Studies on breeding shorebirds at Medusa Bay, Taimyr, in summer 2001

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ABSTRACT

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In the summer of 2001 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 Agricultural Department of the Dutch Embassy in Moscow. The results obtained by the Alterra team are presented in this report. Subjects of study generally concerned breeding biology of arctic breeding shorebirds, especially aspects related to timing of breeding and adult body condition. This report's purpose is not to discuss the findings thoroughly but merely to summarise the research questions addressed and present all basic information collected during the 2001 season. Topics included are spring arrival and autumn departure of waders from the tundra, breeding phenology, nest success, biometrics of adult waders, chick growth rate, return rates of adult shorebirds, and seasonal and weather-related variation in arthropod availability. Where useful, results are compared with data collected in a previous expedition in 2000. More elaborate analyses and discussion of the data will be made elsewhere.

Keywords: arctic, arthropods, breeding, monitoring, predation, reproduction, Taimyr, waders

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1 Introduction

1.1 Organisation and participants

In the summer of 2001 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 participation of Ingrid Tulp was organised through cooperation with Bureau Waardenburg. The expedition was part of a three-year programme.

The findings of this expedition will be reported in several publications. Seperate reports will be prepared for the WIWO (breeding bird survey) and the Dutch Embassy (activities of Russian team). As a background document containing all basic information collected during the 2001 season, the results obtained by the Alterra and part of the results obtained by the WIWO team are 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 2000 and 2002 seasons.

Participants of the expedition were: Hans Schekkerman (researcher Alterra), Ingrid Tulp (volunteer researcher Alterra), Oscar Langevoord (WIWO), Leon Peters (WIWO), Sergei Kharitonov (senior research biologist, Bird Ringing Centre Moscow), Mikhail Berezin (entomologist, Moscow Zoo), Andrei Bublichenko (curator of mammalogy, Zoological Museum, St. Petersburg), Tatyana Kirikova (ornithologist, Azov-Black Sea Ornithological station, Ukraine), Tatyana Varlygina and Tatyana Pereladova (botanists, Moscow State University).

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

Shorebird breeding ecology	Ingrid Tulp, Hans Schekkerman, Oscar Langevoord, Leon Peters, Tatyana Kirikova
Monitoring of breeding birds	Leon Peters, Oscar Langevoord, Tatyana Kirikova, Sergei Kharitonov
Monitoring of lemming population	Andrei Bublichenko
Gull and goose breeding colonies, raptors	Sergei Kharitonov
Monitoring of arthropod abundance	Mikhail Berezin, Hans Schekkerman, Ingrid Tulp
Vegetation mapping	Tatyana Varlygina, Tatyana Pereladova

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. However only a small part of the results of the WIWO team will be presented here, a separate WIWO report will cover all topics.

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 WIWO 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, raising chicks and preparing for migration is hardly more than two months. At the same time food abundance shows a seasonal peak and strong weather dependence. 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-breeding 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 and an indirect approach studying the different selective pressures acting on the timing of breeding. For the direct 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.

These questions can be studied by catching birds upon arrival in the study area to determine arrival date and condition, mark these birds and follow them throughout the season to determine reproductive success. The prerequisites therefore are: 1) a successful catching technique, 2) birds that are caught and marked should also stay in the area to breed and 3) overall breeding success should be at some sort of minimum.

The catching technique we use, a modified version of the wilsternet (a clap net used for catching Golden Plovers in The Netherlands, Jukema *et al*., 2001) is successful in catching migrating waders in stopover and wintering areas but was hitherto never applied in the arctic breeding areas. In 2000 we had the first experience in our study site but were not very successful in catching waders. Furthermore in a year with a high predation rate as in 2000, there is hardly any scope for condition- or arrival date-related effects on reproductive output. The expectations for 2001 were also not very favourable in this respect. 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) was also applied. This approach involved the following parts:

3. Study timing or arrival, and timing of nest start in Dunlins *Calidris alpina* that were colour marked in 2000.
4. Increase the individually colour-marked population of a shorebird species with breeding site fidelity (Dunlin, Pacific Golden Plover *Pluvialis fulva*), for study in the following years.
5. Study seasonal and habitat-related variation in the abundance of invertebrates as food for breeding shorebirds.
6. Measure the timing of breeding of all waders species.
7. Study nest attendance in Little Stints *Calidris minuta* and Curlew Sandpipers *Calidris ferruginea* and possibly other uniparental breeders to investigate trade-offs in time allocation between incubation and feeding in the incubation period in relation to weather conditions.
8. Measure time-budgets of chick-rearing Little Stints.
9. Measure energy expenditure of incubating and chick-rearing Dunlins as a comparison to similar studies in Little Stints, that were carried out in previous years. In combination with time budget data these studies enable investigations of the differences in trade-offs between uniparental and biparental species. Timing of breeding of these species in relation to food

abundance and energy expenditure in the different periods then allows identification of the energetically most stressful period.

In addition to questions related to the effect of arrival time and condition on reproduction, we are also interested in the strategies that shorebirds use during the early part of their autumn migration. Especially whether or not they fuel up before departure (intending to make long continuous flights) or make successive short flights is still an unexplored field of study. Therefore we applied the same catching technique with clap nets in autumn to study:

10. Variation in condition parameters of shorebirds upon departure from the arctic breeding grounds in late summer.

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 within fixed study plots. To enable explanation of trends in numbers also several other biotic and abiotic factors are studied. This monitoring program was evaluated in 1999 and the final program was first carried out in 2000.

The program consists of the monitoring of:
a. Migration and arrival of all bird species using transect counts and counts of visible migration from a fixed observation point.
b. Numbers of breeding birds, using territory mapping and nest searching.
c. Nest success of breeding shorebirds
d. Lemming density
e. Arthropod availability
f. Phenology of plant flowering

The full report of the monitoring program will be published in a WIWO report, and here only data on migrating birds (a) will be presented.

1.3 Results achieved

The catching method, which was first applied in 2000 and not very successful then, was further improved and fine-tuned. Although we were quite successful in catching shorebirds (90 in spring and 300 in autumn) only two of the birds caught in spring stayed in the study area to breed. Therefore, relationships between arrival date and condition and reproductive parameters could not be measured directly.

The season 2001 was expected to be a year in which lemming population would be building up, after the lemming low of 2000. However, there were no lemmings present and although numbers of Arctic Foxes *Alopex lagopus* were not high, predation pressure on wader nests was strong. One fox was seen a few times in the area and skuas also predated a large number of nests. Nevertheless predation pressure was lower than in 2000, and it declined towards the end of the season.

The indirect approach on the other hand yielded very useful results. Arriving birds were caught and apart from standard biometrical data two additional condition parameters were measured: levels of haemoglobin in the blood and total body water (as a measure of body composition). A large proportion of Dunlins colour-marked in 2000 was resighted and arrival dates could be determined. Roughly the start date of the majority of all nests found could be determined. At active nests adults were caught, measured and colour-marked (a selection of species). Regular checks of nests allowed the estimation of nest survival. Chicks in nests were ringed and retrapped to measure growth in relation to weather variables. Energy expenditure was measured in incubating and chick-rearing Dunlins. Data on time-budgets was collected in a large number of nests of uniparental breeders such as Little Stint, Curlew Sandpiper, Pectoral Sandpiper, Ruff *Philomachus pugnax* and Red Phalarope. Abundance of surface-active invertebrates was measured daily. During autumn migration a large sample of actively migrating waders was caught.

1.4 Data analysis

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

1.5 Itinerary

The Dutch part of the expedition departed from Amsterdam on 1 June. Together with the Russian party consisting of Sergei Kharitonov, Andrej Bublichenko and Tatyana Kirikova, we left for Norilsk on 2 June. After a visit to the office of the Great Arctic Reserve in Dudinka to receive the proper documents and permission to enter the reserve, the journey was continued to Dikson. Logistics were all organised by our Russian colleagues. On 5 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 three members of the expedition, Mikhail Berezin, Tatyana Varlygina and Tatyana Pereladova also arrived in Medusa Bay. Most of the Russian researchers and Oscar Langevoord left the station by the end of July, only the Dutch team and Tatyana Kirikova stayed until 10 August. On 13 august we flew back to Norilsk and the same day to Moscow, and we arrived in the Netherlands on 16 August.

Aerial photograph of the study area. Medusa Bay is the round bay in the middle .

2 Study area

The study area is situated 18 km south of Dikson in the west of the Taimyr peninsula at 73°20'N, 80°32'E (fig. 2.1). At the north-eastern end of the river Yenissei, near the mouth, Medusa Bay, measuring 1.2 km in diameter, is situated (fig. 2.2). Northeast of Medusa Bay, on a small peninsula (the Mushroom) 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 up to 15 people. The study area in the monitoring program consists of three parts: an intensive plot measuring 4 km^2 (fig. 2.3) used for monitoring of shorebirds and passerines, a larger area measuring 12 km^2 used for the larger, more widely spread shorebird species. Snowy Owls *Nyctea scandiaca* , Rough-legged Buzzards *Buteo lagopus* and Brent Geese *Branta bernicla* were censused in the largest area of 30 km^2 (fig. 2.3). Shorebird breeding biology studies were undertaken mainly in the 4 km^2 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.

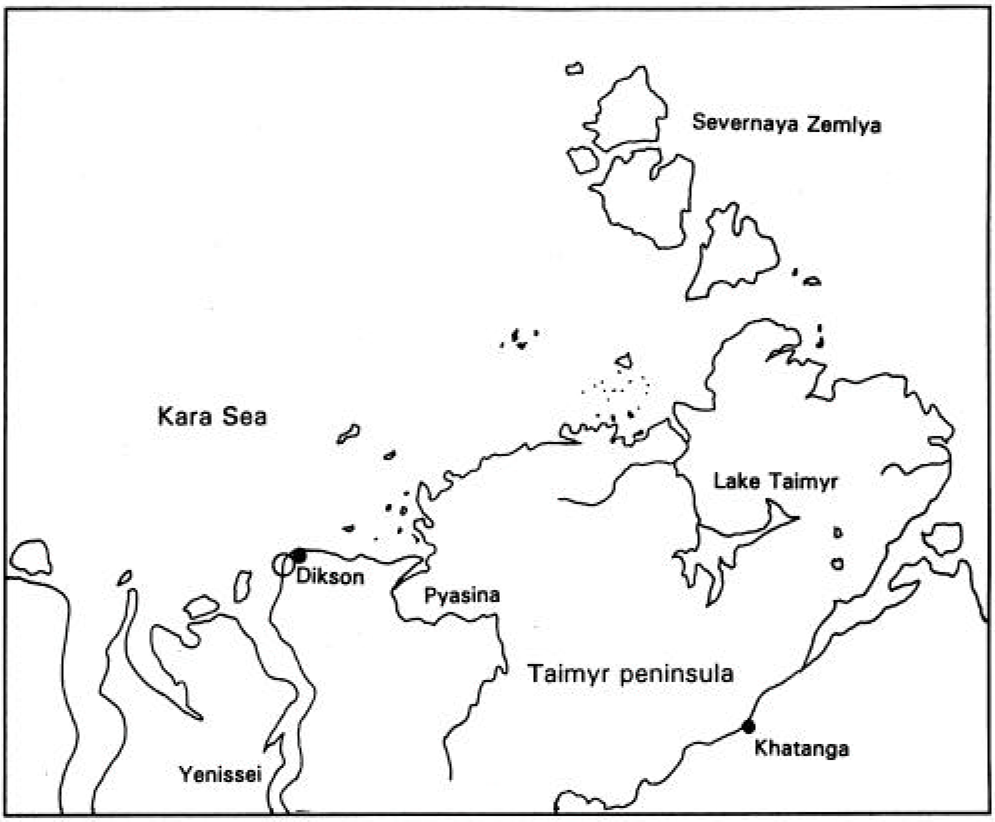


Figure 2.1. Location of the study area (circle near Dikson) on the Taimyr Peninsula.

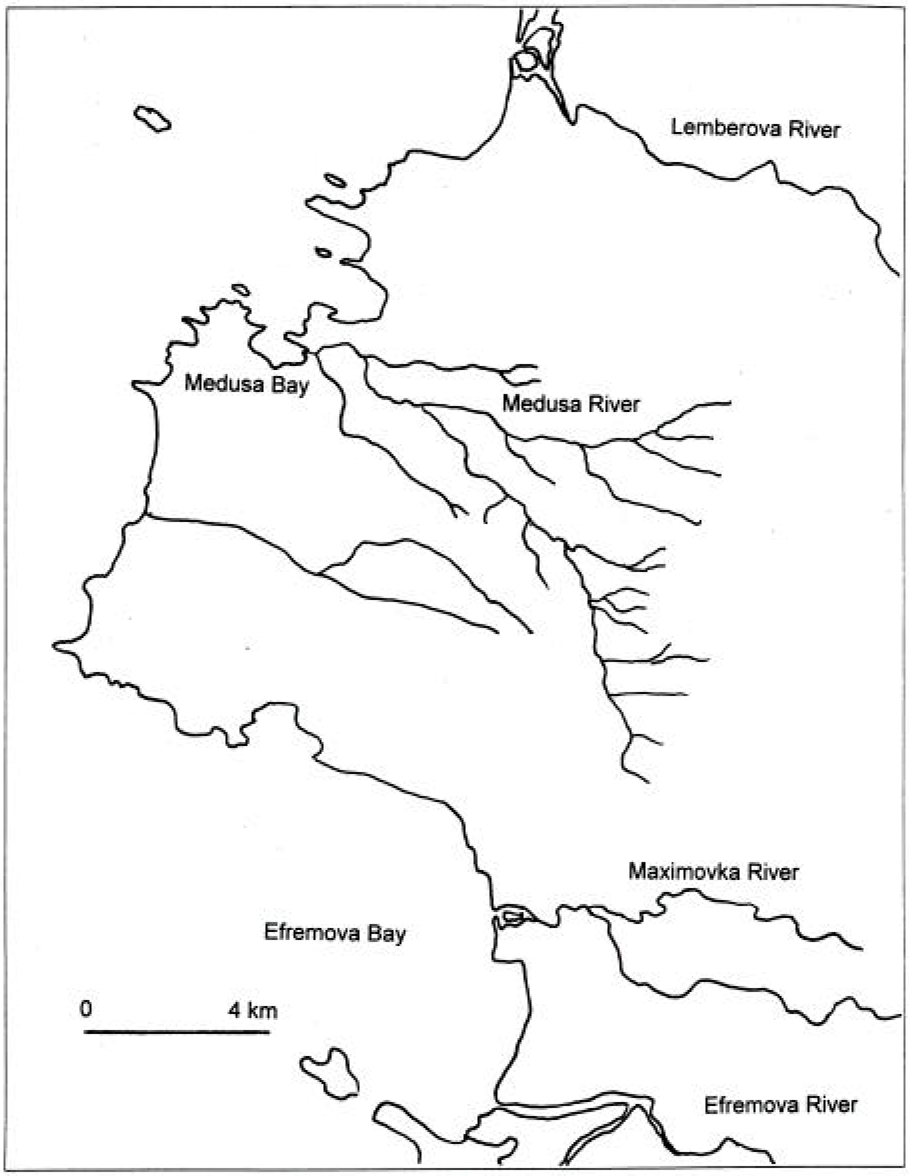


Figure 2.2 Location of Medusa Bay and the Efremova, Maximovka and Lemberova rivers.

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 hill in the intensively studied area measures 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 is adjacent to the mouth of the Yenissei river, the lowest point in the area is as high as sea level. No lakes or small ponds are present. To the east of the study area the relief becomes more distinct, with hilltops reaching as high as 160 m a.s.l. Big rocks formations are present throughout the area and rocky outcrops are often found on steep slopes. Gravel occurs along rivers, at river mouths and on beaches.

The vegetation consists of lichens, mosses, sedges, grasses, Dwarf Willows *Salix polaris*, 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 hilltops, Cotton Grass *Eriophorum* sp. and extensive stands of sedges *Carex* sp. are 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 (*vezdekhods*) 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, *vezdekhods* are used throughout summer now and leave tracks that remain several decades. The number of *vezdekhod* 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 rapid change in environment is not desirable.

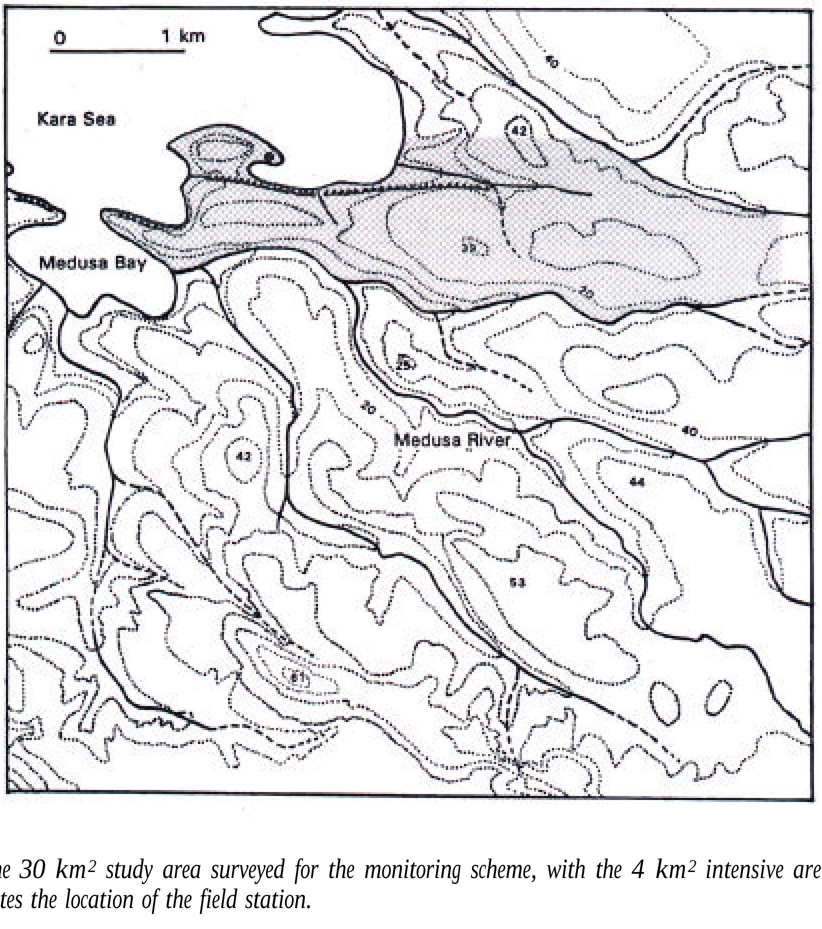


Figure 2.3 The 30 km² study area surveyed for the monitoring scheme, with the 4 km² intensive area (shaded). The dot indicates the location of the field station.

3 Weather and season

Weather data were collected in the camp. A small weather station consisting of three temperature probes and devices measuring, rain, air pressure, wind speed and direction with wireless connections to the central receiver was installed in the station. Additionally air temperature and black sphere temperature (operative temperature, incorporating air temperature and global solar radiation W/m^2) were measured every 15 minutes using TinyTag data loggers, mounted in the shade near the station at 1 m height (air temperature) and in an unshaded place in the tundra near the station (black sphere). To enable comparison with the previous year the data collected using the data loggers are presented here, complemented with precipitation and wind data from the weather station.

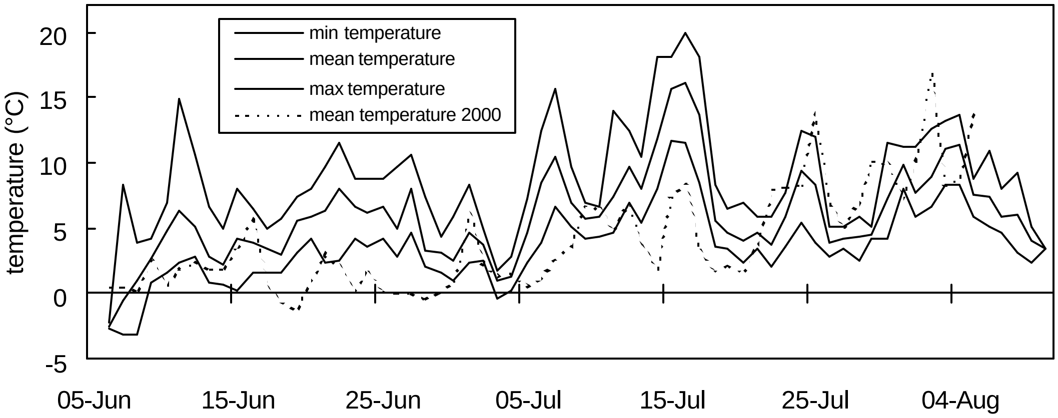


Figure 3.1. Daily mean, minimum and maximum temperatures in the camp in the field period. For comparison also the mean temperature in 2000 is presented.

