br;b/km	f	hs11du	w/yr;w/km	m	?	?		?
w/yr;w/km	m	hs11du	y/br;b/km	f	it45du	r/ww;w/km	f	1900
b/rb;w/km	f	hs6du	w/yr;k/km	m	rk34du	w/yr;k/km	m	79
w/yr;k/km	m	hs6du	b/rb;w/km	f	rk34du	b/rb;w/km	f	
b/yb;w/km	f	it7du	k/ky;y/km	m	hs33du	k/ky;y/km	m	164
k/ky;y/km	m	it7du	b/yb;w/km?	f	hs33du	b/yb;w/km	f	
r/rw;k/km	f	hs14du	r/yy;k/km	m	hs64du	r/yy;k/km	m	107
r/yy;k/km	m	hs14du	r/rw;k/km	f	hs64du	r/rw;k/km	f	
r/yb;w/km	f	hs7du	r/yr;r/km	m	rk35du	r/yr;r/km	m	182
r/yr;r/km	m	hs7du	r/yb;w/km	f	rk35du	r/yb;w/km	f	
b/bb;k/km	f	hs20du	y/yb;r/km	m	new	y/yb;r/km	m	?
y/yb;r/km	m	hs20du	b/bb;k/km	f	new	b/bb;k/km	f	

The birds that produced replacement clutches were also the birds that had started their first clutch the earliest (table 8.2). From 11 clutches that were started before 17 June, ten were predated, one hatched successfully and seven were replaced. The parents of the three other nests that were predated were never seen again. Only nests that were predated before 28 June were replaced. However some of the birds whose nest was predated after that time, may have produced a replacement clutch outside the study area. In our study area new, unringed birds were also observed later in the season as partners in later nests.

Table 8.2. Dates of start of incubation and predation of replaced and replacement clutches

nest1	start of incubation date	predation date	nest2	start of incubation date	outcome
<i>replaced nests</i>					
it9du	11-Jun	23-Jun (21-25)	it45du	1-Jul	pred 2-Jul
it9du	11-Jun	23-Jun (21-25)	rk25du	24-Jun	pred 10-Jul
hs7du	11-Jun	22-Jun (19-25)	rk35du	28-Jun	pred 15-Jul
hs6du	14-Jun	24-Jun (20-28)	rk34du	1-Jul	pred 9-Jul
hs11du	17-Jun	26-Jun(23-29)	it45du	1-Jul	pred 2-Jul
it7du	17-Jun	18-Jun(17-19)	hs33du	27-Jun	pred 1-Jul
hs14du	17-Jun	26-Jun(24-28)	hs64du	1-Jul	hatched 22-Jul
hs20du	17-Jun	27-Jun(24-30)	new	3-Jul	hatched 24-Jul
<i>unreplaced nests</i>					
rk10du	17-Jun	28-Jun			
hs51du	17-Jun	9-Jul			
hs23du	19-Jun				hatched 10-Jul
hs10du	20-Jun	19-Jun			
rk21du	20-Jun	30-Jun			
rk13du	20-Jun	2-Jul			
hs55du	20-Jun				hatched 11-Jul
rk15du	21-Jun	28-Jun			
rk17du	22-Jun	2-Jul			
rk25du	23-Jun	10-Jul			
hs32du	25-Jun	1-Jul			
hs36du	25-Jun	2-Jul			
rk22du	26-Jun	1-Jul			
hs33du	27-Jun	1-Jul			
hs50du	28-Jun	9-Jul			
rk35du	28-Jun	15-Jul			
it45du	1-Jul	2-Jul			
rk34du	1-Jul	9-Jul			
hs64du	1-Jul				hatched 22-Jul
sk1du	< 24 june	25-Jun			

8.3 Broods

In all ten broods encountered the chicks were accompanied by the male only. Only one family with chicks of 5-6 days old was accompanied by both parents. All families were found in marshy areas with sedges. Fledging success (the number of chicks fledged) was not determined, because of the extremely high nest predation rate, but we estimate that inside the study area (4km²) less than 10 Dunlin chicks fledged (<0.3 young per pair)

9 Nest success and observer effects on predation

To be able to estimate nest success nests need to be located and checked at regular intervals. These nest visits may provide predators with cues for finding nests. As a result the estimate of nesting success may be influenced by the method used to estimate this success. Variation in this observer influence may be caused by the frequency of visits, the method used to mark the nest and the method used to check the nest (from a distance, observing the bird sitting on the nest or flying from it, or so close to nest that the eggs are actually visible or even touching the eggs to check their temperature).

In the field we had the impression that our nest visits increased the predation rate. In studies especially designed to study this observer effect on nest predation, a variety of outcomes have been found (Götmark 1992). To reduce observer-induced bias Rotella *et al.* (2000) developed a method that enables simultaneous estimation of observer-induced effects and survival rates of nests from the same data-set.

9.1 Nest survival

Daily nest survival was calculated using the Mayfield method by General Linear Models (Johnson 1979, Aebischer 1999). The midpoint assumption, was used: for nests that were predated, date in the middle of the last two visits was used instead of the date of the last visit. In many Little Stint the nests the actual timing of predation was known, when a nest was supplied with a Tiny Tag datalogger (see chapter 10). In these cases the actual predation date was used. For hatched nests, the calculated expected hatching date was used. Nest survival was only calculated for species with three or more nests.

Table 9.1. Daily nest survival probabilities and hatching probability (daily survival probability to the power of the incubation period: Pacific Golden Plover: 25, Ringed Plover: 23, Turnstone: 22, Little Stint/Temminck's Stint: 20, Dunlin/Curlew Sandpiper: 21, Lapland Bunting: 11, Snow Bunting: 12, Shore Lark: 10, Ptarmigan: 21). In nest losses, predated, deserted, or nests lost otherwise are combined. However more than 95% of nest losses were due to predation. For passerines only the period until hatching of the eggs, not the chick period is included in this calculation.

species	daily survival p	se	hatching probability	n nest days	n nest
Pacific Golden Plover	0.92058	0.01625	0.126	277	30
Ringed Plover	0.93000	0.02551	0.188	100	9
Turnstone	0.86957	0.07022	0.046	23	3
Little Stint	0.76504	0.02269	0.005	349	107
Temminck's Stint	0.97059	0.02898	0.550	34	3
Dunlin	0.84277	0.02887	0.028	159	29
Curlew Sandpiper	0.67742	0.08396	0.000	31	10
Lapland Bunting	0.89256	0.02815	0.286	121	16
Snow Bunting	0.93966	0.02211	0.474	116	14
Shore Lark	0.88889	0.04685	0.308	45	6
Ptarmigan	0.88889	0.06048	0.084	27	4

Amongst shorebirds the plovers had the highest hatching success (table 9.1). Hatching success of Temminck's Stint was higher but the sample was very small. Curlew Sandpipers were the most vulnerable to predation. Compared to shorebird nests, passerines had relatively high hatching success with the highest success for Snow Bunting. This species breeds in between rocks and is probably the least vulnerable to predation, although this is also the habitat where stoats hunt and several nests were predated there as well.