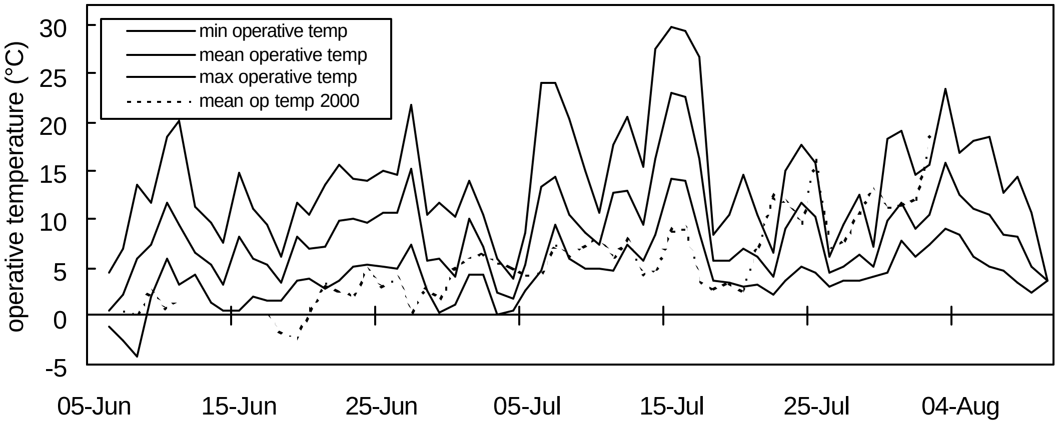


Figure 3.2. Minimum, mean and maximum operative temperature (black sphere) in the camp in 2001 and mean operative temperature in 2000.

Upon arrival a large part (>90%) of the study area was still covered in snow. Also the snow layer was much thicker than in early June 2000. Because June was much warmer than normal, snow melted rapidly and reached 25% cover on 11 June and 10% on 16 June. Medusa river started flowing on 11 June, almost the same date as in 2000 (12 June), and 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.).

June was warm (fig 3.1) with a mean temperature of 4°C (in 2000: 1.2°C) and maximum temperature up to 15°C. Most of the days were sunny with constant, often strong, winds from the northeast (fig. 3.4, 3.5). On two days it rained for long periods. Snowfall was recorded only on one day in June. The first half of July was also warm, where after temperatures dropped. Rain was recorded on many days and especially the last week of July and the first days of August were very wet (fig. 3.3). Compared to 2000 the season was much wetter in general. The total precipitation was 7 mm in 2000 and 59 mm in 2001. In July wind directions generally varied between northwest and northeast (fig. 3.5) in general.

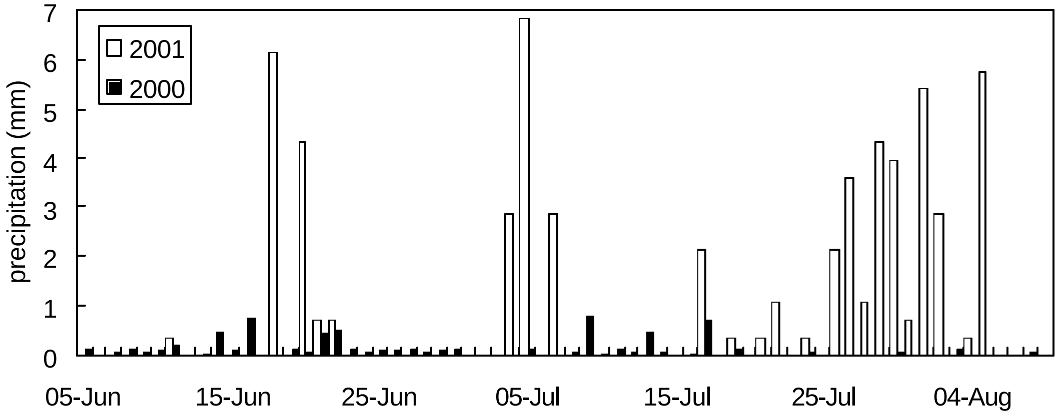


Figure 3.3 Daily precipitation in the camp in 2000 and 2001

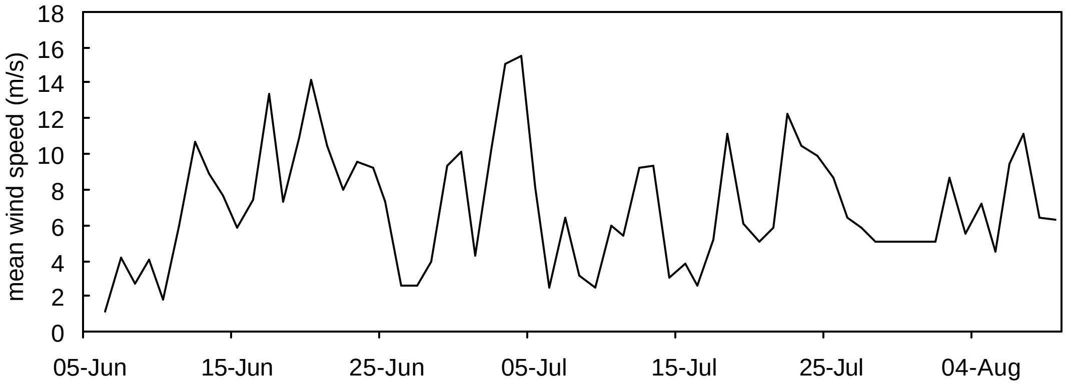
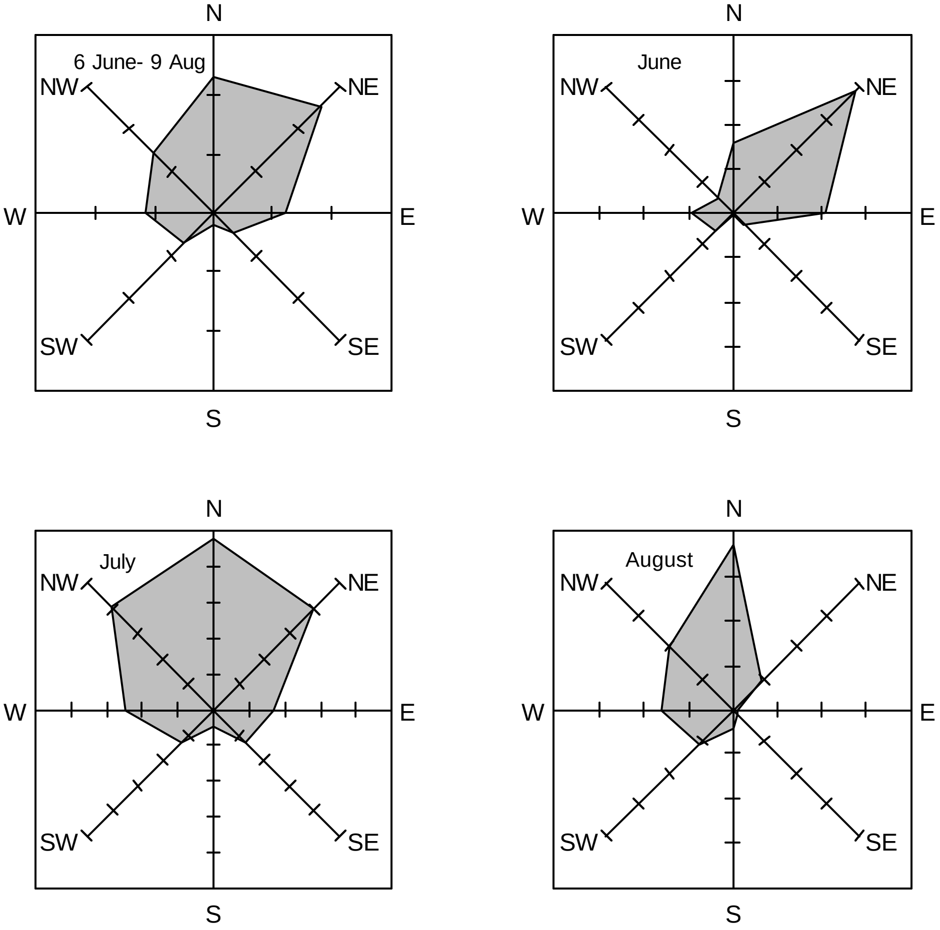


Figure 3.4. Daily mean wind speed in 2001


6 June- 9 Aug

June

July

August

Figure 3.5. Frequency of wind directions in the entire study period (upper left), and in June (upper right), July (lower left) and August (lower right).

4 Lemmings, predators and geese

2001 was expected to be an intermediate year in the lemming cycle. Numbers of lemmings were expected to be building up again after the crash in 2000. However during the whole season only two Siberian lemmings *Lemmus sibericus* were seen. In the standardized trapping scheme operated by Andrei Bublichenko (with walk-in traps that are emptied every three hours during a 24 hr period) not a single lemming was trapped. Local people explained the lack of lemmings by the weather situation in late autumn of 2000. Heavy rains causing floods in the area in late September 2000 were followed by a transition to –30°C, rapidly changing the tundra surface in a solid block of ice. Erosion of tundra surface showed up in the form of mud slides.

The first White-fronted Geese *Anser albifrons* arrived on 8 June, Brent Geese arrived on 9 June and mass migration of Brent Geese took place on 15 June. On 6 July massive moult migration of White-fronted Geese towards the northeast started. It took several weeks before it became clear that at least one Arctic Fox was active in the area. Although we noticed that nests disappeared, initially Long-tailed Skuas *Stercorarius longicaudus* and Pomarine Skuas *S. pomarinus* were thought to be the predators. Unlike in 2000, when several foxes were active at the same time and predated nests were often scent-marked with urine or droppings, this year we hardly ever found marked nests. The first daytime sighting of an Arctic Fox within the 4km^2 plot only took place on 15 June. From data of predated nests that contained temperature-loggers, it was obvious that most predation took place during the night, which also points at foxes as the most likely predators. In contrast to 2000 not a single Stoat *Mustela erminea* was observed.

Arrival of Brent Geese

One pair of Long-tailed Skua started a nest within the 4 km^2 area and two more in the 12 km^2 area, of which only one was not predated. Pomarine Skuas did not breed and also did not establish territories. They were hardly seen in the tundra after 1 July. Snowy Owls, both males and females, were regularly seen in the area, and preyed upon wader nests on several occasions (a feather was found near a predated nest). As is usual in a year with low lemming numbers (Underhill *et al.*, 1993), Snowy Owls did not attempt breeding. Within the 30 km^2 plot one pair Rough-legged Buzzards started a nest, which was later deserted. Outside the 30km^2 plot (in roughly 130 km^2) four more nests were found, of which three were deserted and only one hatched successfully. It is not known whether these chicks fledged eventually.

Two dispersed nests of geese were found within the 30 km^2 plot: one Brent Goose and one White-fronted Goose; both were predated by a fox. Geese were also found breeding on nearby islands, as was one Red-breasted Goose *Branta ruficollis*, but probably only few of these nests hatched (not confirmed); several were either predated or destroyed by people. Taimyr Gulls *Larus taimyrensis*, Glaucous Gulls *Larus hyperboreus* and Arctic Terns also bred on the islands. At the nearby rivers Efremova, Maximovka and Lemberova, Red-breasted Geese bred successfully near nesting Peregrine Falcons *Falco peregrinus.*

On 15 July a herd of at least 1000 Reindeer *Rangifer tarandus* passed through the area. Such large herds normally do not cross this area, but were probably pushed northwards because of prolonged warm weather and southerly winds that also blew mosquitoes northward (Chernov, 1985). Afterwards several wader nests were found predated by Reindeer or deserted, even with hatching eggs or newly born chicks.

Daily migration count

5 Migration

5.1 Counts of visually observed migrating birds

5.1.1 Methods

Every morning (usually between 9.00 and 10.00) visual migration was recorded during one hour from an elevated point near the station where birds flying over the mouth of the Yenissei or following the coastline could be observed. Species, direction and number were recorded as well as observation conditions. These counts were performed on every day of the field period (total 59 hrs). Both binoculars and telescopes were used for observation and counts were mostly performed by one person, sometimes by two or three. In addition during all clap net sessions, all observations of migrating birds were recorded (total 172 hrs). Data from both types of counts were averaged to number of birds seen per hour for each day.

5.1.2 Wader species

From the very first day onwards waders were migrating. Species passing early were Curlew Sandpiper, Grey Plover, Turnstone *Arenaria interpres*, Sanderling *Calidris alba* and Red Knot *Calidris canutus* (fig. 5.1, and 5.2 and for a zoom-in on the spring migration fig. 5.3). The phalaropes (*Phalaropus lobatus* and *Phalaropus fulicarius*), Pectoral Sandpipers (*Calidris melanotus*) and Little Stints passed through later. Dunlin and Ruff were hardly seen during spring migration (fig. 5.2). On autumn migration both these species passed through much more visibly. Adult male Dunlins were observed until early August, when also groups of juveniles were passing through. In Curlew Sandpipers a peak consisting of males leaving the tundra is visible late June-early July, while the females only leave late July and juveniles pass through early August. Little Stints were the most abundant birds during autumn migration. Juvenile Pectoral Sandpipers often flew together with Dunlins and Ruffs. Dotterels *Charadrius morinellus*, Grey Plovers *Pluvialis squatarola* and Red Knots were almost exclusively seen during spring migration. Pacific Golden Plover, a common breeding bird in the area was rarely seen migrating (table 5.1).

Numbers seen during both types of counts show generally the same patterns. For most species the peaks in migration are timed synchronously in the two types of counts. The peak amplitude is for some species more pronounced in the counts near the clap net than in the standardised counts , e.g. Turnstone, Dunlin, species that are very responsive to the sounds.The most numerous wader seen was Little Stint. Especially during autumn migration large flocks of juveniles passed through the area (table 5.1). Also Curlew Sandpiper, Ruff and Dunlin were regularly seen. Species passing through but not breeding in the study area were: Red-necked Phalarope *Phalaropus lobatus*, Sanderling, Grey Plover, Bar-tailed Godwit *Limosa lapponica*, Red-necked Stint *Calidris ruficollis*, Eurasian Golden Plover *Pluvialis apricaria* and Purple Sandpiper *Calidris maritima*. Pectoral Sandpipers were never seen in such large numbers in the seven years that observers have visited the area.

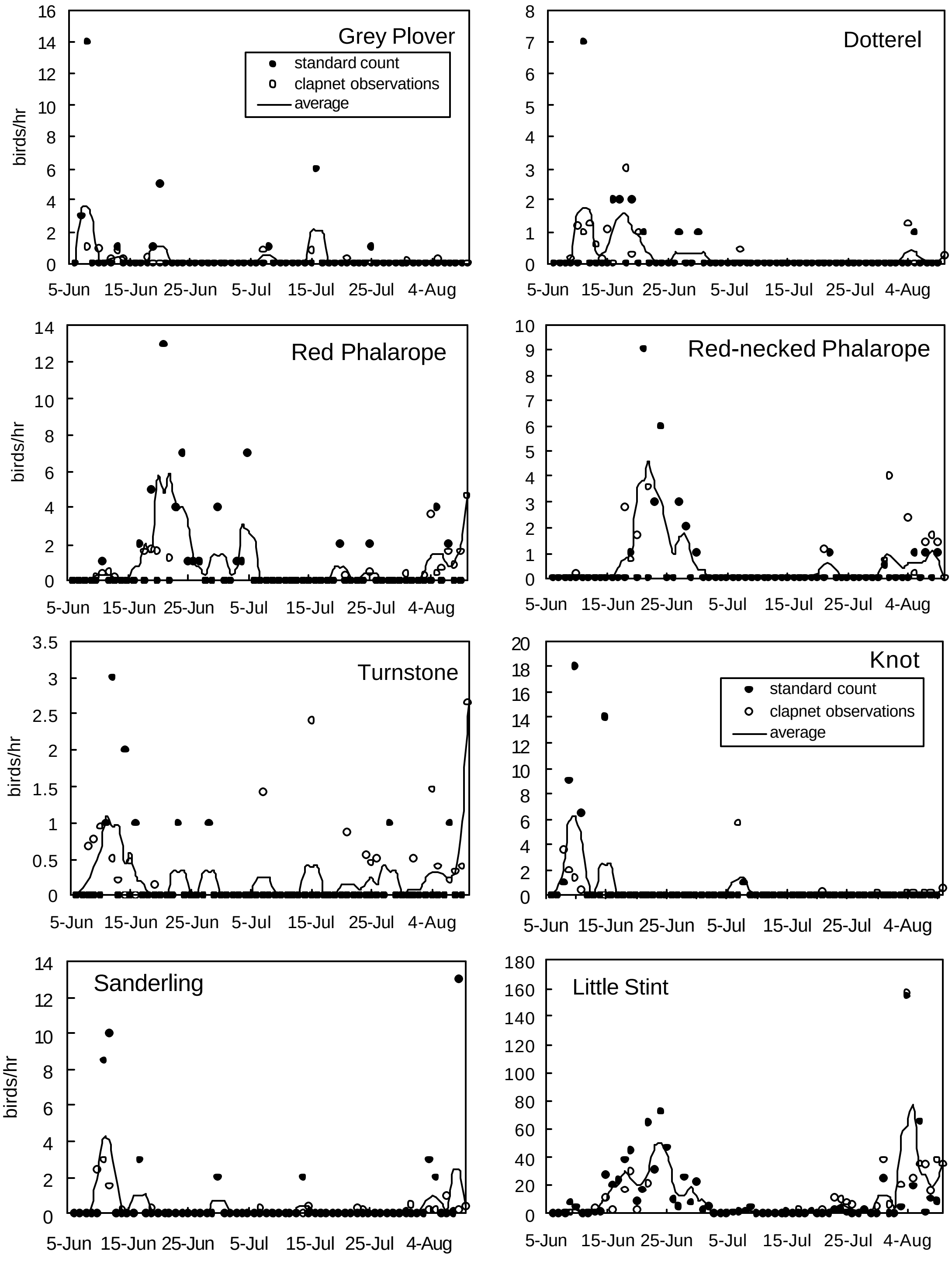


Figure 5.1. Timing of migration of several shorebird species as recorded by the standardised counts and the counts made during catching. The line is a three-day running average through the combined data of both methods. Sums of birds flying in all directions are given; in June most flights were between N and NE; in July and August between SE and W.

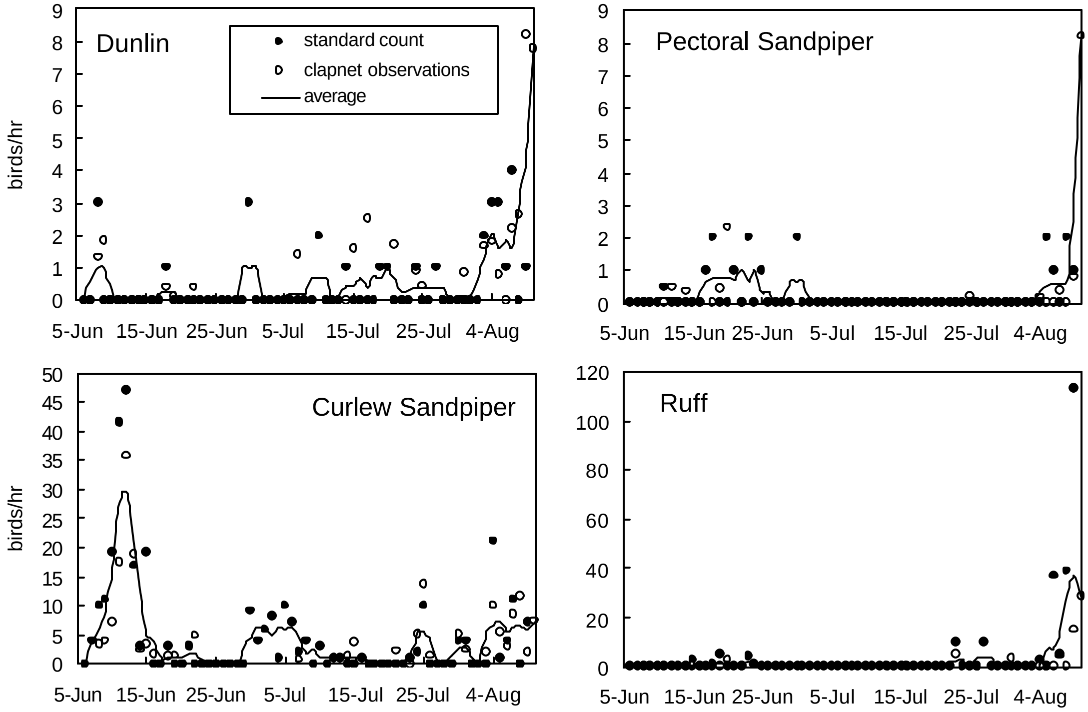


Figure 5.2. Timing of migration of several shorebird species as recorded by the standardised counts and the counts made during catching. The line is a three-day running average through the combined data of both methods. Sums of birds flying in all directions are given; in June most flights were between N and NE; in July and August between SE and W.

Table 5.1. Total numbers of shorebirds observed during standard migration observations and observations during catching at the clap net.

	migration watch total 59 hr	at clap net total 172 hr	total 231 hr
Little Stint	820	2919	3739
Curlew Sandpiper	349	960	1309
Ruff	231	290	521
Dunlin	28	198	226
Red Phalarope	59	109	168
Red Knot	30	89	119
Sanderling	52	66	118
Turnstone	12	84	96
Dotterel	24	64	88
Pectoral Sandpiper	16	60	77
Grey Plover	32	36	68
Ringed Plover	9	14	23
Pacific Golden Plover	1	17	18
Temminck's Stint	1	6	7
Eurasian Golden Plover	0	3	3
Purple Sandpiper	0	2	2
Red-necked Stint	0	1	1

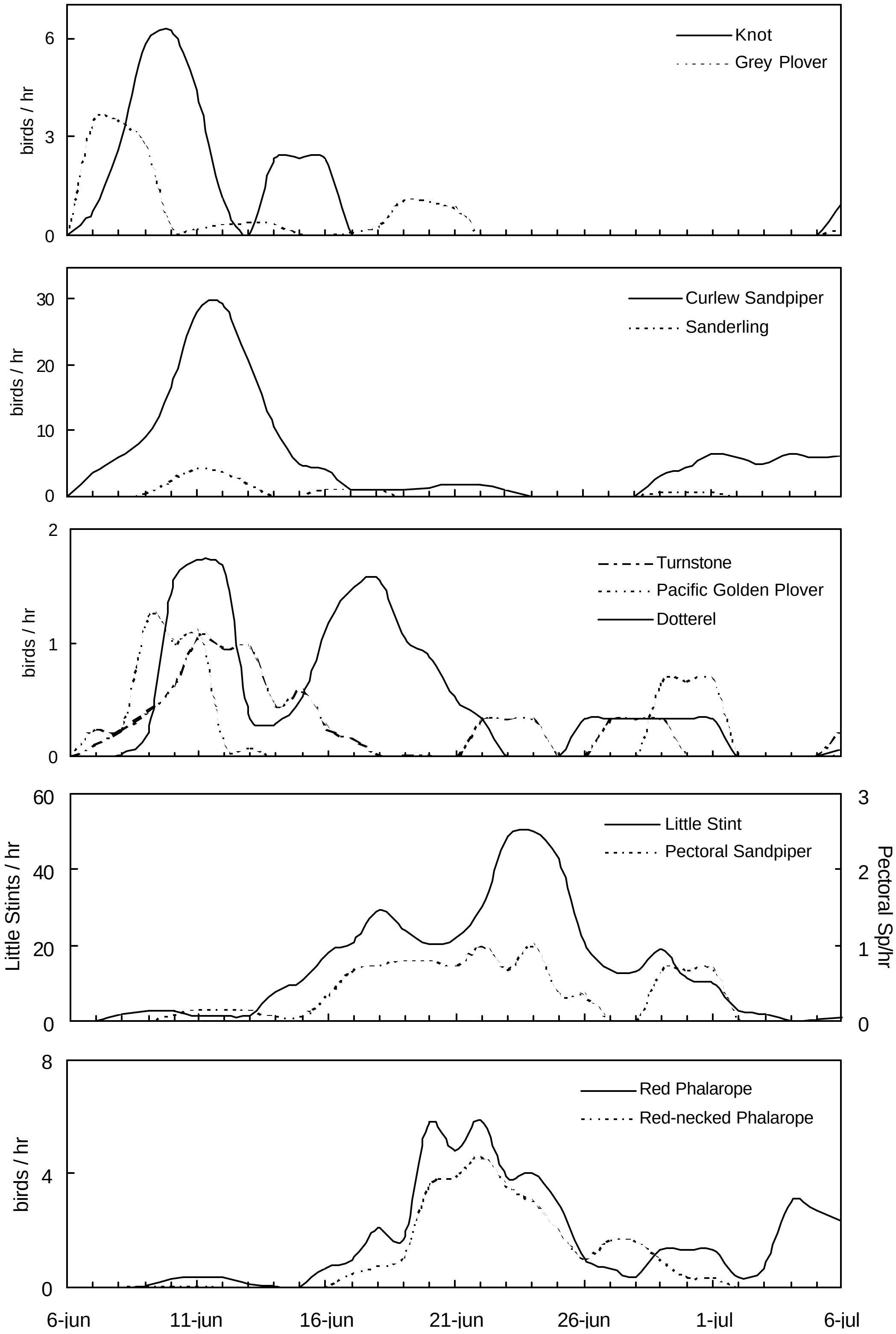


Figure 5.4. Timing of spring migration in several shorebird species. The lines are three day running averages of the combined data from both standard counts and observations during clap-netting.

6 Shorebird breeding parameters

In this chapter an overview of different breeding parameters of shorebirds will be presented. Nest distribution and numbers and breeding success will be given here. For shorebirds egg float curves are presented based on combined data of 2000 and 2001 and these are used to reconstruct the breeding phenology. In Appendix 2 data on egg size and start of incubation for each nest are presented. 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.

6.1 Nests

Nests were searched for making use of nest-indicative behaviour. Depending on the species, the incubating bird alarms (Turnstone, Dunlin, Ringed Plover *Charadrius hiaticula*, Pacific Golden Plover), walks or flies off the nest at a large distance (Pacific Golden Plover, Curlew Sandpiper, Ringed Plover) or flushes off when it is approached (Little Stint, Temminck's Stint *Calidris Temminckii*, Dunlin). The nest positions were recorded with a hand-held Global Positioning System (GPS) with an accuracy 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 generally not marked, only the coordinates were registered. Of each nest found, eggs were measured and floated to determine incubation stage. Nests were checked at regular intervals, but mostly longer than three days, to reduce the risk of predation. 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 eggshell fragments were found in the nest cup, otherwise considered predated. Every empty nest was checked for scent-marks or droppings.

Table 6.1. 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	predated	deserted	hatched	unknown	total nests	total families	total nests +families	outside 4 km²
Pacific Golden Plover	19	0	6	1	26	0	26	8
Ringed Plover	1	0	2	0	3	0	3	1
Dotterel	2	0	0	0	2	0	2	0
Turnstone	6	0	1	0	7	1	8	6
Red Phalarope	0	1	3	0	4	0	4	2
Red Knot	1	0	0	0	1	0	1	1
Little Stint	49	10	14	4	97	33	130	29 (+7 fam)
Temminck's Stint	0	0	2	0	2	0	2	0
Pectoral Sandpiper	5	1	6	0	12	0	12	5
Dunlin	15	1	9	0	25	11	36	6
Curlew Sandpiper	13	0	6	0	19	4	23	4
Ruff	2	0	0	0	2	0	2	1

Little stints were by far the most numerous species (table 6.1). Other common shorebird species include Pacific Golden Plover, Curlew Sandpiper and Dunlin. For the first time since the seven years that the area is regularly visited Pectoral Sandpipers were found nesting. With 12 nests found it was not a rare breeder either. Ruff, Knot and Red Phalaropes have been recorded as breeding species before but are no regular breeders in the area (Khomenko *et al.*, 1999, Tulp *et al.*, 1997, 2000, van Turnhout *et al.* pers. comm.). Despite large numbers of Dotterels passing through on spring migration (chapter 5) only two mails bred in the area.

Nests of passerines and Ptarmigan (table 6.2) were not actively searched for, but whenever a nest was encountered it was registered and it's fate was recorded. Only one pair of both White-fronted Geese and Brent Geese bred inside the area (see also chapter 5). Within the 4 km^2 intensive area only one nest of Long-tailed Skua was found, which was predated shortly after it was found.

Table 6.2. Numbers of nests of geese, passerines and other birds found, predated, hatched and deserted. The majority of the total number of nests were found inside the 4km^2 plot. For passerines only the period until hatching of the eggs, not the chick period is included in this calculation.

Species	predated	deserted	hatched	unknown	total nests	total families	total nests +families	outside 4 km^2
geese								
White-fronted Goose	1	0	0	0	1	0	1	0
Brent Goose	1	0	0	0	1	0	1	1
passerines								
Red-throated Pipit	0	0	6	0	6	0	6	1
Lapland Buntng	1	0	8	6	15	0	15	1
Snow Bunting	0	0	6	3	9	0	9	1
Shorelark	3	0	4	7	14	0	14	1
Pied Wagtail	0	0	1	0	1	0	1	0
Wheatear	0	0	1	0	1	0	1	0
other								
Long-tailed Skua	2	0	1	0	3	0	3	2
Ptarmigan	0	0	3	1	4	0	4	0

6.2 Float curves and estimation of nest start dates

The developmental stage of eggs was determined by floating them in water. An undeveloped egg sinks to the bottom. With progressing development of the embryo, the air sac increases in size, 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 and 2000 in the same area and float curves were constructed (fig. 6.1).

Float curves were used to estimate the start of incubation. For the length of the total incubation period we used: Pacific Golden Plover 25 days, Ringed Plover 23 days, Turnstone 22 days, Little Stint 20 days, Dunlin/Curlew Sandpiper/Pectoral Sandpiper 21 days, Red Phalarope 20 days (Cramp & Simmons, 1983).

In addition to the nest data, families found with chicks were also used to estimate nesting phenology (fig. 6.2). Chicks encountered were caught and measured and their age was estimated using growth curves from Schekkerman *et al.*, 1998b (Curlew Sandpiper), Schekkerman *et al.*, 1998a (Little Stint) and Tulp *et al.*, 1998 (Turnstone). For Dunlin the growth curve of Curlew Sandpiper was used with the mean mass of juveniles caught on autumn migration as the asymptote. The combination of these methods introduces 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. Only for nests of which either the starting or hatching date was exactly known, the full score was given to the observed date.

Little Stint on the nest

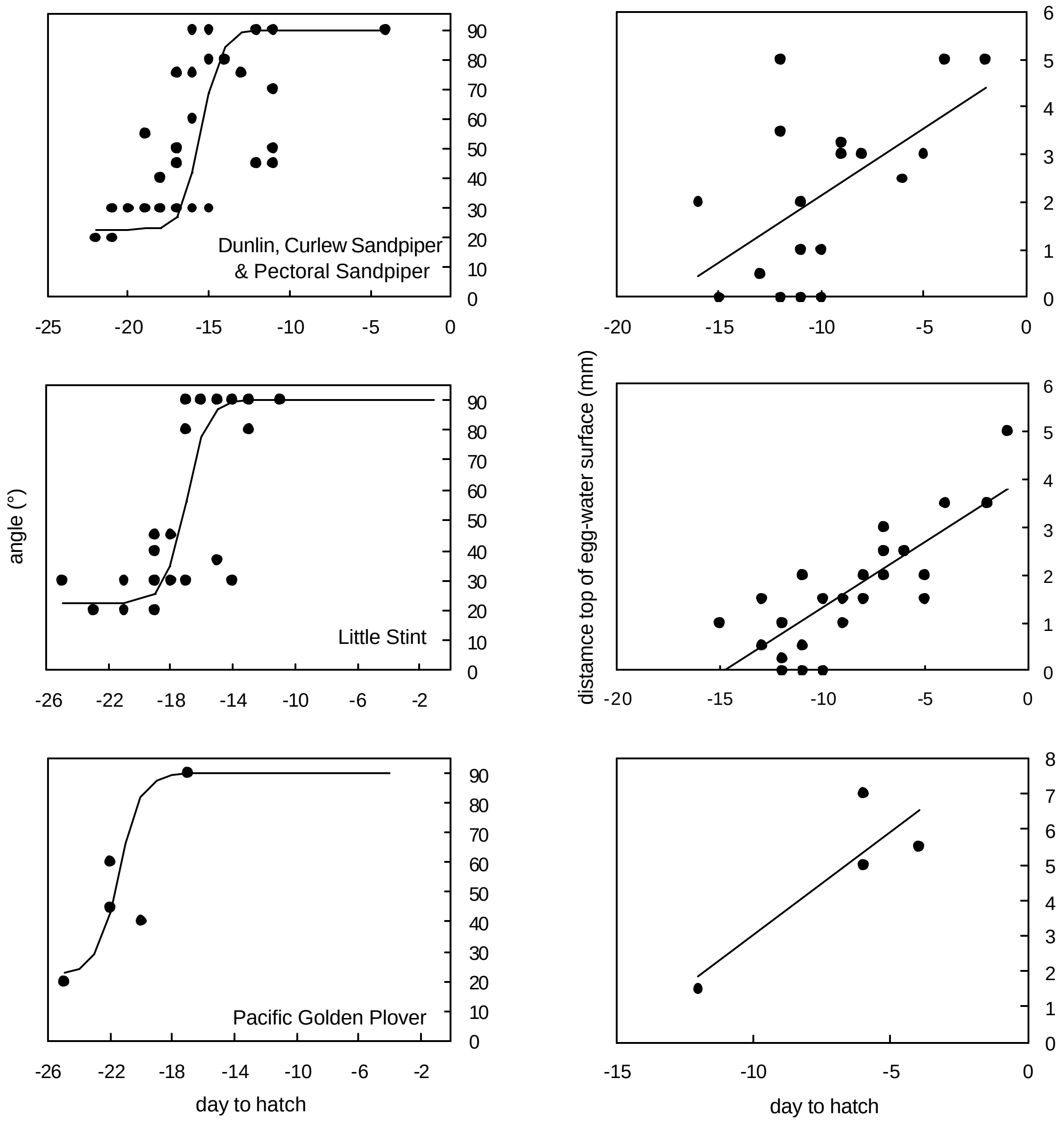


Figure 6.1. Development of incubated eggs in Pacific Golden Plover (PGP), Little Stint (LS), Dunlin (DU), Curlew Sandpiper (CS) and Pectoral Sandpiper (PS). Left panels: the angles of eggs during the first week of incubation in relation to hatching date (dth, (logistic regression equations: PGP: angle =90(0,25+(0,75/(1+EXP(-1,4*dth-30)))), LS: angle =90* (0.25+(0.75/1+EXP(-1.5*dth-25.5)))), DU + CS + PS: angle = 90*(0,25+(0,75/(1+EXP(-1,65*dth-25,5)))). 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: distance =0.5833* dth + 8.8333, LS: distance =0.2737* dth + 4.0755, DU + CS + PS: distance = 0.2809*dth + 4.9548).*

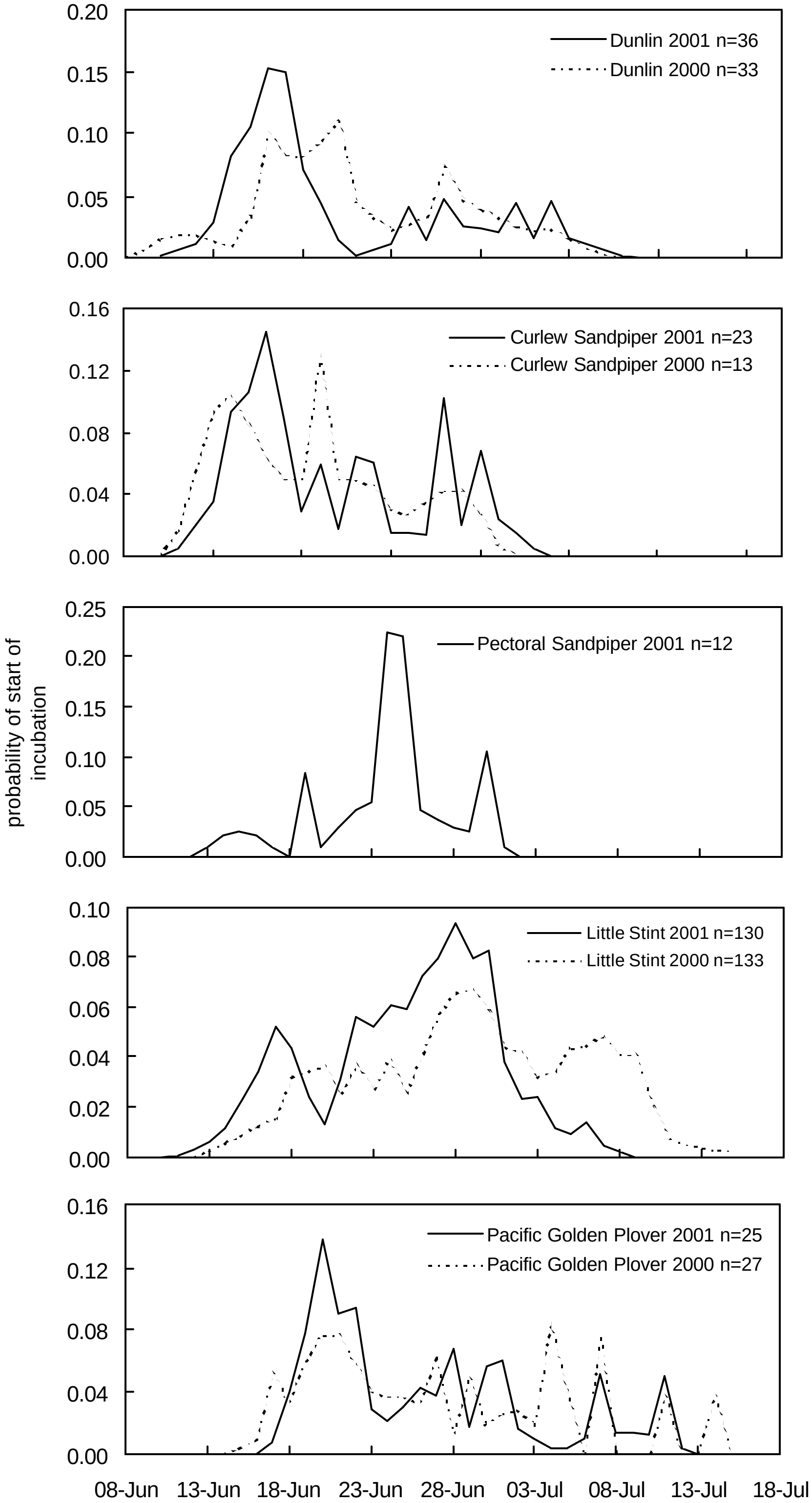


Figure 6.2. Distribution of dates on which incubation started (after completion of clutch) in 2000 and 2001. Dates were observed directly (finding incomplete nests), deduced from floating of eggs or from chick measurements. Distributions appear smoothed because 1-2 day errors in estimation of the hatching date were taken into account (see text). N indicates the number of nests and/or broods on which the distribution is based.

6.3 Timing of breeding

Dunlin started breeding earliest of all species (fig. 6.2). The area where they tend to congregate is situated around the beacon on the ridge of a hill, which is snow-free relatively early. The first clutches were completed on 12 June and the last one on 4 July. Several pairs produced replacement clutches after their first clutch was predated. Curlew Sandpipers also start very early: the first female finished laying her eggs on June 13 and the last one on 29 June. In this species no replacement clutches are produced (the males leave soon after clutch completion). Pectoral Sandpipers started breeding later (they also arrived later see fig. 6.3) and this species also produces one clutch only. Little Stints had a very wide range of starting dates, with the first birds finishing laying on 13 June and the last birds on 6 July. The latest species was Pacific Golden Plover, that finished laying between 19 June and 11 July. For all species, the distribution of the start of incubation was very similar to that of 2000. Dunlin seem to have started slightly later and Little Stints continued producing clutches longer in 2000 than in 2001 (fig. 6.2).

In general date of clutch completion was strongly related to peak migration date among species (the latter derived from the migration counts, see 5.1.2, fig. 6.3). Although a large part of the birds observed migrating may have continued for a few more days before reaching their breeding sites further north on the Taimyr Peninsula, our observations suggest that late arriving species started later than early species. Moreover, later arriving species seemed to take less time between arrival and start of incubation than early arriving species (the slope of the regression line is less steep than 1).

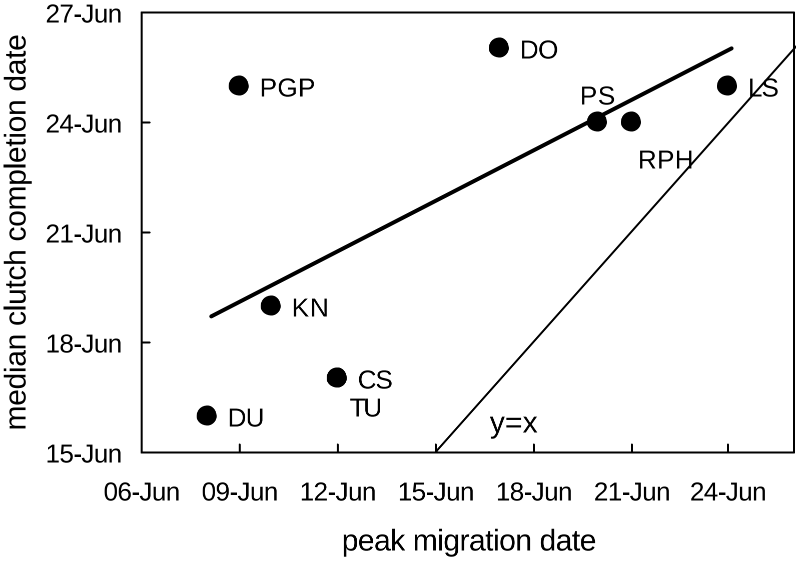


Figure 6.3. Timing of the start of incubation in relation to peak migration date. DU=Dunlin, KN=Red Knot, PGP=Pacific Golden Plover, CS= Curlew Sandpiper, TU= Turnstone, DO=Dotterel, PS= Pectoral Sandpiper, RPH=Red Phalarope, LS= Little Stint. The thick line is a regression line, the thin line represents Y=X.

A considerable proportion of the breeding population of Dunlin was colour-marked in 2000 and therefore arrival dates of known individuals could be recorded in 2001, by checking the study area for marked birds about every other day during the arrival period. If there is a premium of arriving early on the breeding grounds, we might expect a relationship between arrival date and timing of establishing territories, finding a mate and the onset of egg-laying. The start of breeding in Dunlin, however, showed very little variation between individuals and no clear relationship with arrival date was found (fig. 6.4).