Table 9.2. Data set used in the analysis of observer effects on nest survival.

interval (days)	Curlew Sandpiper	Dunlin	P. Golden Plover	Little Stint	Ringed Plover	total
<i>predated</i>						
1	2	7	7	21	0	38
2	2	4	2	14	2	25
3	0	3	5	9	0	17
4	2	3	2	16	0	23
5	3	2	1	9	4	19
6	1	3	0	10	0	15
7	0	1	0	6	0	7
8	0	0	2	4	0	6
9	0	1	0	0	0	1
10	0	0	0	0	0	1
11	0	0	0	1	0	1
15	0	0	0	1	0	1
16	0	0	0	0	0	1
17	0	0	1	0	0	1
total	10	24	20	91	6	157
<i>survived</i>						
1	5	34	17	26	3	89
2	1	13	16	20	5	61
3	0	2	11	9	5	31
4	1	8	7	14	3	35
5	0	3	2	6	1	13
6	0	0	3	2	1	6
7	0	0	4	0	1	5
8	0	0	2	1	2	5
9	0	0	4	2	1	7
11	0	0	0	1	0	1
12	0	0	2	0	0	2
total	7	60	68	81	22	255
<i>predated+</i> <i>survived</i>	17	84	88	172	28	412

9.2 Observer effects on predation

Due to the presence of at least three different Arctic Foxes and the total absence of lemmings, shorebird nests suffered from a high predation rate and nest survival was very low. Stoats were also present and probably have taken a small share of predated nests, but they mainly predated nests of Snow Bunting and not shorebird nests. In a few cases we had the impression that a nest was predated by a skua, but many predated nests were scent marked by Arctic Foxes. A fox may use several methods to locate nests. Nest can be found by searching the tundra in a systematic way, using scent marks or visual cues or focusing on bird behaviour. How these different cues are used is not known. Although this was not an explicit subject of our studies, the data collected on nest survival provide several opportunities to investigate how predation takes place and to identify possible observer effects.

If observer effects occur because foxes find nests by watching observers or by following fresh human scent to nests, the risk of predation should be related to the length of the visiting interval. In that case the daily risk of predation risk is highest on the first day after the observers visit and decreases over time.

Table 9.3. Results of analysis examining observer effects on nest survival.

species		deviance	df	coefficient	se	p
all four species	log(h)			-0.2876	0.0671	<0.001
	log(p)			-0.0772	0.0227	<0.001
	model	13.7	359			
	total	486.4	360			
Pacific Golden Plover	log(h)			-0.2543	0.0886	0.004
	log(p)			-0.0010	0.0190	0.959
	model	0.0	86			
	total	94.3	87			
Little Stint	log(h)			-0.422	0.132	0.001
	log(p)			-0.1081	0.0427	0.011
	model	7.8	170			
	total	237.9	171			
Dunlin	log(h)			-0.024	0.103	0.816
	log(p)			-0.1505	0.0581	0.010
	model	10.39	82			
	total	100.51	83			
Curlew Sandpiper	log(h)			0.168	0.428	0.694
	log(p)			-0.515	0.288	0.074
	model	5.62	15			
	total	23.03	16			

At every nest visit we recorded whether it was predated or not, in what way the nest was checked (from a distance, at the nest, touching the eggs or not) and what other activities took place (installing Tiny Tag, catching, measuring eggs, placing of stick). This data set allows a detailed analysis of predation risk of nests in relation to observer activity. Interval lengths between visits was used in this analysis were not derived from the midpoint assumption (Johnson 1979) or the exact instant of predation as were used to calculate nest survival (table 9.1), but the actual intervals between visits were used instead. The model used to investigate observer effects is:

$$\log(P) = \log(h) + \log(p) \cdot t$$

where P is the probability of survival, h is the observer effect on survival probability and p is the probability that a nest survives natural mortality each day and t is the interval length. In table 9.2 the data set used in this analysis is given. For the four species with sufficient data the model converged. A significant negative short-term effect of nest visits on clutch survival was found in Little Stint and Pacific Golden Plover. The effect was not significant in Dunlin and Curlew Sandpiper (table 9.3). The model including all four species yielded a significant negative observer effect. Unfortunately inclusion of factors such as installing Tiny Tags, catching, measuring eggs or placing of a stick could not be tested, since none of these models converged.

Daily survival rates seemed to improve for longer interval lengths in all species except Curlew Sandpiper (table 9.4). Daily survival rates for each interval length were estimated by raising the proportion that survived each interval length to the inverse interval length. This effect is the result of a smaller influence of a short-term observer effect as intervals lengthen.

Table 9.4. Daily survival probability for different interval lengths

species	interval length				
	1	2	3	4	5
Pacific Golden Plover	0.708	0.943	0.883	0.939	0.922
Little Stint	0.553	0.767	0.794	0.827	0.833
Curlew Sandpiper	0.714	0.577	0.000	0.760	0.000
Dunlin	0.829	0.874	0.737	0.923	0.903

9.3 Timing of predation

As part of the study of energetics of incubating Little Stints we used Tiny Tag dataloggers to register nest attendance. As a large proportion of nests under investigation were predated the logger automatically also recorded the time of predation. This unplanned side effect provided us with data on timing of predation by Arctic Foxes. Nests were predated throughout day and night, without any clear

seasonal trend in time of predation (fig. 9.1). Most nest predation took place in late evening, night and early morning, but also in the middle of the day predators were active (fig. 9.2). If Arctic Foxes use scent marks to find nests we would expect the highest predation rate shortly after nest visits. However, there does not seem to be a relationship between the time between the last visit and the percentage of nests predated (fig. 9.3). This last finding seems to contradict the smaller observer effect at longer visiting intervals. The difference in time scale (five days in table 9.4 versus maximum three days in figure 9.3) might be the cause of this discrepancy.