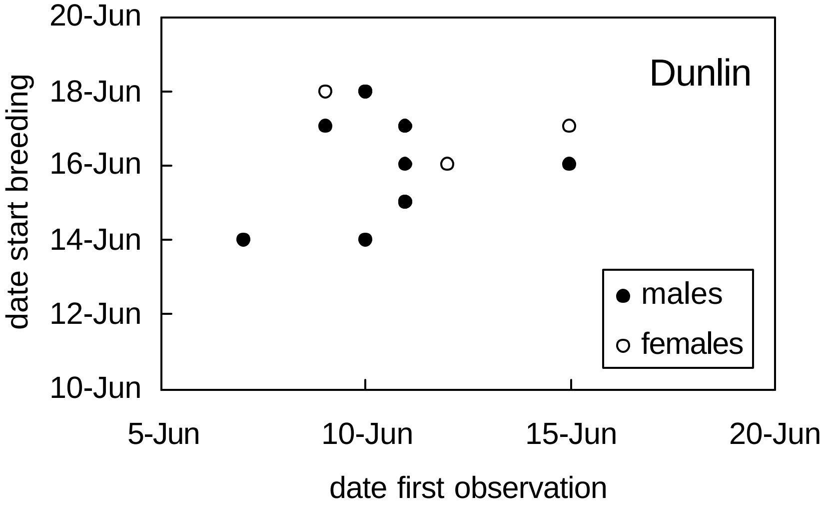


Figure 6.4. The start of breeding in relation to the date of first sighting in Dunlin in 2001.

6.4 Nest distribution

Pacific Golden Plover nests are generally situated on dry slopes (fig. 6.5) in frost-heaved tundra. Later when they have chicks they move to lower lying areas close to streams. Nest distribution between the two years was very similar, although in 2000 more nests were found, due to a greater searching intensity. The 2001 season was characterised by a number of unusual breeding species such as Pectoral Sandpiper, Ruff and Red Phalarope (fig 6.5). Pectoral Sandpiper occurred in the same habitat as Dunlin (fig. 6.6) and were found on the plateau around the beacon in the area that is most affected by the *vezdekhod* tracks. In the North and East nests are found in more natural sedge, rather wet, areas. The Ruff and Red Phalarope nests were found in sedge tundra. Species that breed in the river valleys are Turnstone and Ringed Plover (fig. 6.5). Despite the differences in snow situations between the two years the distribution of nests of Little Stint is very similar, which is probably caused by the relatively late starting date of this species. Curlew Sandpipers inhabit dry frost-boiled tundra on slopes facing southwards and were slightly more abundant in 2001 than in 2000 (fig. 6.6).

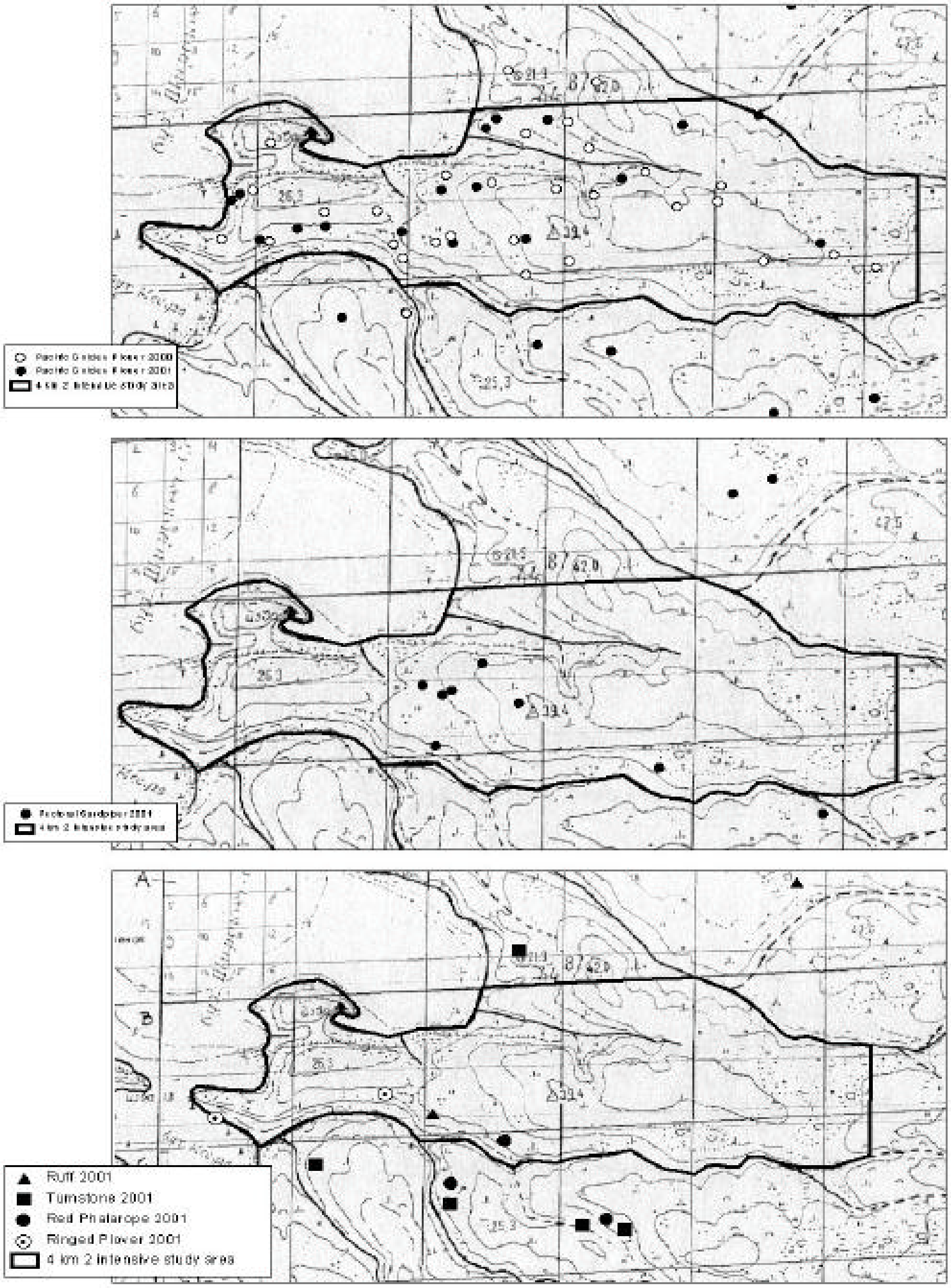


Figure 6.4. Distribution of nests of Pacific Golden Plover in 2000 and 2001 (upper), Pectoral Sandpiper in 2001 (middle) and Ruff, Turnstone, Red Phalarope and Ringed Plover in 2001 (lower). The maps are slightly deformed because of problems of matching the original map (with unknown projection) to actual points (with know GPS coordinates) in the field. The nest sites, however, are based on actual GPS coordinates and are situated correctly with respect to landscape features.

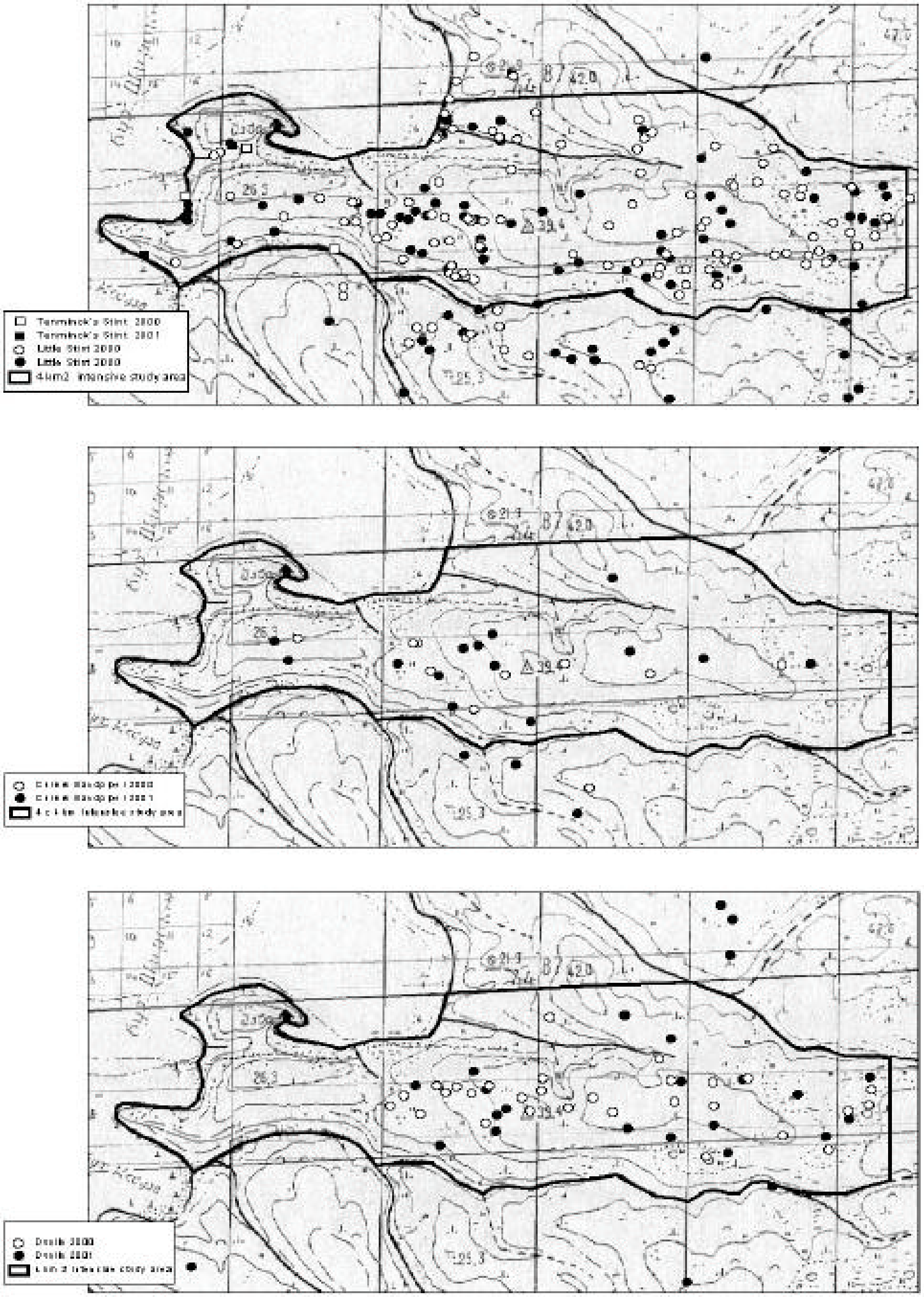


Figure 6.5. Distribution of nests of Little Stint, Temminck's Stint (upper), Curlew Sandpiper (middle) and Dunlin (lower) in 2000 and 2001.

6.5 Nest survival

Daily nest survival was calculated using the Mayfield method by General Linear Modelling (Johnson, 1979, Aebischer, 1999). The midpoint assumption was used for nests that were predated: the clutch was presumed to have disappeared hafway between the last two visits. In some nests the actual timing of predation was known, from temperature recordings with a Tiny Tag data logger. In these cases the actual predation date was used. For hatched nests, that were checked after the chicks left the nest, the expected hatching date was used to calculate the exposure period. Nest survival was only calculated for species of which two or more nests were found. Passerine nests were checked very irregularly and only for Red-throated Pipits *Anthus cervinus* enough data were collected to calculate the probability of nest survival.

For nearly all species, hatching probability was higher in 2001 than in 2000 (table 6.3). For several species number of nests on which calculation of nest success is based is very limited. Of species with sample sizes of more than 10 nests, Pectoral Sandpiper and Dunlin had the highest hatching probabilities (32 and 24 %). The lowest hatching probabilities were found for Pacific Golden Plover and Curlew Sandpiper (both 8%).

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. In 2000 observer effects on predation risk were evaluated using the method developed by Rotella *et al.*, 2000, using the expectation that if nest visits affect the survival probability of nests, the risk of predation should be related to the length of the visiting interval (Tulp *et al.*, 2000). To enable this analysis, nest visits should be recorded accurately. Due to the large number of fieldworkers working in the area in 2001, we are not confident that all nest visits have been recorded and therefore we decided not to carry out the same analysis for this year.

Table 6.3. Daily nest survival probabilities (p) and probabilities of surviving the total incubation period (p to the power of the incubation period). In nest losses, predated, deserted, or nests lost otherwise are combined, but more than 95% of nest losses were due to predation. For Red-throated Pipits only the period until hatching of the eggs, not the chick period, is included in this calculation. For comparison also the hatching probability in 2000 is given.

	daily survival		hatching	n nest	n	incub.	hatching
species	p	se	probability	days	nests	period	prob 2000
Pacific Golden Plover	0.905	0.020	0.082	200	25	25	0.126
Ringed Plover	0.988	0.011	0.761	85	3	23	0.188
Dotterel	0.857	0.093	0.021	14	2	25	
Turnstone	0.877	0.046	0.056	49	7	22	0.046
Red Phalarope	0.973	0.026	0.578	37	4	20	
Little Stint	0.918	0.010	0.182	723	93	20	0.005
Temminck's Stint	0.999	0.000	0.999	28	2	20	0.550
Pectoral Sandpiper	0.947	0.020	0.321	114	12	21	
Dunlin	0.935	0.015	0.242	245	25	21	0.028
Curlew Sandpiper	0.889	0.028	0.086	118	19	21	0.000
Ruff	0.778	0.138	0.005	9	2	21	
Long-tailed Skua	0.937	0.042	0.212	32	3	24	
Ptarmigan	0.999	0.000	0.999	59	3	21	0.084
Red-throated Pipit	0.999	0.000	0.999	43	6	11	

6.6 Timing of predation

As part of the study of energetics of incubation in uniparental breeding waders we used Tiny Tag temperature data loggers to register nest attendance. In the considerable proportion of nests under investigation that were predated the logger also recorded the time of predation. From a total of 24 nests (10 Curlew Sandpiper, 8 Little Stint, 2 Ruff and 4 Pectoral Sandpiper, fig. 6.7) the moment of predation could be determined. Seven of these nests (29%) were predated between 06:00 and 20:00 (fig. 6.8), the other 71% was predated in the 'night' period. This indicates that Polar Fox was the most likely predator in many cases, as skuas were observed to be more or equally active during the day than at night. Unlike in 2000 when skuas were hardly present, in 2001 the area was regularly visited by groups of skuas roaming around and even some territorial pairs. Nevertheless skuas were not thought to be the main predator given the large proportion of nests predated at night. In 2000, 30 of 69 timed cases of predation (43%) took place during the day. In contrast to 2001, in 2000 Polar Foxes were seen regularly during the day, which is reflected in the higher proportion of nests taken during daytime.

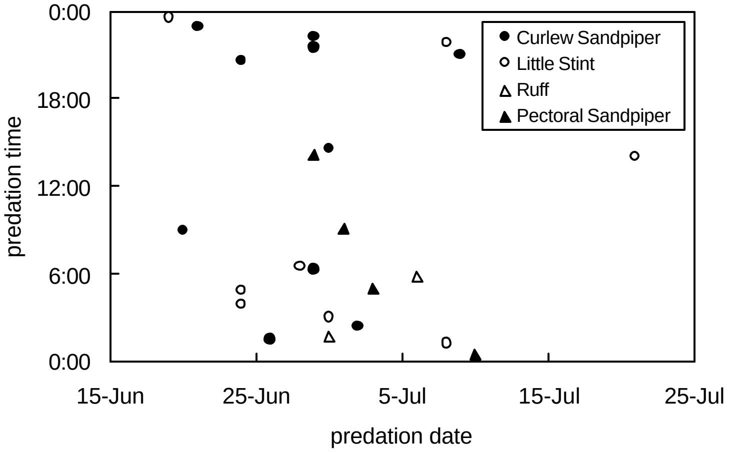


Figure 6.6. The time of day at which nests of different species were predated in relation to date.

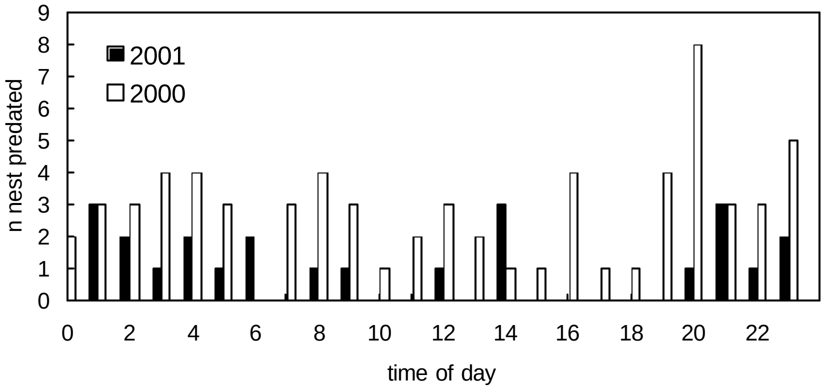


Figure 6.7. The occurrence of nest predation in relation to time of day.

Clap net in operation

7 Biometrics of adult shorebirds

7.1 Methods

During the first two weeks of the season (6-20 June) we tried to catch shorebirds that had just arrived to the breeding grounds. A clap net measuring 10x1.5 m and operated through a pulling line at a distance of c. 20 m was used (fig. 7.1). 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 waders. Once a bird was inside the trapping area the net was released. The same method was used to capture birds on autumn migration between 9 July and 10 August. The advantage of using tapes is that *actively* migrating birds are 'pulled down' from the air, often from considerable altitudes. We also tried using mist nets both on spring and autumn migration. During autumn migration we put up a section of mist nets across the Medusa River and in a valley close to the camp.

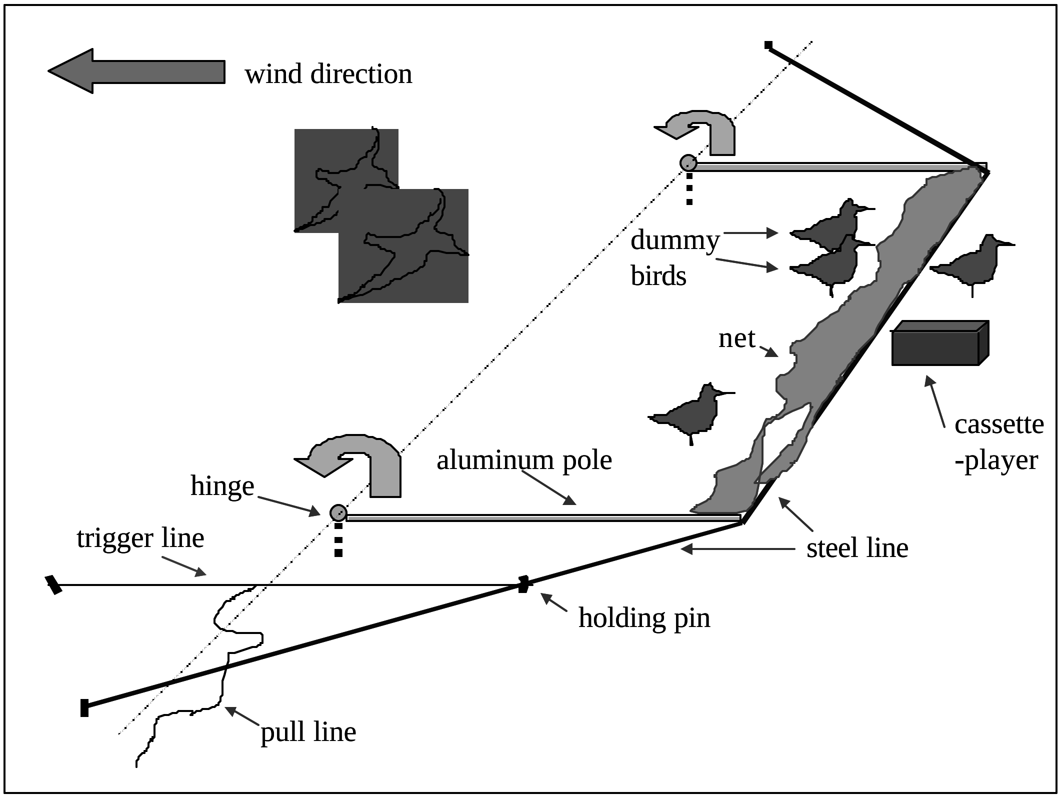


Figure 7.1. Setup of clap net used to catch waders during migration.

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 sit on the eggs. To avoid nest desertion, this was done from the second week of incubation onwards. Birds with chicks were 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 parents 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.

Captured birds were ringed with metal rings and adult 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 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, 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. 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. To enable sex determination by DNA analysis we took blood samples of all adult Little Stints.

Dotterel

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 (Klaassen *et al.*, 2001).

Another co-operative project concerned the collection of preen-gland waxes for Jeroen Reneerkens (Netherlands Institute for Sea Research). From preliminary studies it has become clear that shorebirds adjust the composition (fractions mono- and di-esters) in relation to breeding stage (Reneerkens *et al., 20*01). We collected a large sample of different species in different phases of their breeding cycle.

7.2 Results

7.2.1 general

In general the same trapping method was used as in 2000. Total catching time could be increased due to a larger battery capacity for the tape-recorders, and the number of decoys was increased. During spring migration strong winds blew nearly constantly from a north-easterly direction, forcing migrating waders to fly low. In 2001 also the migration was much more noticeable than in 2000. Possibly the attraction to the sounds and decoys was stronger under such circumstances than in 2000 when winds were variable. The scarcity of snow-free patches in early June for birds to land on and feed was another factor positively influencing catching success. We set up the net at one of these patches and birds were attracted to this location and started feeding along the snow edges. In total 89 waders were caught during spring migration of nine different species of which Curlew Sandpiper, Dotterel and Little Stint were the most common (table 7.1). During autumn migration the catching method proved to be even more successful and nearly 300 birds were caught, of which Little Stints and Curlew Sandpipers were the most numerous.

During incubation birds were caught on the nest from the second week of incubation onwards. Because a large part of the nests found were predated, the parents of many nests could not be caught.

In total 374 adult shorebirds were newly ringed, 16 birds were recovered (excluding resightings of individually colour-ringed birds, table 7.1, see chapter 10 for an overview of resightings and recoveries). All recoveries concerned birds ringed at the same location in earlier years.

Table 7.1. Number of shorebirds caught at Medusa Bay in 2001. Numbers presented include recaptures (see footnotes). Recaptures carried out for doubly labelled water measurements are not included.

Species	adult		sex	adult		
	female	male	unknown	total	juvenile	chick
spring migration						
Dotterel	13	9	0	22	0	0
Turnstone	4	5	0	9	0	0
Grey Phalarope	0	1	0	1	0	0
Red Knot	0	1	2	3	0	0
Sanderling	0	2	0	2	0	0
Little Stint	6	11	1	18	0	0
Temminck's Stint	1	0	0	1	0	0
Dunlin	1	6	0	7	0	0
Curlew Sandpiper	13	13	0	26	0	0
total	**38**	**48**	**3**	**89**	**0**	**0**
on nest						
Pacific Golden Plover	3	3[1]	1	7	0	17
Dotterel	0	1	0	1	0	0
Red Phalarope	0	2	0	2	0	7
Little Stint	27[2]	28	2	57	0	65
Temminck's Stint	1	1	0	2	0	4
Pectoral Sandpiper	7	0	0	7	0	8
Dunlin	11[3]	13[3]	0	24	0	20
Curlew Sandpiper	9	0	0	9	0	7
total	**58**	**48**	**3**	**109**	**0**	**128**
with brood						
Turnstone	0	2	0	2	0	6
Red Phalarope	0	0	0	0	0	1
Little Stint	3	10	9[4]	22	0	109
Pectoral Sandpiper	1	0	0	1	0	4
Dunlin	2[5]	9[5]	0	11	0	36
Curlew Sandpiper	3	0	0	3	0	16
total	**9**	**21**	**9**	**39**	**0**	**172**
autumn migration						
Turnstone	1	1	0	2	5	0
Red Phalarope	0	0	0	0	1	0
Red-necked Stint	0	0	0	0	1	0
Little Stint	13	30	38	81	129	0
Temminck's Stint	0	0	1	1	0	0
Dunlin	4	12	0	16	8	0
Curlew Sandpiper	37	0	0	37	14	0
total	**55**	**43**	**39**	**137**	**157**	**0**
overall total	**160**	**160**	**54**	**374**	**157**	**300**

[1] of which 2 recaptures of birds ringed in 2000 and in an earlier year (probably 1994)

[2] of which 2 recaptures of birds: 1 ringed on the nest, one ringed during spring migration

[3] of which 9 recaptures of males and 2 recaptures of females ringed in 2000

[4] of which 1 recapture of a bird ringed on the nest in 2001

[5] of which 1 recapture of a male ringed in 2000 and two recaptures of males ringed on the nest in 2001

Table 7.2. Mean (and sd) biometrics (mm, mass in g) of shorebirds captured during spring migration, incubation, chick-rearing or autumn migration. In Little Stints no distinction between sexes is made in the chick-rearing and autumn migration period because the plumage is fading at that stage. Little Stints and Dotterels were provisionally sexed on plumage colour in the arrival and incubation period. This method is prone to involve some errors. N values refer to all birds caught, including a few recaptures. For recaptures only body mass is included twice.

Species	group	N	bill	total head	tarsus	tarsus+toe	wing	mass
Pacific Golden Plover								
incubating	females	3	22.5	56.3	43.7	73.8	167.0	130.3
			1.0	1.4	1.1	2.3	1.7	11.9
	males	4	22.1	56.1	42.8	73.8	167.3	129.3
			1.1	0.5	0.6	0.3	2.9	5.0
Dotterel								
spring migration	females	12	16.4	50.4	38.2	63.3	158.0	125.3
			0.5	1.2	1.7	2.4	3.2	6.7
	males	9	16.7	50.6	38.1	63.2	157.1	123.3
			1.0	1.3	1.1	1.8	3.7	8.9
Turnstone								
spring migration	females	4	22.9	51.1	25.8	51.9	155.5	107.8
			1.0	1.4	1.2	1.4	1.9	11.7
	males	5	22.0	50.1	25.8	50.8	156.0	98.6
			0.6	0.8	0.6	0.4	3.1	2.5
autumn migration	juveniles	5	20.4	48.2	25.4	51.1	147.2	85.2
			1.0	1.7	0.6	0.9	4.5	7.6
Red Knot								
spring migration	adults	3	33.7	64.1	33.3	61.0	170.3	126.0
			1.2	1.2	1.2	2.8	3.2	7.9
Little Stint								
spring migration	females	6	18.8	39.8	21.5	39.9	99.2	27.2
			0.7	0.5	0.8	1.5	1.2	2.2
	males	11	17.9	38.5	21.5	40.9	97.4	24.8
			0.9	1.5	1.2	1.7	2.4	3.0
	adults	18	18.2	38.9	21.5	40.5	97.9	25.7
			1.0	1.4	1.0	1.6	2.1	2.8
incubating	females	28	18.8	39.4	21.8	40.8	100.0	30.1
			0.8	1.5	0.9	2.0	2.2	3.3
	males	30	18.0	38.6	21.6	40.2	97.2	30.6
			1.0	1.2	0.9	1.3	2.3	2.8
	adults	58	18.4	39.0	21.7	40.5	98.6	30.4
			1.0	1.4	0.9	1.7	2.7	3.0
chick-rearing	adults	22	18.5	39.0	21.7	40.3	98.6	27.0
			1.0	1.4	1.0	1.5	3.0	2.3
autumn migration	adults	78	18.6	39.1	21.5	40.1	98.3	25.3
			1.1	1.2	0.9	1.3	3.2	2.6
	juveniles	129	18.2	38.4	21.9	40.3	98.9	23.2
			0.8	1.0	0.8	1.1	3.0	1.6
Pectoral Sandpiper								
incubation	females	7	27.7	51.9	27.9	53.6	131.4	62.3
			1.3	2.0	1.3	2.2	4.0	4.7

Table 7.2. Continued

Species		group	n	bill	total head	tarsus	tarsus + toe	wing	mass
Dunlin									
	spring migration	males	7	32.1	56.1	25.0	46.4	117.6	48.9
				2.4	3.5	0.6	1.6	2.4	2.7
	incubating	females	11	35.8	60.3	26.2	49.1	118.8	53.9
				1.5	1.4	0.5	1.3	2.1	3.3
		males	13	32.0	56.2	24.7	46.8	117.0	51.4
				1.4	1.6	0.6	1.4	1.9	3.5
	chick-rearing	males	9	31.9	56.2	25.2	47.9	116.2	47.4
				1.1	1.6	0.6	1.3	1.5	2.7
	autumn migration	females	4	37.0	61.8	26.9	49.6	119.0	50.4
				1.4	1.7	1.1	1.4	2.9	3.3
		males	12	32.7	56.6	25.2	46.5	113.3	46.0
				1.2	1.6	0.9	1.0	2.9	2.9
		juveniles	8	31.6	55.6	25.9	48.1	120.5	46.5
				1.6	2.0	0.8	1.5	2.7	2.9
Curlew Sandpiper									
	spring migration	females	13	39.0	63.8	31.2	54.0	133.1	60.1
				1.8	2.0	1.4	2.0	3.1	4.8
		males	13	35.4	60.0	30.4	52.5	131.0	56.4
				1.0	1.0	0.8	1.4	2.0	2.9
	incubating	females	9	39.4	64.6	32.6	55.8	132.3	67.4
				1.1	1.2	1.7	2.3	3.2	4.0
	chick-rearing	females	3	39.3	63.0	31.4	53.2	133.0	57.3
				1.2	1.4	1.6	2.4	4.6	6.8
	autumn migration	females	37	40.0	64.5	31.5	55.0	132.5	56.3
				2.1	2.1	1.0	1.6	3.3	3.5
		juveniles	14	35.5	59.8	31.0	53.6	130.9	51.6
				2.8	2.8	1.6	1.5	3.0	2.6

Mean biometric data for shorebirds during spring migration, incubating, chick-rearing and autumn migration are given in table 7.2. Only for groups that consisted of at least three individuals means are given. Individual values, also for species/groups not presented in table 7.2, are given in Appendix 1. Below, patterns in body mass will be discussed per species and if possible in relation to different periods in the annual cycle. For this purpose we use two reference points: the midwinter body mass in tropical wintering sites as a value for (near) lean mass, and the mass prior to long-distance migration as a value for maximum mass attained during the year. In figures 7.2 to 7.5 combined data from 2000 and 2001 are presented.

7.2.2 Pacific Golden Plover

Because catching Pacific Golden Plovers on the nest is normally a lengthy procedure, we only caught them when eggs were hatching. Parents tend to return to the nestcup much faster and catching is easier. We only caught seven Pacific Golden Plovers of which two concerned recoveries. Size and mass are very similar between sexes. Mean body mass of females caught in 2001 was 5 g less than in 2000, a difference most likely caused by a different timing of catches.

7.2.3 Dotterel

Dotterels were caught during spring migration (21) and one male was caught on the nest. The distinction between sexes was carried out based on plumage characteristics. However, plumage differences were not very obvious. Dotterels were the most responsive to the tape recordings of all waders and even if a bird was missed when the net was pulled, the same bird might return shortly after and be caught in the end. Several times a group of five or more birds congregated near the net and approached the dummies. Body mass was similar for males and females (112-140 g), the one bird caught on the nest was the lightest one of all (111g). Reported winter mass values are very scarce, the only value found is 108 g for Iran in February (Cramp & Simmons, 1983). Masses before long-range departures are not known.

7.2.4 Turnstone

Turnstones were caught during spring and autumn migration and chick-rearing (9, 5 and 2 individuals respectively). Birds caught in autumn were mostly juveniles and weighed less than the Turnstones caught in spring (fig. 7.2). After correction for size (wing, $F_{1,19}=15.38$, $p<0.001$) no significant differences between body mass in the different stages of the breeding cycle was found. Spring body masses were much lower than values recorded for departure mass in West Africa (Ens *et al.*, 1990). Although for most individuals spring mass were in the range of midwinter mass reported for West Africa, some individuals were heavier. Incubating birds and birds with chicks were also rather light compared to midwinter masses.

7.2.5 Red Phalarope

Only three Red Phalaropes were caught, two males on the nest and one juvenile during autumn migration. The nesting birds weighed 56 and 59 g, the migrating bird 43 g.

7.2.6 Little Stint

Distinction between females and males was based on plumage characteristics. Also blood samples of all adult Little Stints were taken for DNA analysis to determine sex. Because these analyses have not been carried out yet, the sexes as presented here are only based on plumage characteristics and subject to error. Arrival masses were highly variable: some birds were down to lean values reported for mid-winter, others must have still had considerable reserves left (fig. 7.3). During incubation Little Stints are relatively heavy, which is a general phenomenon recorded in most arctic breeding areas (Tulp *et al.*, 2002). Chick-rearing birds loose weight, while birds caught during autumn migration were again variable in mass: both low and high values were recorded. After correction for size (wing $F_{1,390}=44.16$, $p<0.001$) significant differences in body mass were found between the different phases ($F_{1,\ 390}= 158.01$, p<0.001, birds on nest>birds with chicks>spring migrating birds>autumn migrating birds, $F_{3,390}$=158.01, p<0.001) and ages ($F_{1,390}$=60.95, p<0.001, adults>juveniles). Juveniles caught during autumn migration were not heavy but body masses were similar to values reported in other studies (22-24 g for the same area: Lindström, 1998, Schekkerman *et al*., 1998a). No significant increase in body mass was found in adults nor juveniles caught during autumn migration.

7.2.7 Temminck's Stint

In total three birds were caught, of which one bird two times. The one bird caught during spring migration was lighter than the two nesting birds. The bird caught twice weighed 32.1 g when caught on the nest and 28.9 g during chick-rearing.

7.2.8 Dunlin

Arriving birds must have had fairly little reserves left, because most body mass values found were not much larger than those recorded for the wintering situation (fig. 7.4). Incubating birds were heavy and body mass dropped during chick-rearing. Apart from one exception birds caught during autumn migration were generally very light. Strikingly late migrating males had similar masses compared to juveniles. After correction for size (total head $F_{1,101}$=69.87, p<0.001), significant differences were found between the different phases of the incubation cycle (incubating birds>birds with chicks>spring migrating birds>autumn migrating birds, $F_{3,101}$=125.23, p<0.001) but not between age or sex classes. If incubating birds are analysed separately females are on average 3.4 g heavier than males ($F_{1,50}$= 12.81, p<0.001).

7.2.9 Curlew Sandpiper

During spring migration a large variation in body masses was found, especially in females (fig 7.5). Lowest masses were recorded for males and were close to midwinter mass. Incubating females were relatively heavy, but still weighed less than birds preparing for long-distance migration. During chick-rearing body mass was less and during autumn migration females with relatively low masses were recorded. In early August a few females with higher masses passed through. After correction for size (bill, $F_{1,108}$=27.86, p<0.001) significant differences were found in body mass between the different phases ($F_{3,112}$=42.02, p<0.001, birds on nest>birds with broods>spring migrating birds>autumn migrating birds) and age ($F_{1,108}$=64, p=0.020, juveniles< adults). No differences between sexes were found. Juveniles were generally very light.

7.3 Patterns in body mass

In all species incubating birds were heavier than birds with chicks. In general body mass on the breeding ground is intermediate to values found in the (tropical) wintering areas and values reached before long-distance departures. During the spring arrival period a large variation in body mass was found, but generally most birds did not seem to have completely depleted their energy stores. In none of the species a clear preparation for autumn migration expressed by an increase in body mass with time, as known from migratory stopover areas, was apparent. Therefore it seems that a preparation for autumn migration similar to that before spring migration does not take place on the breeding grounds. While during spring migration, waders reach the breeding grounds in a few long flights, on the return journey in autumn it seems more likely that they start off with several shorter hops. A different migration strategy on the way south compared to the spring migration can have different causes: 1. If birds are not time-stressed during autumn migration, they might be able to afford shorter hops. 2. Food might not be sufficient to allow for extensive fattening. 3. If fuelling rate is (much) higher at stopover sites further along the route, it may pay to leave with relatively low stores. 4. Since in the breeding grounds birds are very scattered, they might use the short flights to congregate and form groups.

In the first week of August a mudflat-type of habitat became exposed in Medusa Bay, due to a prolonged period with winds from the northeast and several hundreds of waders congregated here and fed on the mudflats. Whether these sort of areas are abundant along the Russian northcoast is not known. What they were feeding on here and whether this is a food source that is abundant enough to allow for fattening is not known either.

Dunlin and juvenile Curlew Sandpipers feeding on a mudflat in Medusa Bay in early August

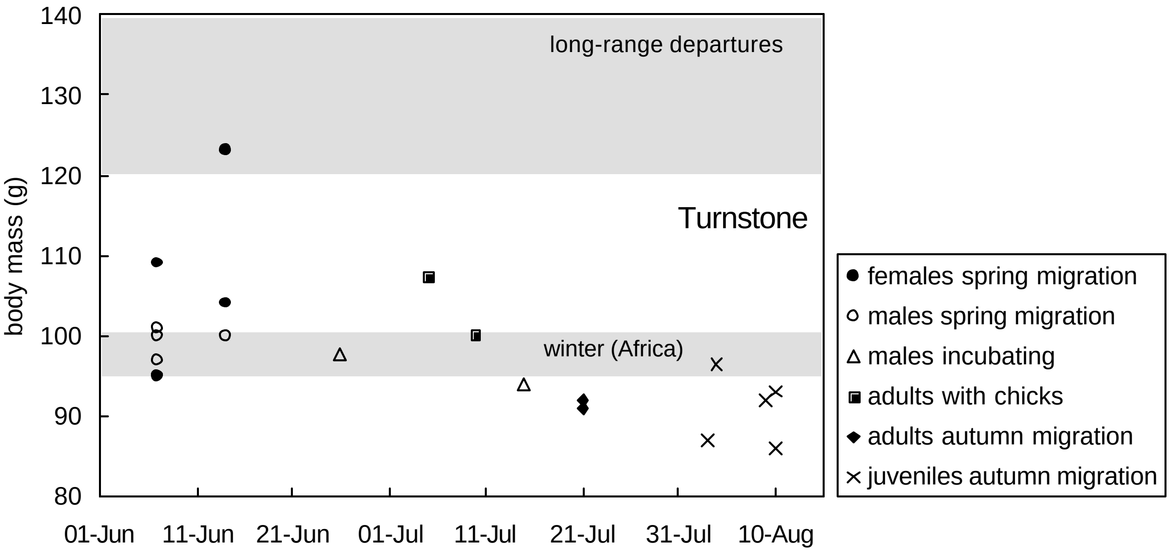


Figure 7.2. Body mass of Turnstones during spring migration, incubation, chick-rearing and autumn migration relative to catching date. The ranges of masses of wintering Turnstones and Turnstones before long-range departures were derived from Ens et al. (1990) and Zwarts et al. (1990). Data from 2000 and 2001 are combined.

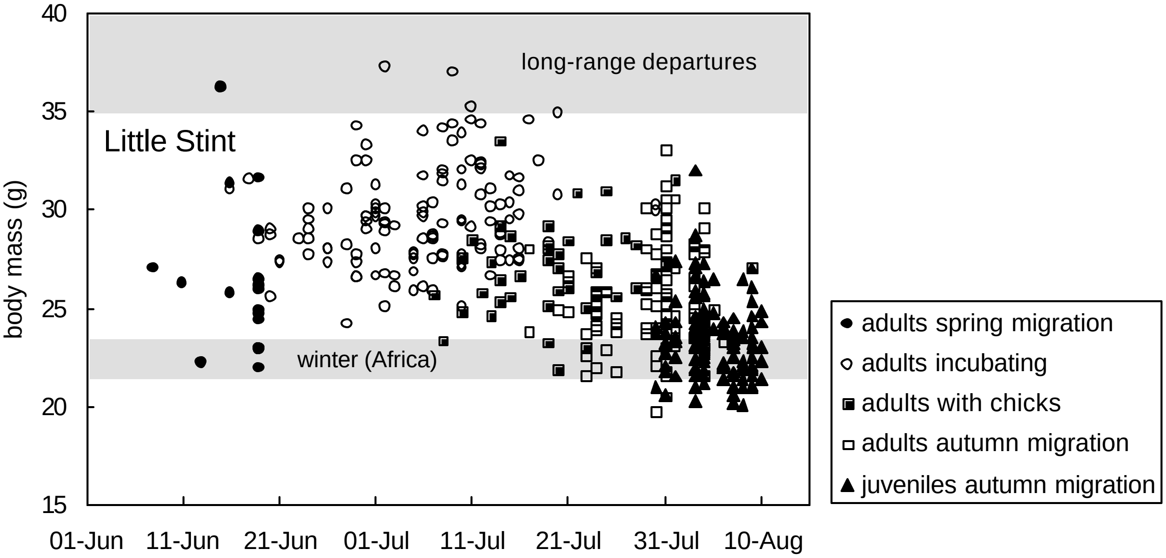


Figure 7.3. Body mass of Little Stints during spring migration, incubation, chick-rearing and autumn migration relative to catching date. Sex determination is based on plumage characteristics and can deviate from actual sex. Because of fading of plumage no distinction between sexes was made in chick-rearing and postbreeding individuals. The ranges of wintering and premigratory masses were derived from Zwarts et al., 1990. Data from 2000 and 2001 are combined.