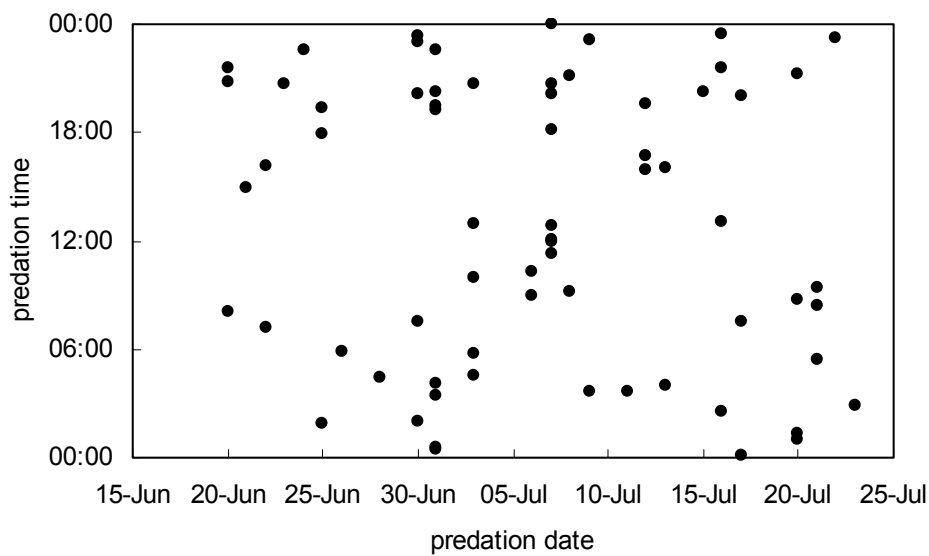


Figure 9.1. The time of day at which nests were predated in relation to date.

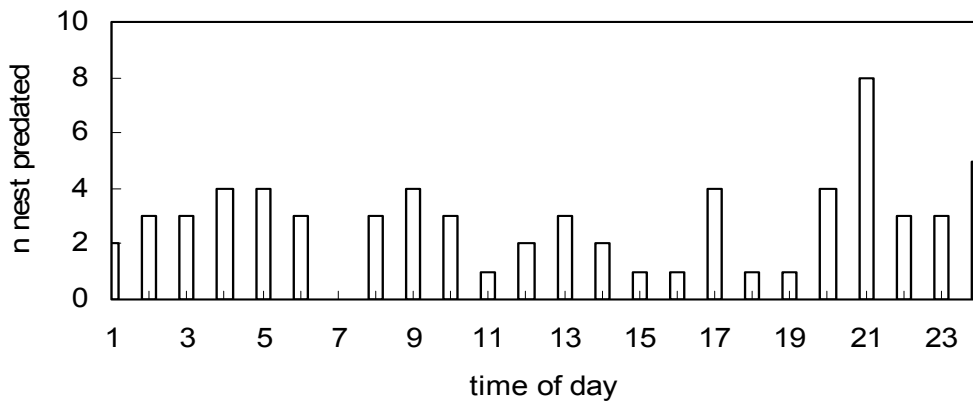


Figure 9.2. The occurrence of nest predation in relation to time of day.

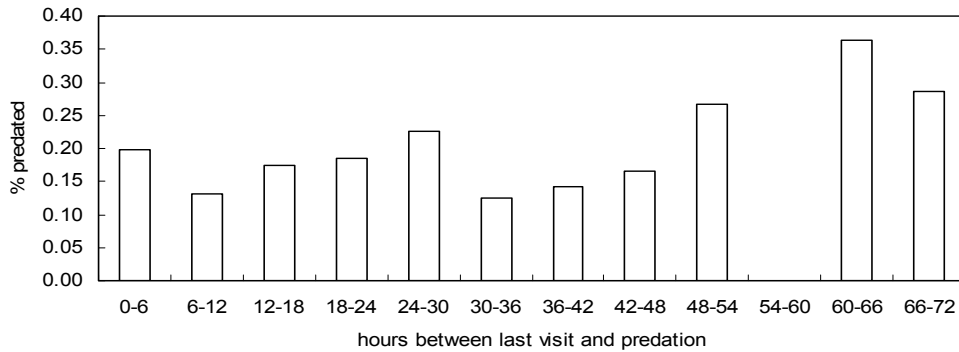


Figure 9.3. The proportion of nests available within each 6 h period since the last visit that was predated in that period.

9.4 Probability of desertion after catching

Because we assumed predation would be high regardless of our activities at the nest and our experience that Little Stints are very tame and quickly return to the nest after capture, we started off capturing Little Stints as soon as clutches were complete. In years with less predation we usually wait with catching until after the first week of incubation. To avoid the risk of losing all nests to predation before any data could be collected we chose to catch the birds as soon as the nest was found. The Tiny Tag data allowed an analysis of the time between capture and return to the nest (fig. 9.4). In 13 cases nests were deserted after capture. The majority of these concerns nests that were started very late in the season. During the first week of incubation, the time between capture and return often lasted several hours. Little Stints that were incubating longer than one week returned to the nest within one hour in most cases.

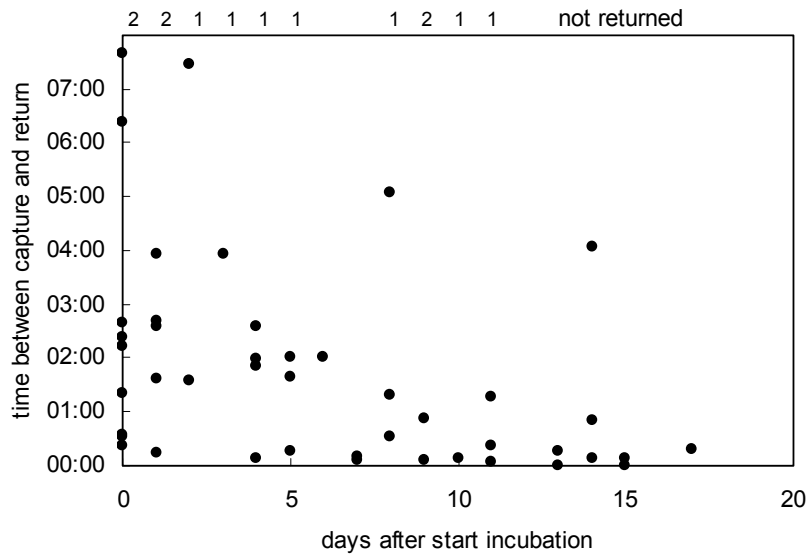


Figure 9.4. The time between capture and return in relation to the brooding stage. the numbers indicated the number of nests that were deserted after capture.

9.5 Conclusions

The calculations of nest survival indicate that at least in Little Stint, Dunlin and Curlew Sandpiper there is an observer effect, which is only significant for Little Stint. The increase in daily nest survival with increasing interval length also indicates that the most recently visited nests run the highest risk of predation. Whether or not activities carried out at the nest further increased the risk of predation could not be tested, but from our experience in the field we had the impression that actually touching the nest (when eggs were measured, data-loggers inserted or the bird caught) increased the risk of predation. The timing of predation on Little Stint nests that were supplied with a data logger shows no clear trend with time since the last visit. Most predation took place late June until the second week of July, which is not unexpected as this is also the period when most nests were present (fig. 5.2).

10 Energetics of brood-rearing in Little Stints

In this chapter a short overview will be given on some preliminary results of a study on energetics of Little Stints during chick-rearing. For comparison measurements on energy expenditure in incubating Little Stints, that were collected in 1996 will also be presented here.

Little Stints have a double-clutch breeding system (Chylarecki & Kania 1992). The female lays two clutches and both males and females incubate a clutch alone. The resulting trade-off between time spent on incubation and feeding was subject of study in 1996 in the same area. Measurements of energy expenditure on incubating birds were combined with time budgets, measured with temperature data-loggers placed in the nest. Last season we expanded this study to the chick-rearing period. The one advantage for precocial birds in comparison to altricial birds is that precocial chicks feed for themselves and parents do not need to collect food and bring it to their young. In fact most of the time chicks are feeding, adults could theoretically spend feeding for themselves. The continuous daylight of the arctic summer allows birds to search for food 24 hrs per day. However, the low temperatures limit this possibility. Young shorebird chicks rely on parental brooding to maintain their body temperature (Beintema & Visser 1989, Visser & Ricklefs 1993). So the parent's feeding time is limited by brooding and looking after their chicks. While in altricial birds the chick-rearing period is often the energetically most expensive period for adult birds, because food needs to be collected and transported to the nestlings (Daan *et al.* 1990, Williams 1996), in precocial birds the incubation period might be more costly for the parent. A reduction of the feeding time constraint, combined with an increase in food supply and higher temperatures in the chick period compared to the incubation period might make this phase less energetically stressful for adult Little Stints. To investigate this expectation we carried out measurements of energy expenditure in Little Stints with chicks and made a first start with observations on time budgets in this period.

10.1 Energy expenditure during brood-rearing versus incubation

Energy expenditure of free-living chick-tending adult Little Stints was measured using the doubly-labelled water method (DLW, Lifson & McClintock 1966, Speakman 1997). Little Stints with chicks varying in age between 0 and 8 days were captured. At first chicks were located and captured. One or two chicks were placed in a small cage while the other two were kept warm using a warm water bottle. The sound of the peeping chicks usually lured the adult bird immediately to the chicks. The adult was then caught by placing a mist net over it or using a clap net placed over the chicks. The chicks were then kept warm together using a warm water bottle, while the adult was injected (subcutaneously near the brood patch) with 0.1 DLW. DLW contains stable isotopes of hydrogen (^2H instead of ^1H) and oxygen (^{18}O instead of ^{16}O). It takes about one hour before the injected water has mixed with the body water pool, and the initial blood sample can be taken using glass capillaries.

Table 10.1. Energy expenditure of incubating and chick-rearing Little Stints. Mean mass represents the mean of the mass at injection and at the time when the final blood sample was taken (24 hrs later).

ring	days to hatch/ age chicks	n chicks	wing (mm)	mean mass (g)	dmass (g)	mean operative temperature (°C)	DEE (kJ/day)
incubating Little Stints							
FS08202	15		97	28.4	-0.4	16.6	144.3
FS08205	19		99	24.7	-1.6	9.3	164.2
FS08207	13		94	27.9	-0.6	16.0	145.2
FS08209	16		95	32.0	0.9	15.0	159.0
FS08210	13		95	27.7	-1.4	9.8	145.2
FS08215	10		97	28.3	-0.2	13.8	154.7
FS08218	15		97	27.0	0.9	7.4	159.0
FS08220	8		96	29.9	0.0	9.5	134.8
FS08224	14		98	29.2	-0.2	10.5	156.4
FS08231	17		98	26.4	-0.2	6.9	165.0
FS08232	16		99	27.1	-0.8	10.0	129.6
FS08233	17		100	28.1	-0.7	9.5	129.6
FS08251	18		100	31.8	-1.6	9.7	159.0
FS08256	9		101	31.0	-1.9	14.5	141.7
FS08257	17		102	27.7	-2.3	15.0	127.9
FS08258	6		95	30.9	-1.2	14.1	129.6
FS08259	1		100	27.8	-1.0	9.4	171.1
chick-rearing Little Stints							
FS10037	1	4	95	24.8	0.3	3.1	227.2
FS10033	3	4	97	27.4	-1.3	2.5	193.2
FS10088	1	3	95	22.1	0.6	5.5	152.8
FS10089	1	4	102	31.2	0.8	13.1	140.5
FS10039	7	4	99	31.1	0.3	10.3	170.8
FS10047	6	4	101	27.1	0.6	10.5	151.6
FS10050	1	4	98	27.0	-3.2	9.6	134.2
FS10096	4	4	98	27.7	-1.0	12.0	142.1
KS06151	2	3	101	28.7	-2.5	10.4	201.6
KS06153	2	4	104	28.2	-4.0	11.0	140.2
KS06152	5	4	102	27.6	0.5	11.0	142.8
KS06246	5	2	102	30.7	-1.7	18.5	121.5

After 24 hrs the bird was recaptured and a second blood sample taken. The loss of the stable isotope in the past 24 hrs was later determined in the lab. The loss in ^2H gives a value for water turnover and the loss in ^{18}O is indicative of water turnover and CO_2 production. From these values it is possible to calculate energy expenditure.