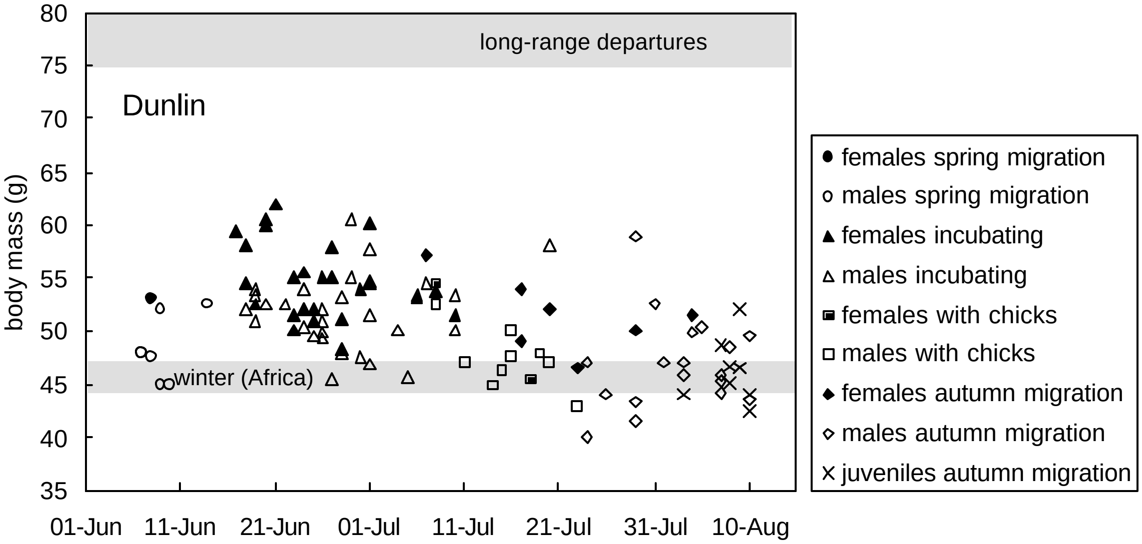


Figure 7.4. Body mass male and female Dunlins during spring migration, incubation, chick-rearing and autumn migration relative to catching date. The ranges of wintering and premigratory masses were derived from Zwarts et al., 1990. Data from 2000 and 2001 are combined.

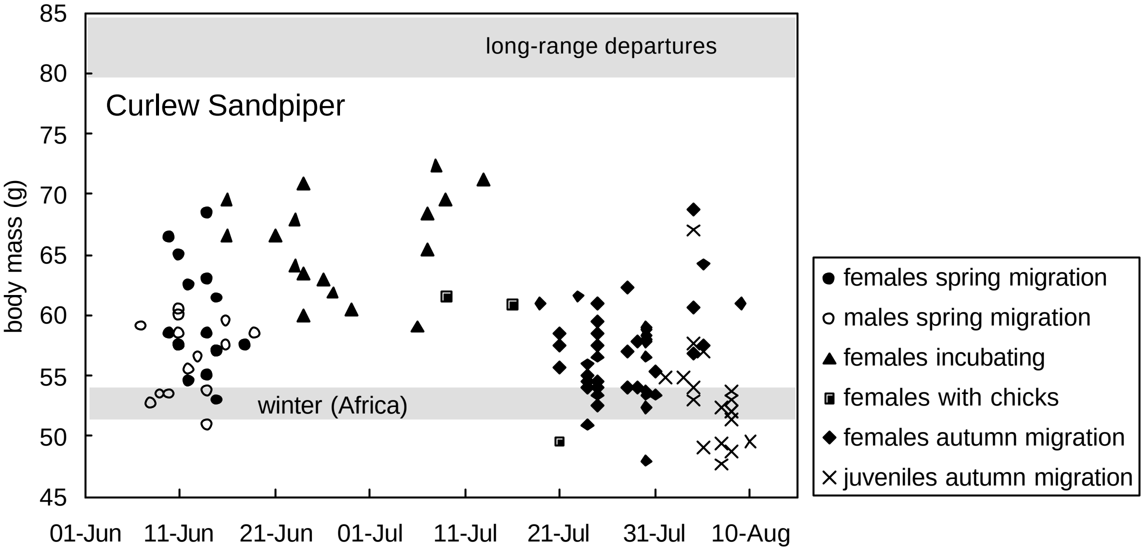


Figure 7.5. Body mass of Curlew Sandpipers during spring migration, incubation, chick-rearing and autumn migration relative to catching date. The ranges of wintering and premigratory masses were derived from Zwarts et al., 1990 and Summers & Waltner (1978). Data from 2000 and 2001 are combined.

7.4 Primary moult in Dunlin

Dunlins start moulting their primaries during incubation. Already in the second week after the start of incubation the first Dunlins start shedding primaries. During the rest of the incubation period and chick-rearing they undergo complete wing moult. Females caught during autumn migration were in progressed states of wing moult but had not finished yet (fig. 7.6). Also in males only one migrating bird was caught that had completely finished wing moult, but a strikingly high proportion of the birds migrated with only the outermost primary still growing (moult scores 47-49, fig. 7.6, and photograph). The fact that all females and most males start migration with still growing primaries shows that their apparent haste to move to the stopover and wintering areas. On the other hand, there seems to be a reason for the males to stay on until their moult is almost complete. This might have to do with establishing territories for next year; Dunlin males proved to be more site-faithful than females.

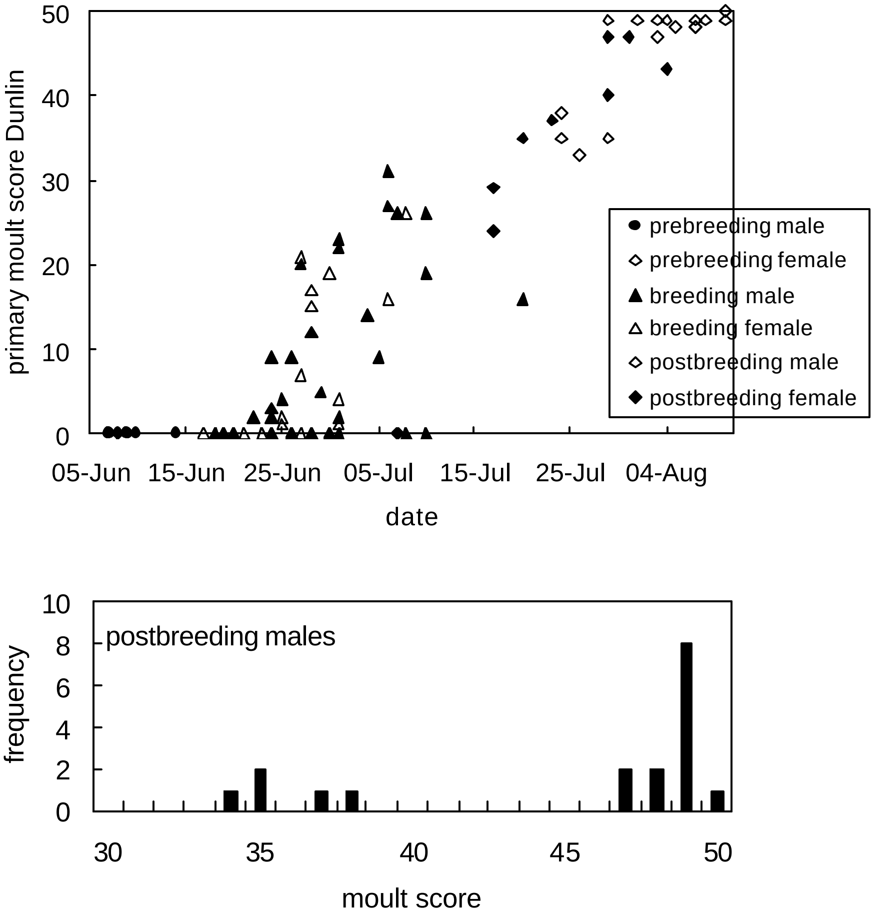


Figure 7.6. Primary moult score in relation to catching date (upper graph) and frequency of moult scores in postbreeding Dunlin males (lower graph)

Dunlin with nearly finished wing moult, departing on autumn migration

Male Red Phalarope brooding his chicks

8 Condition and reproductive parameters

The main aim of the study was to describe (variation in) arrival date and arrival condition of arctic breeding shorebirds and to study correlations between these variables and reproductive parameters such as (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 only two of the waders caught during spring migration nested in the area the direct measurement of reproductive output in relation to arrival condition was not possible. Nevertheless several possibilities remain to investigate this problem using a more indirect approach.

The start of incubation (which was estimated using float curves, chapter 6) provided a measure of timing. Because of the high predation rate, breeding success, chick survival and the overall reproductive success was so low and showed such small variation between individuals that we could not use these parameters as a fitness measure. The remaining parameter indicative of fitness that is not affected by high predation rates was egg size. In several shorebird species egg size is related to chick size and survival (Galbraith, 1988, Grant, 1991, Blomqvist *et al.*, 1997), though not in all (Jager *et al.,* 2000). Furthermore many birds were caught on the nest and among other parameters body mass was measured. Especially for Little Stint, Dunlin, Curlew Sandpiper, Pectoral Sandpiper and less so for Pacific Golden Plover, we collected a large enough data set to investigate the relation between condition and reproductive parameters.

Pacific Golden Plover performing broken wing display to distract predators from the nest

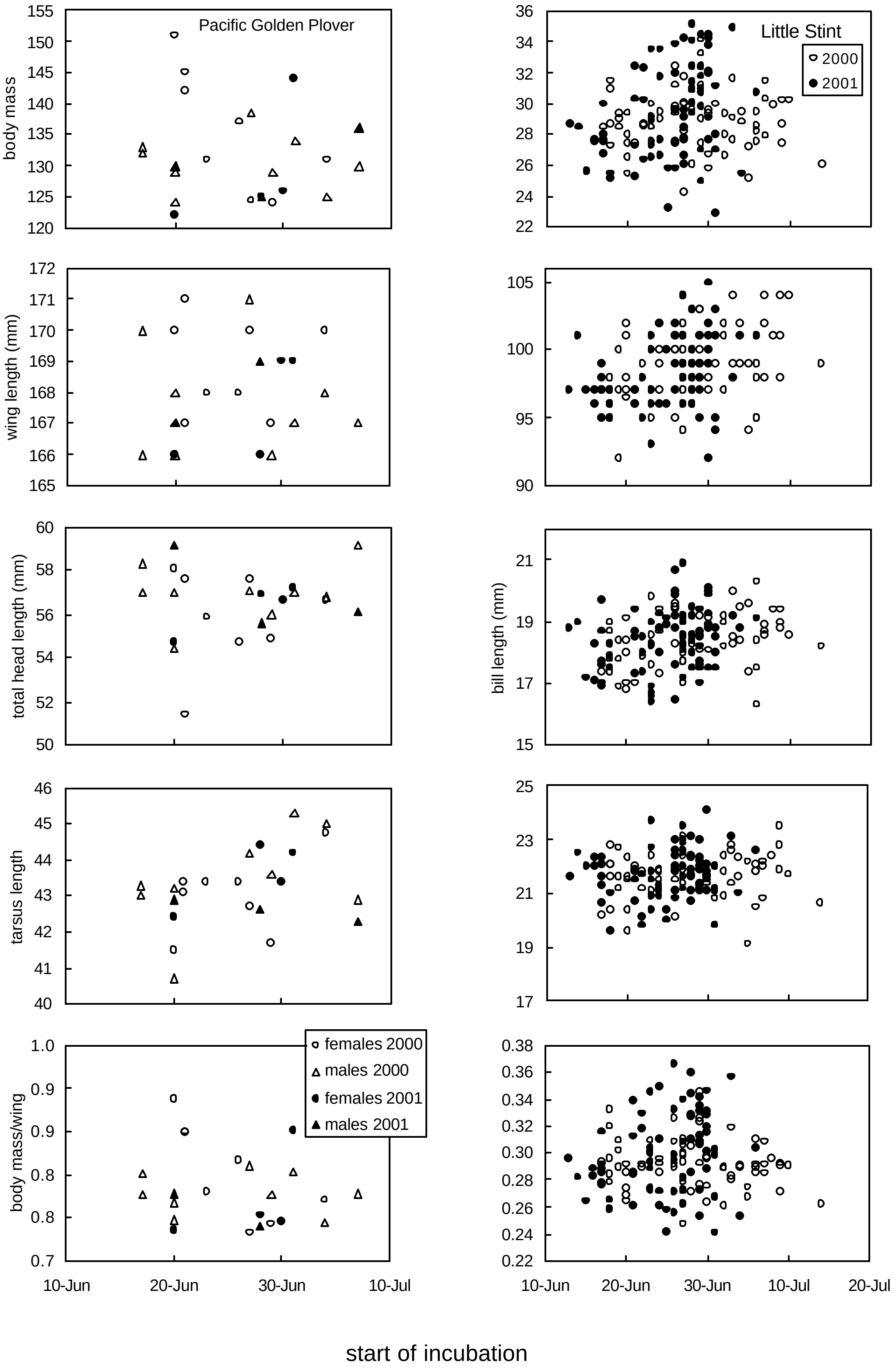


Figure 8.1. Biometric data in relation to the start of incubation (excluding egg laying) in Pacific Golden Plover and Little Stint. Note that none of the measurements were taken at the start of incubation. This is not a problem for constant data (wing length), but body mass values may vary throughout incubation.

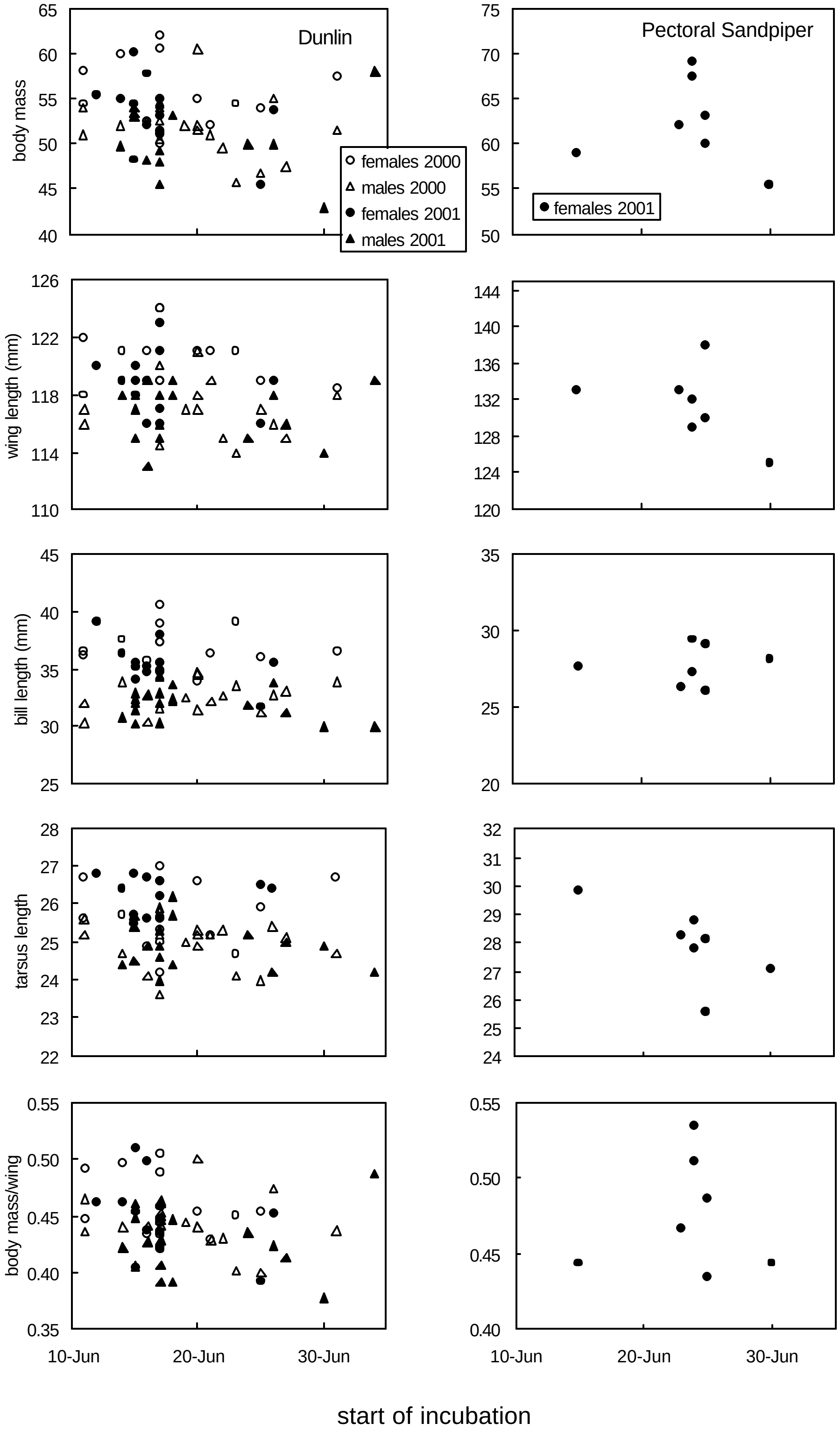


Figure 8.2. Biometric data in relation to the start of incubation in Dunlin and Pectoral Sandpiper. Note that none of the measurements were taken at the start of incubation. This is not a problem for constant data like wing length, but body mass values may vary throughout incubation.

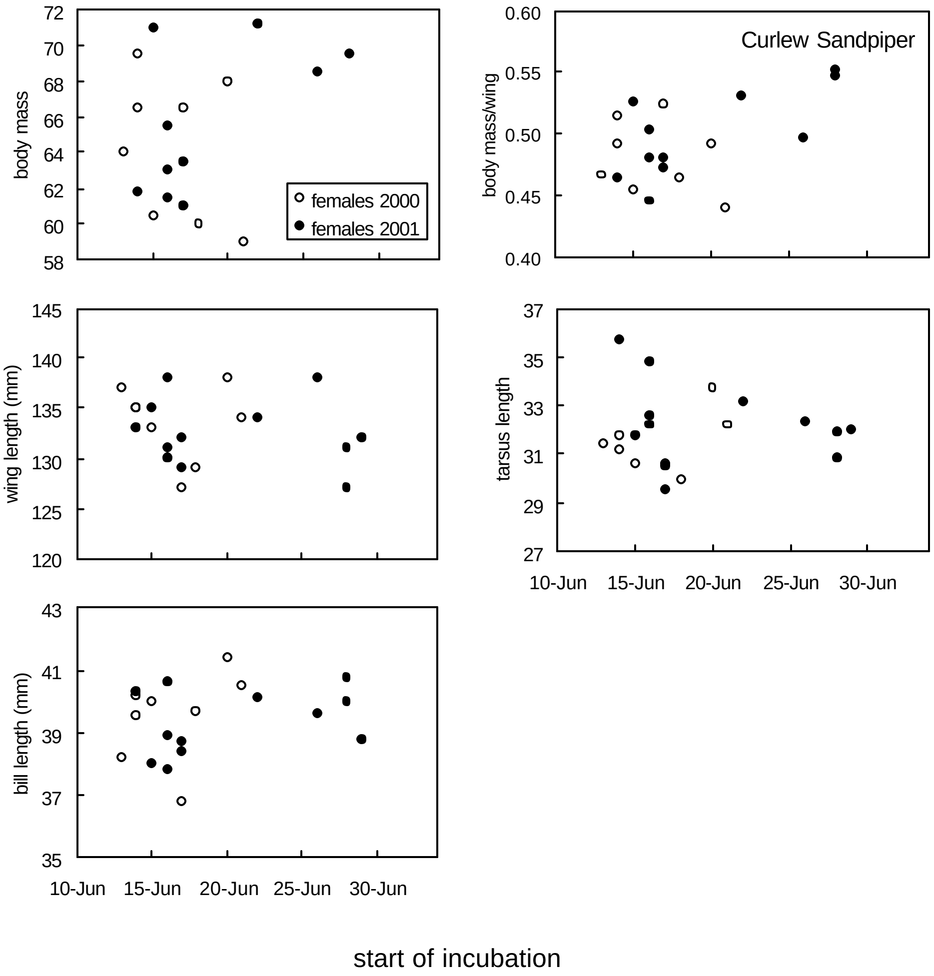


Figure 8.3. Biometric data in relation to the start of incubation in Curlew Sandpiper. Note that none of the measurements were taken at the start of incubation. This is not a problem for constant data like wing length, but body mass values may vary throughout incubation.

8.1 Timing of breeding

If an early timing of breeding is important for successful reproduction, then it is of interest to see if measurements indicative of physical condition or size correlate with timing: are birds that start early heavier or larger than later arriving birds? Ideally, the timing of breeding (start of incubation) should be investigated in relation to condition upon arrival. But since the majority of the birds caught during autumn migration did not stay in the area to breed we only have condition data of birds caught on the nest during incubation.

In contrast with the Pacific Golden Plover data from 2000 alone the combined data for the two years did not show any relation between biometric data and the start of incubation (fig. 8.1). In 2001 only very few Pacific Golden Plovers were caught on the nest due to high predation rates. Also when treating sexes separately no significant relationship is found.

In Little Stints no significant relationship between body mass or body mass corrected for structural size (wing length) and laying date was found (fig. 8.1). Wing length, however, showed a increase with time ($F_{1,139}$=25.98, $p<0.001$). Also bill length ($F_{1,140}$=18.18, $p<0.001$) but none of the other biometric values showed this pattern. An increase in wing and bill length is most likely caused by a higher proportion of the larger females incubating later in the season (Tulp *et al.*, 2002). This is the result of the double-clutch breeding system found in this species (Chylarecki & Kania, 1992). Blood samples that can be used for sex determination have not yet been analysed, therefore a confirmation of this idea is not possible at this moment.