Table 10.2. ANCOVA analysis of daily energy expenditure in relation to body mass, phase (incubation or chick-rearing) and operative temperature. F, P-values represent values when other variables are included ($R^2=41.5$).

	$F_{1,24}$	P	estimate	se
mass (average)	1.16	0.293	2.01	1.87
mean operative temp	13.96	0.001	-6.07	1.44
phase	4.83	0.038	-48.0	21.8
phase.mean operative temp	4.23	0.051	3.93	1.91

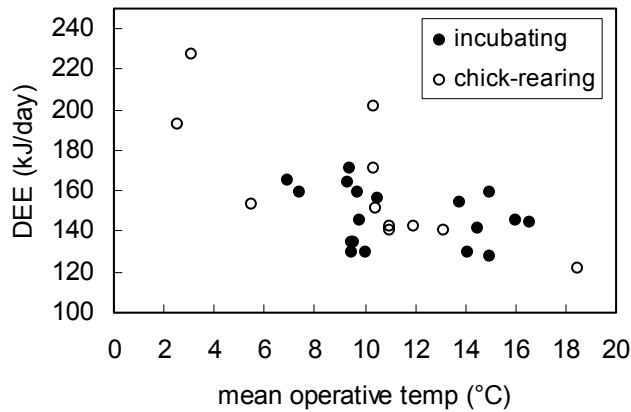


Figure 10.1. Daily energy expenditure in relation to mean operative temperature in incubating and chick-rearing Little Stints.

Energy expenditure was positively related to mean operative temperature (in the period of measurements, fig. 10.1, table 10.2). The mean values for DEE were very similar for both phases (mean incubation=158.0, se=3.4, mean chick-rearing=159.9, se=9.2). The temperature range in which points were collected was larger in incubating birds. In an ANCOVA analysing DEE in both phases simultaneously, the effect of body mass was not significant. Besides operative temperature also breeding phase was a significant predictor. The interaction term between phase and mean operative temperature was near-significant, pointing at a difference in slope for the relation between DEE and mean operative temperature between the two phases. The fact that incubating birds are sheltered from the wind when they sit on the deep lying nests may explain the smaller temperature effect in this phase. For both phases the mass change over the measurement period was unrelated to DEE.

10.2 Time budgets in the first eight days of brood rearing

As described in chapter 9, most Little Stint nests were predated. Fortunately, when the hatching of broods started it turned out that several nests had managed to survive the foxes. One Little Stint brood was very close to the camp and we used this brood to measure time budgets. We observed this family the first eight days of chick development for several hours, especially early in the morning and late in the evening, as these are the periods when the transition between mostly foraging to continuous brooding takes place. Notes were taken on duration of brooding and feeding bouts and activity of parent and chicks during feeding bouts. The idea was to arrive at age- and temperature- specific estimates of brooding time. Chicks were weighed every two days.

During a total of 17 observation hours chicks were brooded 37% of the time. Most of the remaining time was spent foraging by the chicks and less than 5% on other behaviours such as preening and alarm behaviour. Although the 24 hrs daylight period allowed continuous foraging, a period of constant brooding took place in the coldest part of the night, *i.e.* between 01.00 and 06.00. With increasing age chicks were brooded for a decreasing proportion of the time (fig. 10.2, table 10.3), therefore potential feeding time for the adult increased as a result. Operative temperature also

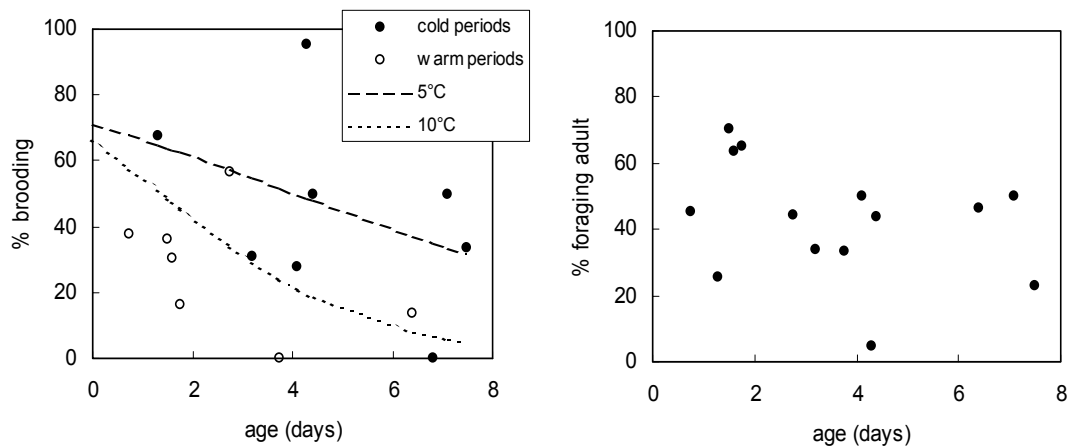


Figure 10.2. Modelled brooding times of Little Stint chicks (upper panel) and time spent foraging by chick-tending parents (lower panel) in relation to the age of the chicks.

had a negative effect on proportion of time that chicks were brooded. Wind speed had a small effect on brooding time, but the interaction term between operative temperature and age was significant, suggesting that the temperature effect varies depending on the chick's age. Results were similar if body mass was used instead of age. The proportion of time that the parent was observed actually foraging varied very little with age of the chicks and was on average 43% (fig. 10.2).