For all Dunlins (years and sexes combined) there was a significant decline in mass with progressing starting date ($F_{1,51}$=4.08 $p=0.049$, fig. 8.2). None of the other biometric measurements showed a significant relationship with starting date. When males and females are analysed separately, mass is not significantly related to starting date.

Also for breeding (female) Curlew Sandpipers and Pectoral Sandpipers no significant relationship between any of the biometric parameters and the start of incubation was found (fig. 8.2 and 8.3).

Female pectoral Sandpiper

8.2 Egg size in relation to timing and female size

Clutch size showed very little variation, most nests contained four eggs. Some late nests had three eggs, and one Little Stint nest was found with five eggs (with one slightly lighter coloured than the others). At this nest there were no indications of more than one parent present (the adult was colour-ringed). For the analyses of egg size in relation to start of incubation the data from 2000 and 2001 were combined (fig. 8.4). Egg size was calculated as the mean volume of the four eggs. For each species we tested whether there is a relationship between egg size and starting date of incubation and if so if it was different in the two seasons.

In Pacific Golden Plovers egg size significantly decreased with starting date. ($F_{1,48}$=5.00, p=0.03). This might be caused by a greater proportion of second clutches late in the season. There was no significant difference between the two years. For none of the other species a relation was found between egg volume and starting date of incubation. In Curlew Sandpiper the data for 2000 alone showed a negative slope, but combined with data from 2001 this effect is no longer present.

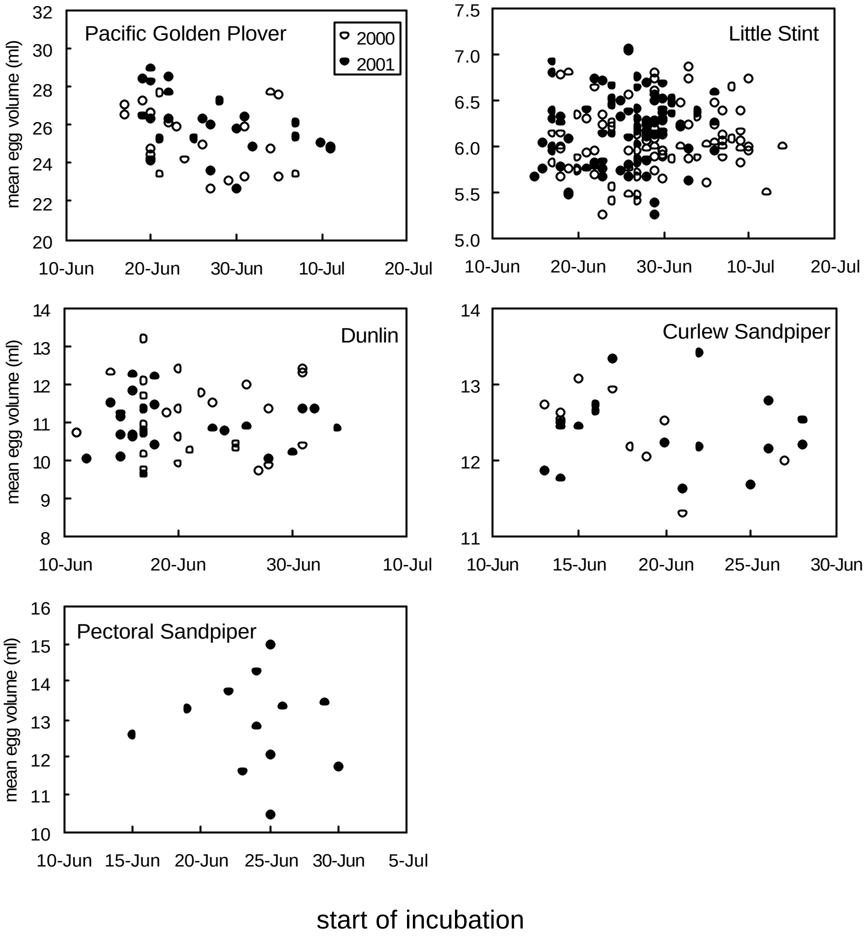


Figure 8.4. Egg size in relation to the start of incubation in Pacific Golden Plover, Little Stint, Dunlin, Curlew Sandpiper and Pectoral Sandpiper.

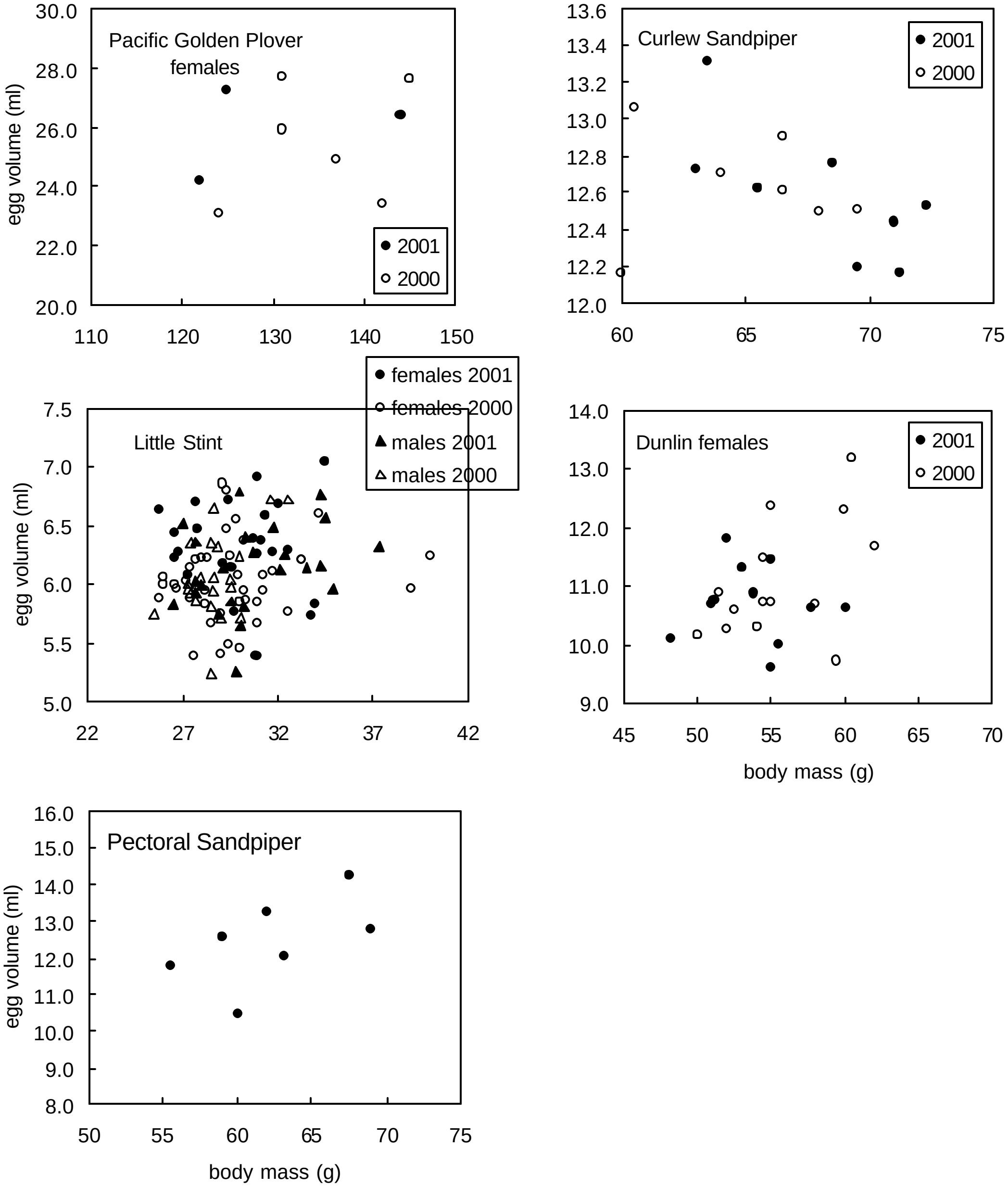


Figure 8.5. Egg size in relation to adult body mass in five waders species. For Little Stints a distinction is made between sexes (bases on plumage characteristics).

After a correction for wing length none of the species showed a significant relationship between egg volume and adult mass (fig. 8.5). Without the size correction a significant positive trend in egg volume was only found for male Little Stints ($F_{1,45}$=6.99, p=0.01). This would suggest that the heavier males find mates that produce larger eggs. Since in this species it is hardly possible to catch both mates of each pair we can not test this idea. However, because a similar relationship is lacking in females, males should use a signal other than size or mass to select a mate.

8.3 Other condition parameters

Apart from general biometrical data, also alternative condition measurements were taken. Haemoglobin levels of several species were determined during the different phases of the breeding cycle. Measurements were made with a HaemoCue B-Hemoglobin fotometer (HaemoCue, Angelholm, Sweden) using the sodium nitrite method (Vanzetti, 1966) on one droplet of blood taken from the brachial vein.

Subcutaneous fat was assessed by blowing the feathers apart in the furculum, on the belly and abdominal area. For each of these areas a class of 0-3 was given (0= no fat, 1= a very thin layer of fat, 2=a clearly visible layer but intestines still visible on belly, furculum filled up but not ‘topping up’, 3=fully covered in fat with no signs of intestines, and furculum completely filled with a ‘top’. From these three scores the average was used as an alternative measure of condition (fig. 8.6). This method could not be used in species that have a thick skin or dense cover of body feathers such as Turnstone, Pacific Golden Plover and phalaropes.

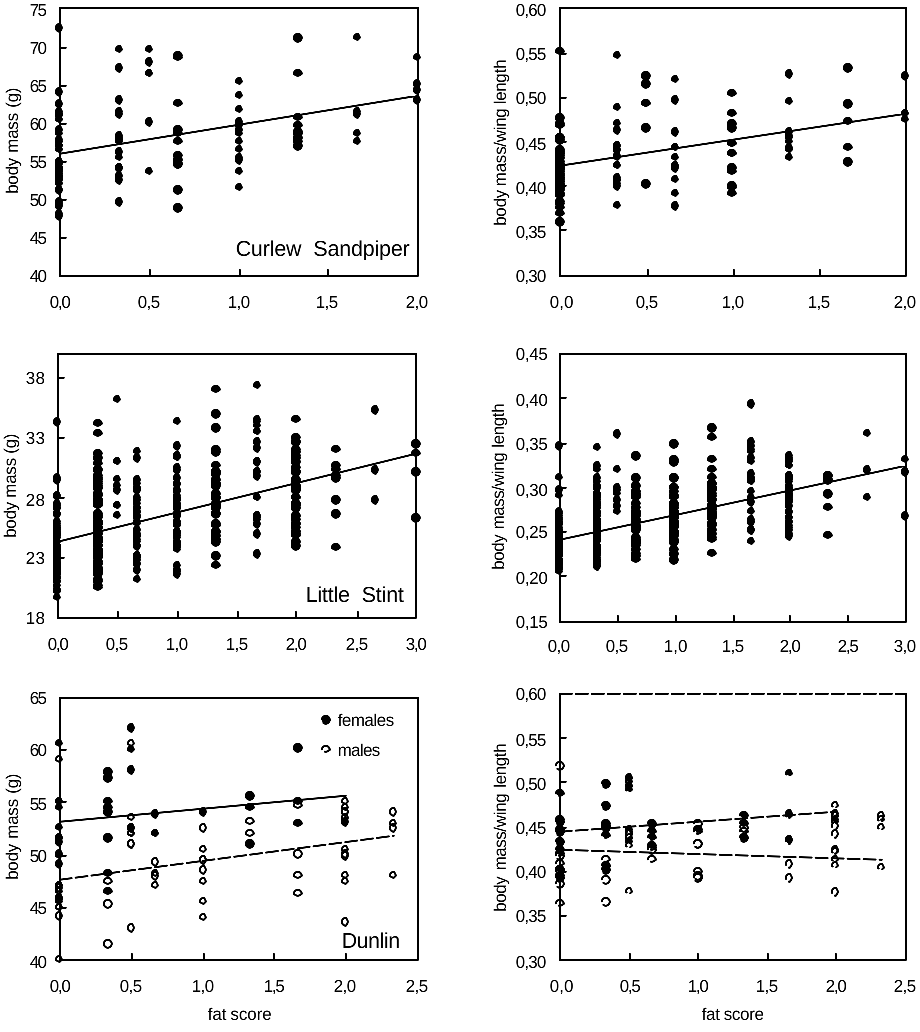


Figure 8.6. Body mass in relation to fat score (left) for three species and body mass corrected for size in relation to fat score (right) in Curlew Sandpiper, Little Stint and Dunlin. Lines are linear regressions.

Table. 8.1. Haemoglobin values (mmol/l) for different wader species in different periods of the breeding cycle.

species	class	sex	average	sd		n
Dotterel	spring migration	females	12.84	0.66	11	
		males	12.51	0.54	8	
	incubation	males	12.30		-	1
	total		*12.68*	*0.61*	*20*	
Turnstone	spring migration	females	11.93	0.66	4	
		males	12.66	0.35	5	
	total		*12.33*	*0.61*	*9*	
Red Knot	spring migration		12.63	0.12	3	
Sanderling	spring migration	males	12.15	0.64	2	
Little Stint	spring migration	?	11.60			1
		females	11.52	0.16	5	
		males	11.52	1.32	11	
	incubation	?	11.40		-	1
		females	11.07	0.75	18	
		males	10.79	0.69	17	
	with chicks	males	11.17	1.25	6	
	autumn migration		11.83	0.86	17	
	all		*11.29*	*0.94*	*76*	
Pectoral Sandpiper	incubating	females	11.45	0.54	6	
Dunlin	spring migration	females	11.60		-	1
		males	12.18	0.48	6	
	incubation	females	11.76	0.60	11	
		males	11.28	0.66	11	
	with chicks	females	12.40		-	1
		males	10.60	0.57	2	
	autumn migration	males	12.37	0.42	3	
	all		*11.68*	*0.71*	*35*	
Curlew Sandpiper	spring migration	females	12.41	0.60	13	
		males	13.05	0.60	13	
	incubation	females	11.04	0.61	8	
	autumn migration	females	12.21	0.90	9	
	all		*12.31*	*0.95*	*43*	

The relationship between fat class and body mass was significant in Little Stints ($F_{1,411}$=82.68, p<0.001), after correction for structural size (wing length $F_{1,411}$=42.36, p<0.001) and age class ($F_{1,411}$=296.66, p<0.001). In Dunlin fat class was not a good predictor for body mass, only wing length related significantly to body mass ($F_{1,80}$=35.71, p<0.001). In Curlew Sandpipers a positive relationship existed between body mass and fat class ($F_{1,112}$=16.90, p<0.001) after correction for structural size (total head $F_{1,112}$=23.93, p<0.001) and differences between age classes (juveniles have lower mass than adults $F_{1,112}$=4.48, p=0.037).

Haemoglobin concentrations ranged between 8.9 and 14.2 mmol/l. (overall average=11.8, sd=1.0, another unit often used in literature is g/100 ml, 1 mmol=16.10 g, so range equals 14.3-22.9 g/100 ml). Mean values were highest for Dotterel and Red Knot and lowest for Little Stint (table 8.1). On an interspecific level there was a trend of increasing haemoglobin concentrations with size, both when including all different phases (species: $F_{7,170}$=12.17, p<0.001, phase $F_{3,170}$=12.67, p<0.001) and within each phase. In multiple linear regressions the relationships between haemoglobin levels and body mass were investigated after (if necessary) corrections for size (wing or bill length, depending on which measurements yielded the best fit). Other condition measures were also tested for, such as average fat score and number of parasites, but if an effect was found, body mass always turned out to give the best fit. Also haemoglobin differences between sexes and/or stages (migrating, incubating or chick-rearing) were tested for. Models were investigated using the SELECT directive in Genstat (Genstat 5 Committee, 1993).

In general, haemoglobin levels were higher during migration (both spring and autumn) than during the breeding phase itself (table 8.1, figs 8.7 to 8.11). For Dotterels a significant negative relationship was found between body mass and haemoglobin (fig. 8.7, $F_{1,17}$=5.23, p=0.035). Also values were lower for males than for females ($F_{1,17}$=5.40, p=0.033). However, the sexing in this species was difficult and based on plumage characteristics only. Haemoglobin levels in migrating Turnstones could not be explained by any of the parameters, although there was a near significant difference between the sexes with higher values in males (fig. 8.8). Red Knots had relatively high values but only three birds were caught. Sanderlings had higher values than the overall average. In Little Stints significant differences were found (after correction for size $F_{1,71}$=4.40, p=0.040, increasing effect with size fig. 8.9) between the stages of the breeding cycle, with higher values for migrating birds ($F_{1,71}$=12.13, p<0.001). As females are generally larger the size effect could also represent a sex effect. No relationship with body mass was found within the breeding or migrating birds. When, however the migrating birds caught in autumn were considered separately, haemoglobin concentration was positively related to body mass ($F_{1,15}$=8.71, p=0.010). Haemoglobin levels in Pectoral Sandpipers showed no effect of body mass, but sample size was very small. In Dunlins a significant positive effect of body mass was found ($F_{1,31}$=4.50, p=0.042, fig. 8.10) taking differences between stages into account ($F_{1,31}$=7.65, p=0.009, fig. 8.8). Curlew Sandpipers showed (after correction for size $F_{1,42}$=24.92, p<0.001) a significant positive effect of body mass ($F_{1,42}$=5.49, p=0.024, fig. 8.11) and differences between stages (with haemoglobin values for spring migration being intermediate to those of autumn migration and incubation). Within the birds caught during spring migration males had significantly higher haemoglobin levels than females ($F_{1,25}$=8.04, p=0.009), a finding also reported by Prinzinger & Misovic (1994).

Concluding, we can say that haemoglobin concentrations show large variations between the migrating and breeding stage. Concentrations are especially high during phases when hard muscle work is needed, such as long-distance flights. In Bar-tailed Godwits, caught in the Wadden Sea, preparing for long-distance migration, Piersma *et al.* (1996) found a gradual increase in haemoglobin concentrations in the days before migratory departure. Haemoglobin concentrations found in premigratory Bar-tailed Godwits (mean 12.00 mmol/l) are very similar to those found in our study. Within phases, a significant positive relationship with body mass is found in Little Stint, Dunlin and Curlew Sandpiper, but a negative relationship in Dotterel. Piersma *et al.* (1996) also found a significant increase of haemoglobin concentration with body mass.

A pair of Curlew Sandpipers caught on spring migration

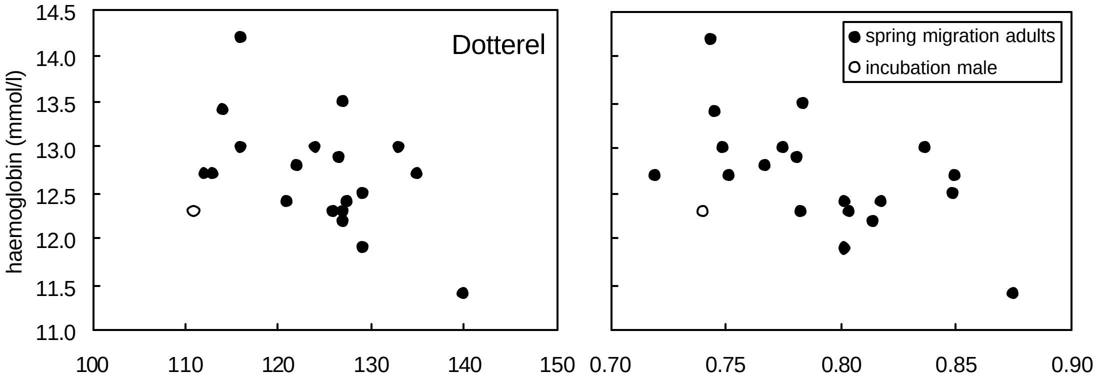


Figure 8.7. Haemoglobin concentration in blood in relation to body mass for Dotterel.

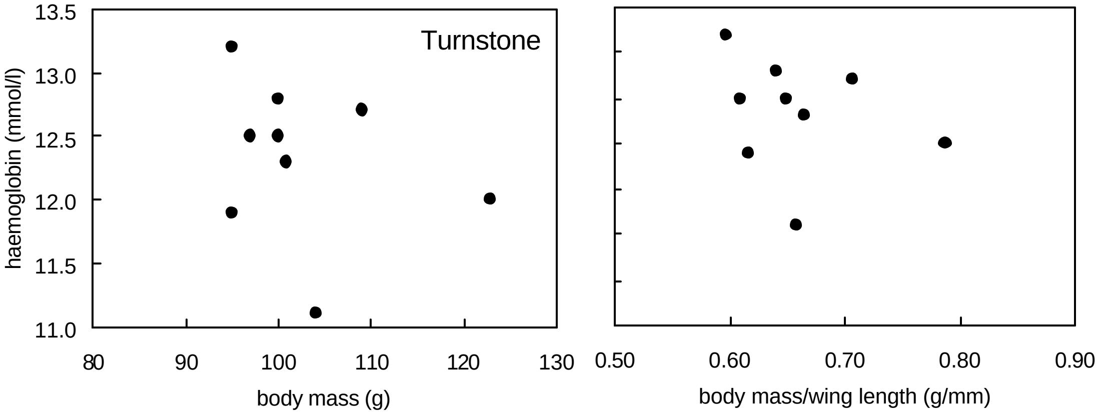


Figure 8.8. Haemoglobin concentration blood in relation to body mass for Turnstone.