Table 10.3. Logistic regression analysis of the proportion of time that Little Stint chicks were brooded by the parent in relation to age, temperature, wind speed and time of day.

model	change in df	change in deviance	p	coefficient	se
constant				1.147	0.319
age (days)	1	12.06	<0.001	0.0419	0.0751
operative temp (°C)	1	164.63	<0.001	-0.0467	0.0282
wind speed	1	5.43	0.020		
if 'night'	1	1.18	0.277 ns		
age.operative temp	1	31.40	<0.001	-0.05309	0.00973
age.wind speed	1	0.16	0.691 ns		
operative temp.wind speed	1	0.04	0.850 ns		
age.night	1	0.07	0.796 ns		
residual	11	257.9			
total	14	466.0			

10.3 Energy budget

By combining the energy expenditure with the total available foraging time, it is possible to calculate the required intake rates in both phases. During incubation, the time the adult spent brooding was related to temperature and varied between 70 and 90% (Tulp *et al.* 1997). As a result on average 20% of the time is available for feeding. During incubation the adult bird spends on average 43% of the time foraging. When taking mass loss during the DEE measurement into account the resulting

metabolised energy (ME) was on average 148.8 kJ/day for incubating birds and 161.9 kJ/day for chick-rearing birds. These values do not take into account the variation in temperatures in which the values were obtained. If this is done, both values are even more similar due to the relatively cold points in incubating birds. The required intake rates calculated from ME and foraging time then becomes 9.3 J/s for incubating birds and 4.4 J/s for chick-rearing birds (table 10.4). Hence, during incubation Little Stints are more energetically stressed than during chick-rearing. For the same daily required energy they only have half the amount of foraging time and therefore they have to have an intake rate more than twice the intake rate required during chick-rearing. The very hasty impression that incubating Little Stints gave when they were off the nest to feed, as compared to the more leisurely way of feeding when they had chicks, already gave us this idea in the field. The actual measurements on how they manage to have such a high intake rate in this period is still lacking. A switch in diet from benthic larvae early in the season to surface-dwelling arthropod prey later, could be a possibility. Observation on intake rates in different periods in the breeding cycle could provide a clue to this question.

Table 10.4. Calculation of required intake rates based on measured energy expenditure and time budgets of Little Stints. Values for available foraging time are obtained from Tulp et al. 1997 for incubating birds and from observations in 2000 for chick-rearing birds. The observed value refers to time actually spent foraging by the adult. Maximum available foraging time represents all the time that is not spent brooding the chicks, i.e. potential foraging time. These two values are used to arrive at the 'observed' and 'minimum' required intake rates.

	incubation	chick-rearing
DEE (kJ/day)	148.0	159.9
ME (kJ/day)	148.8	161.9
available foraging time (hr/day)	4.4	10.3 (observed) 15.5 (maximum)
required intake rate (J/s)	9.3	4.4 (observed) 3.7 (minimum)

11 Arthropod abundance

11.1 Introduction and methods

Arthropods are the major food for arctic breeding shorebirds. Adult birds have an alternative food source in soil arthropods such as worms and larvae, but chicks rely entirely on surface-dwelling and flying arthropods.

Arthropod abundance was sampled for two different purposes. Therefore two different methods were applied. As part of a long term monitoring scheme, running since 1998, seven lines of ten 500 ml (\varnothing 11 cm) pitfalls each were placed in permanent positions. The aim of this scheme is to investigate differences in composition of arthropod communities between different habitats, between year fluctuations in numbers and coarse-scale seasonal patterns. This scheme was run by Dr. Mikhail Berezin and pitfalls were emptied once a week, between 10 June and 31 July

Two of the seven pitfall lines were used to analyse variations in arthropod abundance related to seasonal and weather-induced variation. These lines were situated close to camp and emptied daily at 24:00 between 10 June and 4 August. One line was situated on top of a hill close to the station in relatively dry, frost-heaved tundra. The other line was placed in a depression close to the camp, where snow melt was late, in a marshy area with sedges and grass. The samples were sorted to family level and the length of each individual was measured to the nearest 0.5 mm (arthropods < 5 mm) or 1 mm (> 5 mm). Dry mass of arthropods was calculated using the length-dry mass relationships given for different orders in Rogers *et al.* (1977) and Schekkerman (1997). Log-linear regressions were used to analyse effects of season and weather on numbers and biomass caught.

11.2 Results and discussion

Total numbers of arthropods increased very slowly from the second week of June to mid July (fig. 11.1). Only in the last two weeks of July numbers increased sharply. The same pattern was observed in total dry mass, although most peaks are less pronounced, caused by a relatively large proportion of small arthropods. On most days more arthropods were caught in the wet line than in the dry line (fig. 11.2). Numbers of insects caught are both influenced by weather and season (see also Maclean & Pitelka 1971). Part of the variation caused by weather is already incorporated in season. Therefore we chose to enter weather variables first in a model describing total number and dry mass (table 11.1). In the analysis of total numbers, mean air temperature and mean wind speed were significant predictors. The remaining deviance still showed a significant seasonal effect (fig. 11.3). Inclusion of both date and date² further improved the model significantly. In the model describing total mass, the occurrence of rain was also significant. This model results in a peak in arthropod abundance at 22 July, which is 16 days later than in 1996 (Tulp

et al 1997). Entering the variable in a different order with date and date² first, followed by weather variables, in general yields the same results (table 11.2, fig. 11.3). Different taxonomic groups showed a difference in timing of emergence. Araneae (spiders) and Coleoptera (beetles) were the first emerging groups (fig. 11.4). Nematocera (midges) appeared late June, while Brachycera and Cyclorrapha (flies) and Hymenoptera (wasps) were the last groups to emerge. Numbers of Araneae, Coleoptera and Nematocera all had declined again before the end of the study while Brachycera and Hymenoptera were still present in high numbers at that time. Clear differences in patterns between the wet and the dry series occur in Araneae, with much higher numbers in the wet series. Hymenoptera showed a clear peak in late July only in the dry series, while they were nearly absent in the wet series. In absolute numbers, Brachycera, Araneae and Nematocera were the most important groups. The difference in total numbers between 1996 and 2000 is mainly caused by a difference in numbers and timing of emergence of Diptera. Especially Brachycera and Cyclorrapha only emerged in large numbers after 20 July. The relatively cold month of June could have delayed the emergence. Since most Brachycera live on nectar from flowering plants, the emergence is most likely related to the timing of flowering plants. Tipulids only emerged in early July and were present until early August (fig. 11.4). Although numbers caught hardly ever exceeded ten individuals per ten traps per day, they were far more abundant in some of the other pitfall lines.

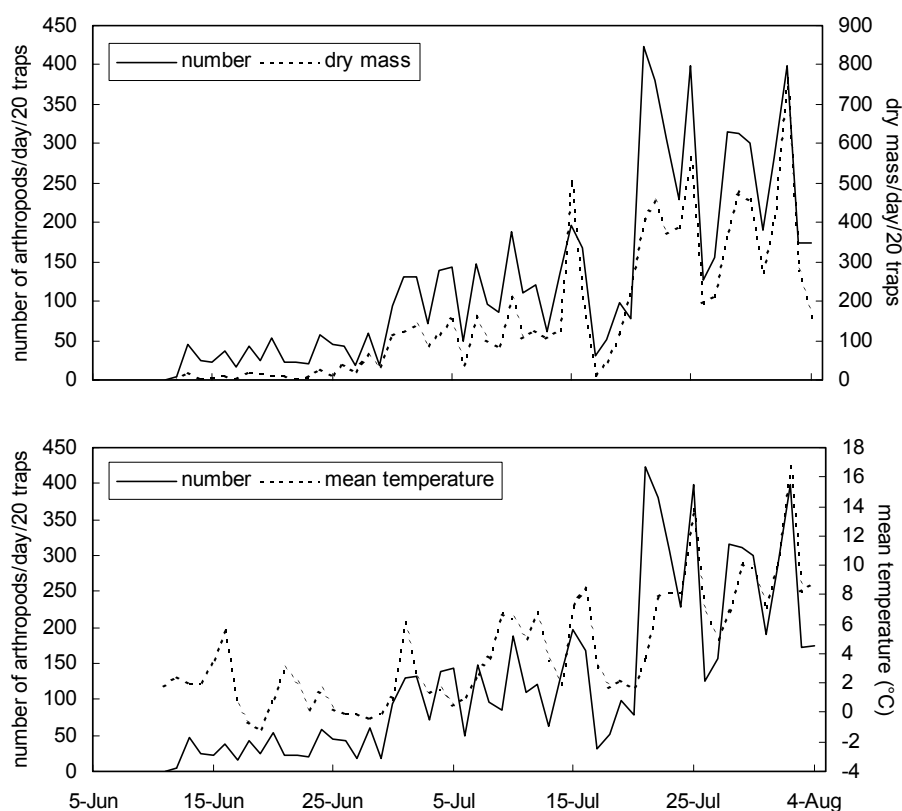


Figure 11.1. Seasonal pattern in total number and dry mass of arthropods (upper) and mean temperature and total number of arthropods (lower).

Table 11.1. Loglinear regression analysis of the total numbers and total dry mass of arthropods. The null model includes the constant only, the final model includes all variables shown. Significance of parameters was tested by dropping them one at a time from the maximum model, using the change in deviance. The variables tested included: day since 1 June (date and date², together describing a parabolic curve), mean air temperature (temp in °C), mean wind speed (wind in m/s) and the occurrence of precipitation (prec) was entered as a factor. Weather variables were included first, whereafter the seasonal pattern was included by entering date and date².

response variable	model	(change in deviance)	(change in df)	p	coefficient	se
number/ 20 pitfall traps/day	null model	5175	54			
	final model	4280	50			
	constant				2.4240	0.1340
	temp	+2839	+1	<0.001	0.0999	0.0043
	wind	+791	+1	<0.001	-0.1244	0.0066
	if prec			ns		
	date	+407	+1	<0.001	0.1104	0.0059
	date ²	+243	+1	<0.001	-0.0011	0.0000
total dry mass/ 20 pitfall traps/day	null model	8994	54			
	final model	7816	49			
	constant				1.6300	0.1440
	temp	+5641	+1	<0.001	0.1216	0.0038
	wind	+996	+1	<0.001	-0.1114	0.0060
	if prec	+72	+1	0.011	-0.0645	0.0254
	date	+672	+1	<0.001	0.1428	0.0060
	date ²	+436	+1	<0.001	-0.0013	0.0001

Table 11.2. Loglinear regression analysis of the total numbers and total dry mass of arthropods. The null model includes the constant only, the final model includes all variables shown. Significance of parameters was tested by dropping them one at a time from the maximum model, using the change in deviance. The variables tested included: day since 1 June (date and date², together describing a parabolic curve), mean air temperature (temp in °C), mean wind speed (wind in m/s) and the occurrence of precipitation (prec) was entered as a factor.

response variable	model	(change in deviance)	(change in df)	p	coefficient	se
number/ 20 pitfall traps/day	null model	5175	54			
	final model	4299	49			
	constant				2.2380	0.1410
	date	+3324	+1	<0.001	0.1138	0.0059
	date ²	+166	+1	<0.001	-0.0011	0.0000
	temp	+427	+1	<0.001	0.1048	0.0045
	wind	+363	+1	<0.001	-0.1179	0.0068
	if prec	+19	+1	<0.001	0.1218	0.0280
total dry mass/ 20 pitfall traps/day	null model	8994	54			
	final model	+7816	49			
	constant				1.6300	0.1440
	date	+6182	+1	<0.001	0.1428	0.0060
	date ²	+305	+1	<0.001	-0.0013	0.0001
	temp	+972	+1	<0.001	0.1216	0.0038
	wind	+351	+1	<0.001	-0.1114	0.0060
	if prec	+6	+1	0.011	-0.0645	0.0254

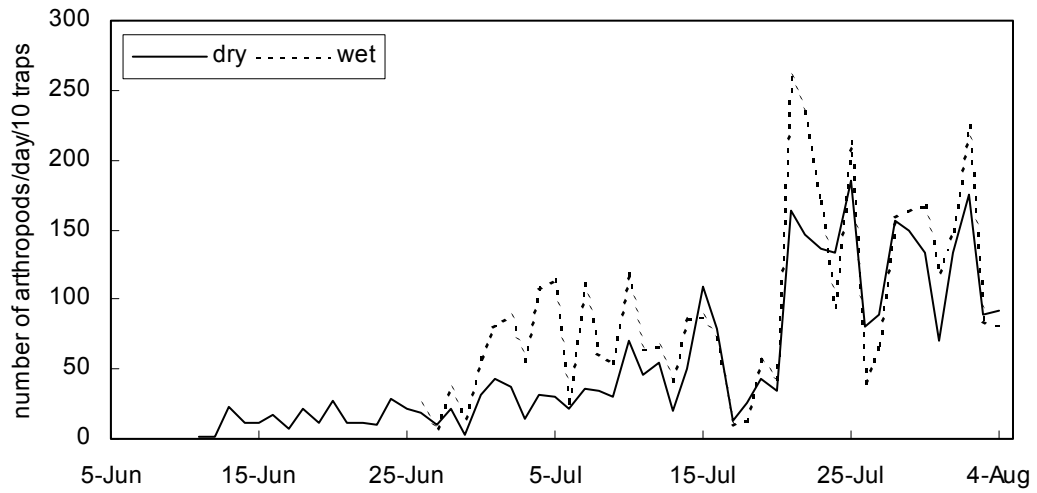


Figure 11.2. Seasonal pattern of arthropods for the dry and the wet series separately.

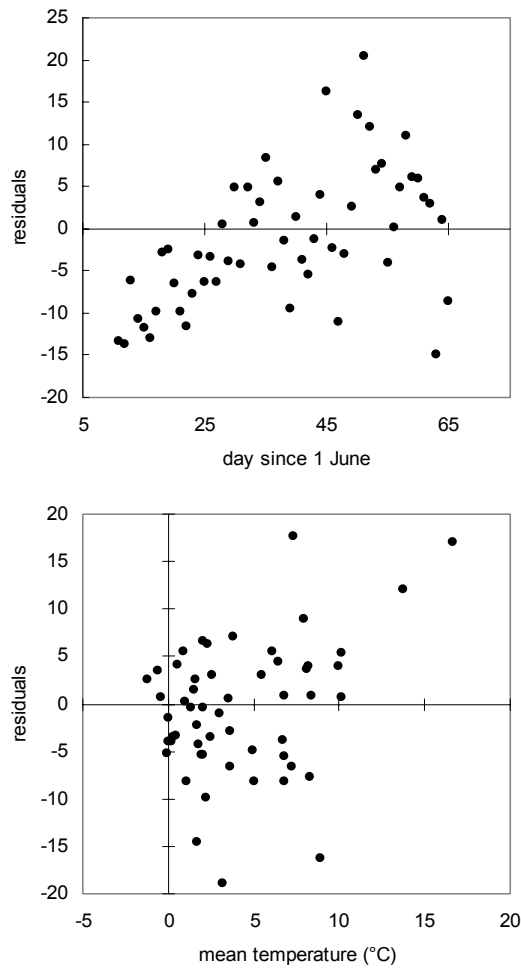


Figure 11.3. Residuals of the regression of dry mass with temperature and wind as explanatory variables in relation to date and residuals of the regression of dry mass with date and date² as explanatory variables in relation to mean temperature.

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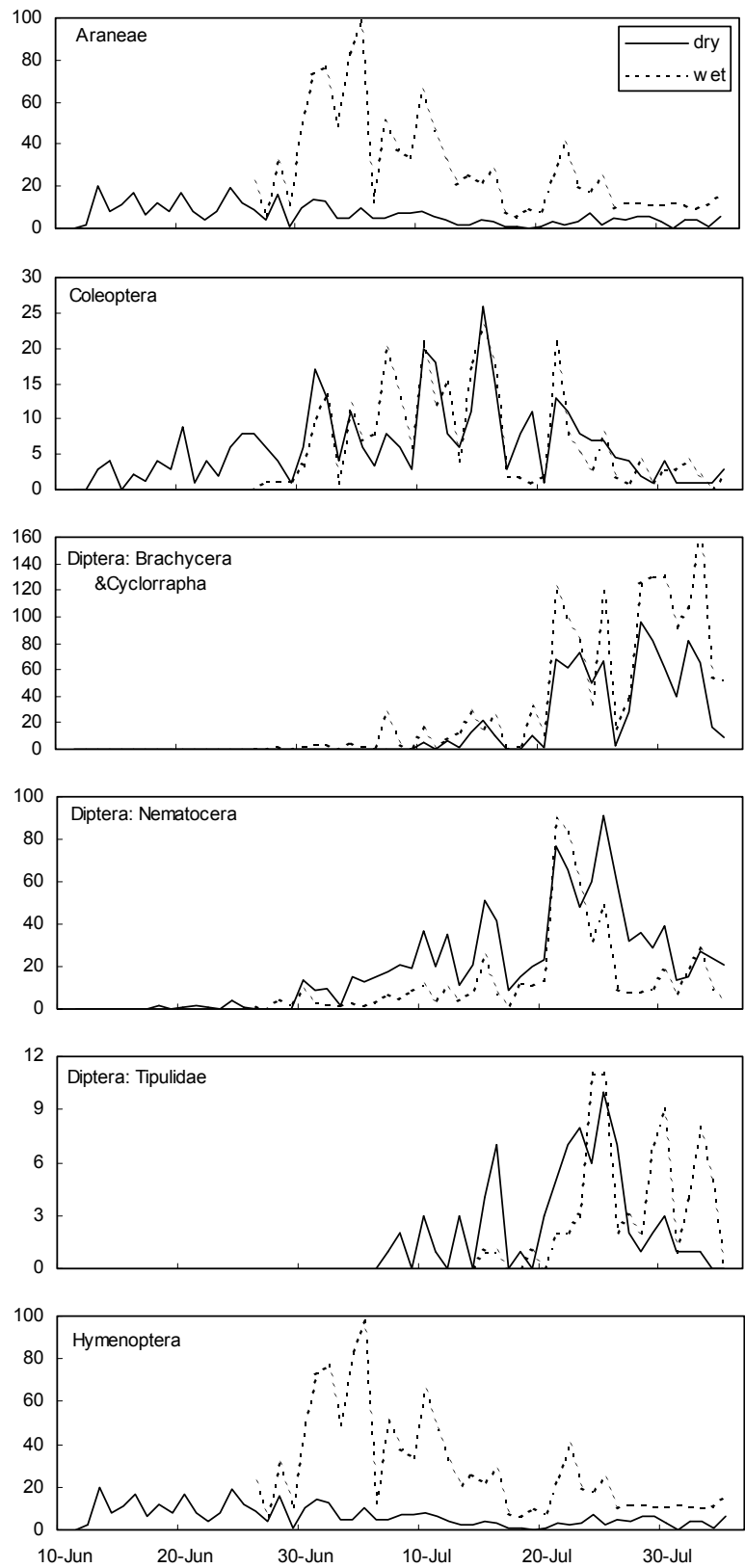


Figure 11.4. Seasonal pattern in numbers (per 10 traps per day) of several groups of arthropods.

12 Acknowledgements

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