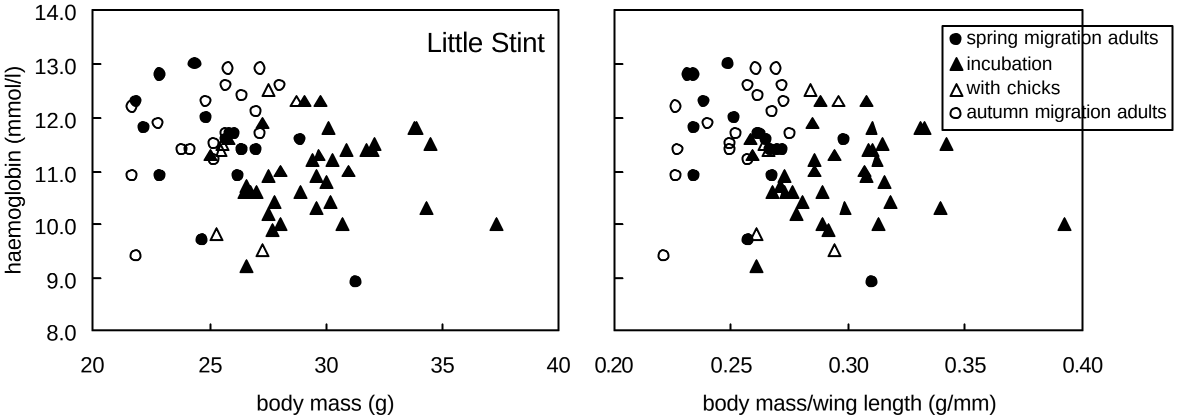


Figure 8.9. Haemoglobin concentration in blood in relation to body mass for Little Stint.

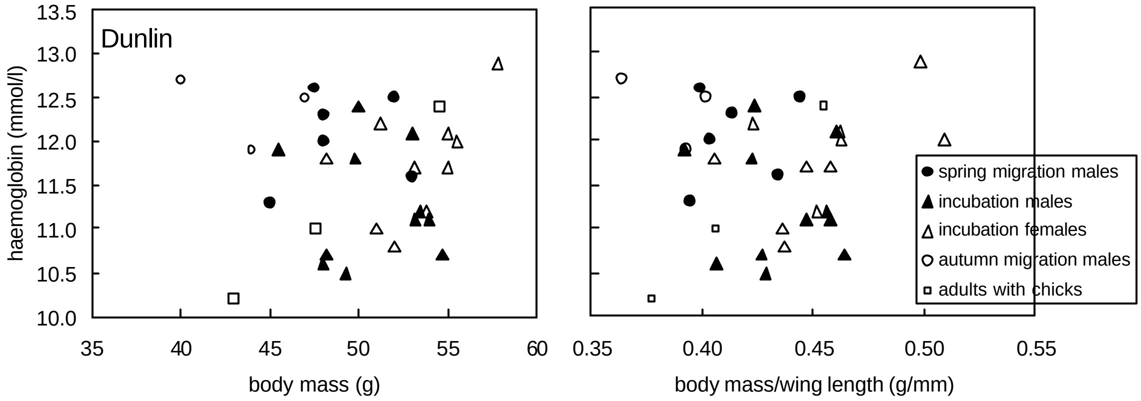


Figure 8.10. Haemoglobin concentration in blood in relation to body mass for Dunlin.

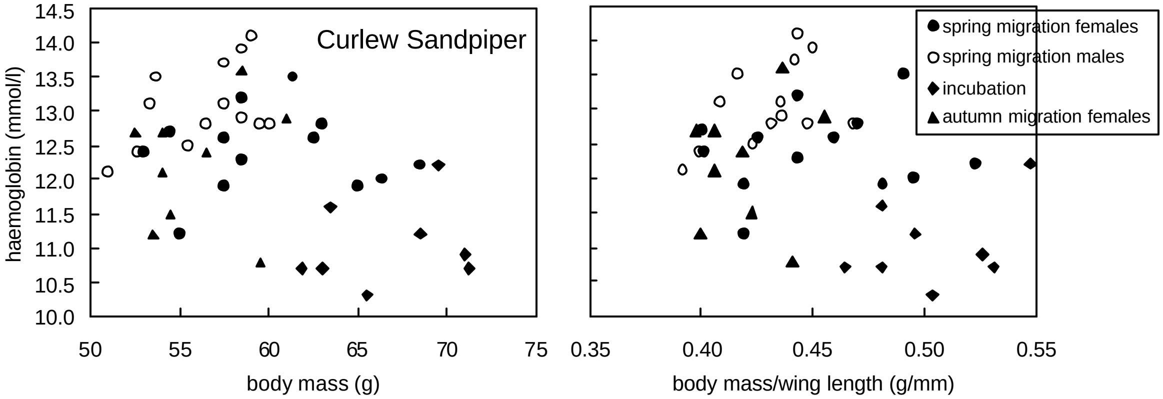


Figure 8.11. Haemoglobin concentrations in blood in relation to body mass for Curlew Sandpiper.

Growth of wader chicks

9 Growth of wader chicks

9.1 Methods

On the expected hatching date, nests were visited to ring and measure the newly hatched young. Afterwards, chicks were retrapped whenever a known family (with colour-ringed adult) was encountered and new families (of which we did not find the nest) were also caught and ringed. Chicks of known families were caught as often as possible to measure growth over intervals of several days. The presence of chicks can be easily deduced from the adults' behaviour. Using alarm calls they warn their chicks that crouch until danger has disappeared. Chicks were searched for by looking from a distance until the parent bird stopped alarming and chicks started moving again. Using the chicks, the unringed parents of new families could often be caught, because of their urge to brood the young. This only works under cold conditions, otherwise the chicks do not cool down and stay quiet. Only in Little Stint and Dunlin, enough recaptures were made to search for patterns with weather and/or food abundance.

Because mass growth is not linear in shorebirds but follows an S-shaped curve, growth rates of chicks at different ages and over different intervals cannot be compared directly. Therefore, growth rates were transformed to an index, by dividing the observed growth by the growth expected over the same interval from logistic curves based on published growth data (Dunlin: Soikelli, 1967; Little Stint: Schekkerman *et al.*, 1998a). Hence, a growth index of 1 means that chicks grew exactly as fast as expected from this curve, while 0 denotes that chicks did not grow at all, and negative values indicate mass loss. These growth indices were used to analyse the dependence of growth rate on temperature and food availability (surface-active arthropods, chapter 11) during the recapture interval. Since wader chicks often loose mass during the first day(s) after hatching, and this is not reflected in the fitted standard growth curves, growth indices for chicks first weighed when less than a day old (often still in the nest) tend to be lower than those for older chicks. Therefore, we analysed neonates (<5 g, resp. <8 g at start of recapture interval) and older chicks separately.

Especially in families with older chicks, that do not need brooding so often, chicks are not easily seen and it is very difficult to count exact numbers of chicks in each family. As a crude measure of brood survival, we used the probability that a brood of small chicks was recaptured or seen again (with marked adult) two days or more after the initial capture. Up to the last days of July and less frequently into early August, the study area was searched almost every day, especially the sites that were most preferred by broods (marshes, valleys with streams). Hence, while an absence of repeat observations for a brood is no proof that the chicks did not survive for long, it certainly is an indication.

9.2 Results and discussion

Figure 9.1 shows the mass development of the subsample of Dunlin and Little Stint chicks of which the age was known because they where ringed when still in the nest, with published growth curves for the species shown for comparison. Little Stints in 2001 grew somewhat more slowly than the average curve based on data from several years and sites in Taimyr. The few observed fledging weights (at 15-20 days) were a little lower than the 23.8 g reported by Schekkerman *et al.* (1998). The mean mass of juveniles caught while departing from Taimyr on autumn migration in 2001 was 23.2 g, somewhat below the estimated asymptotic mass of 26.4 g.

The few growth data of known-age Dunlin can be compared only to a published growth curve for the Baltic subspecies *C.a. schinzii*, which is slightly smaller than the form occurring on Taimyr (*C.a. centralis/alpina*). That most Dunlin points lie above the published curve, may thus be explained by the chicks growing towards a larger asymptotic mass.

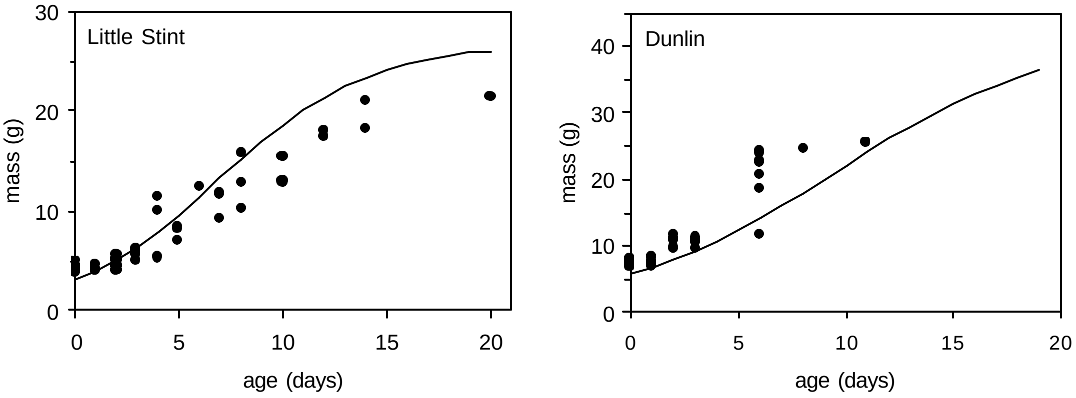


Figure 9.1. Development of body mass in chicks of Little Stint and Dunlin of which the exact age was known (ringed when still in the nest; dots). The lines show published growth curves for these species (Little Stint: from Taimyr, Schekkerman et al., 1998; Dunlin, C.a. schinzii *from Finland, Soikkeli, 1967).*

Figure 9.2 shows growth rates over recapture intervals, in relation to mid-interval date and arthropod availability. To provide a background, the mean arthropod biomass and temperature over recapture intervals are also shown in relation to date. In both species, chick growth rate was positively related to arthropod availability. Because the average arthropod biomass declined strongly with mid-interval date, especially after 15 July, chicks grew more slowly as the season progressed. These relationships were more clearly expressed in very young Little Stints than in older ones, but about equally strong in both groups of Dunlins. Also in both species, the reduction in growth rate with date was paralleled by a declining probability that broods with young chicks (up to *c.* 4 days) were recaptured or seen again at least two days later. This indicates that the declining arthropod availability affected chick survival.

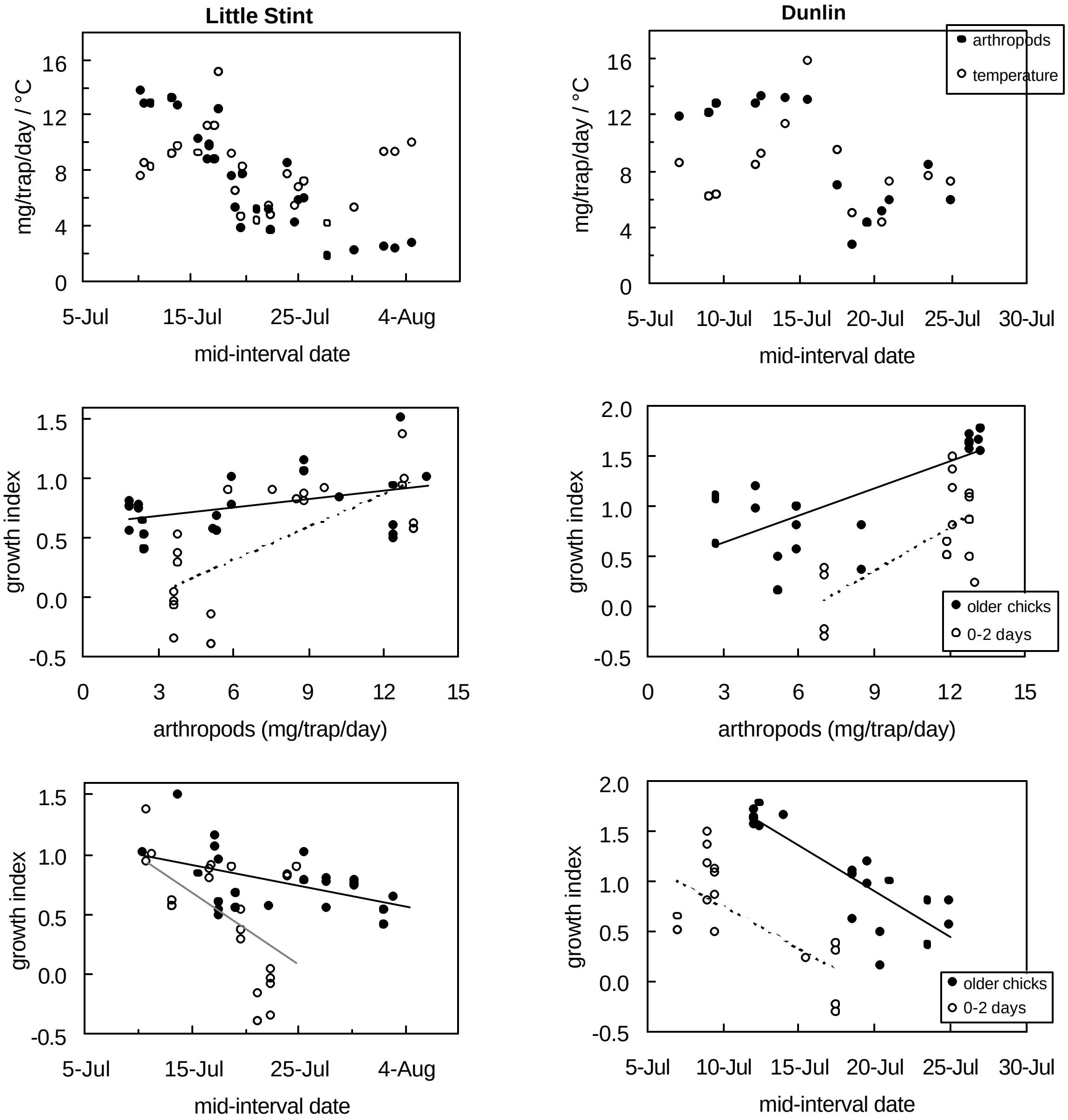


Fig. 9.2 Upper two graphs: food availability and temperature in the different intervals in which chicks were recaptured for Little Stint (left) and Dunlin (right). Growth index over recapture intervals in relation to arthropod availability (middle two graphs) and mid-interval date (lower twp graphs). Data are from 2001 only. For the explanation of growth index see text.

Growth rates of chicks may be influenced both by the availability of surface-active arthropods (affecting feeding success) and by temperature (affecting energy expenditure and the time available for foraging instead of being brooded by a parent). Temperature showed a less clear trend with date than arthropod availability. Regression analyses suggested that arthropod biomass was a better predictor of growth rate than temperature. This was also found in another arctic-breeding wader species, the Red Knot (Schekkerman *et al.* MS).

In summary, our data show that Little Stints and Dunlins in 2001 hatched late in relation to the seasonal peak in arthropod availability, which occurred relatively early in this year. Growth rate, and probably also survival, of chicks suffered accordingly. It is therefore likely that breeding success would have been higher if the birds could have achieved a better match between hatching and growth of chicks and the food peak.

Juvenile Little Stint, ready to leave the tundra on migration

10 Return rates, nest site fidelity and mate retention in Dunlin and other waders

10.1 Return rates

Throughout the season, colour-ring combinations of waders observed were read whenever possible. These data allow calculation of return rates, defined as the number of previously marked individuals observed in the study area in 2001, divided by the number marked in 2000. Because birds marked during the pre- and postbreeding migration periods in 2000 may have originated from breeding sites well outside the study area (none were seen in 2001), only birds marked as breeders in the study area have been used in the calculation. The return rate is the product of the probabilities of (1) surviving between summer 2000 and summer 2001, (2) returning to the study area when alive and (3) being noticed while present in the study area. Sixteen out of 18 Dunlins, 9 out of 11 Pacific Golden Plovers and 2 out of 3 Turnstones resighted in 2001 were seen more than once during the season, so we think that the resighting probability (3) was high for most species, but this can be confirmed quantatively only with more than two years of data.

In Pacific Golden Plover, Dunlin and Turnstone, more than half of the individuals marked in 2000 returned to the area in 2001 (table 10.1). In contrast, none of the Little Stints and Curlew Sandpipers were resighted in 2001, indicating that breeding site fidelity is absent in these species. Although the species is not colour-marked in our study, in 2001 Ringed Plovers with metal rings were observed at 2-3 sites where birds had been ringed in 2000, indicating that some degree of breeding site tenacity also occurs in Ringed Plovers. These findings agree with those of Tomkovich & Soloviev (1994).

Table 10.1 Return rates of waders in the study area between 2000 and 2001. Sex differences in return rates were tested with X^2-tests.

species	sexes combined				sexes separate			sex difference
	marked 2000	seen 2001	%	sex	marked 2000	seen 2001	%	
Pacific Golden Plover	17	12	71 %	males	9	7	78 %	$X^2=0.48$
				females	8	5	63 %	$P=0.49$
Dunlin	35	22	63 %	males	21	15	71 %	$X^2=1.64$
				females	14	7	50 %	$P=0.20$
Turnstone	3	2	67 %	males	2	1	50 %	
				females	1	1	100 %	
Little Stint	78	0	0 %					
Curlew Sandpiper	8	0	0 %					

In Pacific Golden Plovers, slightly more males than females were resighted, but the difference was far from significant (table 10.1). Johnson *et al.* (2001) found that return rates were much lower for females (25%, n=16) than for males (77%, n=60) in an Alaskan study site. One of the males resighted in 2001 had been ringed in our study area in 1996 (and controlled in 2000). Among the birds newly caught in 2001, one male had been ringed in the area as long ago as 1994, and wore two faded colour-rings. This bird was also seen in 2000, as was another male with old colour-rings from the same year, that bred close to the station in both 2000 and 2001 but was not caught in either year. Hence, at least two males have been present in (or returned to) the study area for at least eight years and one for at least six years. These observations suggest that return rate is male-biased at Medusa Bay too, but the 1994 birds were not included in table 10.1 as the incomplete colour-marks may no longer be individually exclusive.

In Dunlin, there was some indication for a sex difference in return rate although it was not significant; males being resighted more often than females. A higher site fidelity in male Dunlins was also found in Sweden (Jönsson, 1991) and Britain (Jackson, 1994), but hardly so in Germany (Heldt, 1966) and Finland (Soikelli, 1970). In these studies, male return rates varied from 56 to 90%, and those in females from 48 to 77%.

The number of Turnstones resighted is too small to comment on sex differences.

Colour-ringed Dunlin

10.2 Mate retention

At the end of the 2000 breeding season, there were three Pacific Golden Plover pairs of which both partners were colour-ringed. All birds returned in 2001. Of one pair, it remained unclear whether they again formed a pair in 2001 (seen together once, but female also once seen with a different male); one pair reunited and one pair did not (female mated to different ringed male, former male's status unknown).

Eleven Dunlin pairs were fully colour-marked in 2000. Of two of these pairs, neither partner was resighted in 2001, of four only the males were seen, and of one only the female. Of the four pairs of which both sexes returned, three stayed together and one split up; both ex-partners found a new mate. Hence, in five out of six known cases of pair break-up, one of the partners did not return to the study area. Interestingly, the case of divorce in proven surviving birds occurred already in the breeding season of 2000: after losing their first clutch to predation, the female produced a second clutch with a different male. In 2001, the female, the first and the second male all paired with yet different partners.

10.3 Nest site fidelity

In total 15 matches could be reconstructed between Dunlin nests sites in the two years. On average the distance between the nest in 2000 and 2001 was 175 m (sd=147 m, n=13). This value is excluding two extreme distances of two birds mated with another bird after they lost their clutch in 2000 (the divorce case, see 10.2) for which the distances between the second nest in 2000 and the nest in 2001 were 2111 m and 2189 m. Distances between first and replacement clutches within the same season (data from 2000 and 2001 combined) averaged 152 m (sd=78 m, n=6, also excluding the extreme two cases).

In Pacific Golden Plovers eight matches could be made between nests of both years resulting in a mean distance of 168 m (sd=167 m, n=8). The two replacement nests of which the location and parents were known in 2000 and the single replacement nest in 2001 were on average 219 m apart (sd=137 m, n=3) from the first nest.

10.4 Assortative mating in Dunlin?

In 2000 and 2001, both partners were caught, ringed and measured in a total of 22 Dunlin pairs. These data were used to investigate whether Dunlins seem to choose mates randomly or assortatively with respect to body measurements, mass, moulting schedule or feather mite loads (fig. 10.2). This was examined by plotting these parameters for males and females within pairs. Some individual birds occur more than once in the dataset, but each time in a different pair combination. None of the parameters showed a significant within-pair correlation, except tarsus length ($p<0.01$), but that correlation was only apparent in 2000. This indicates that mating was essentially random with respect to the parameters examined.

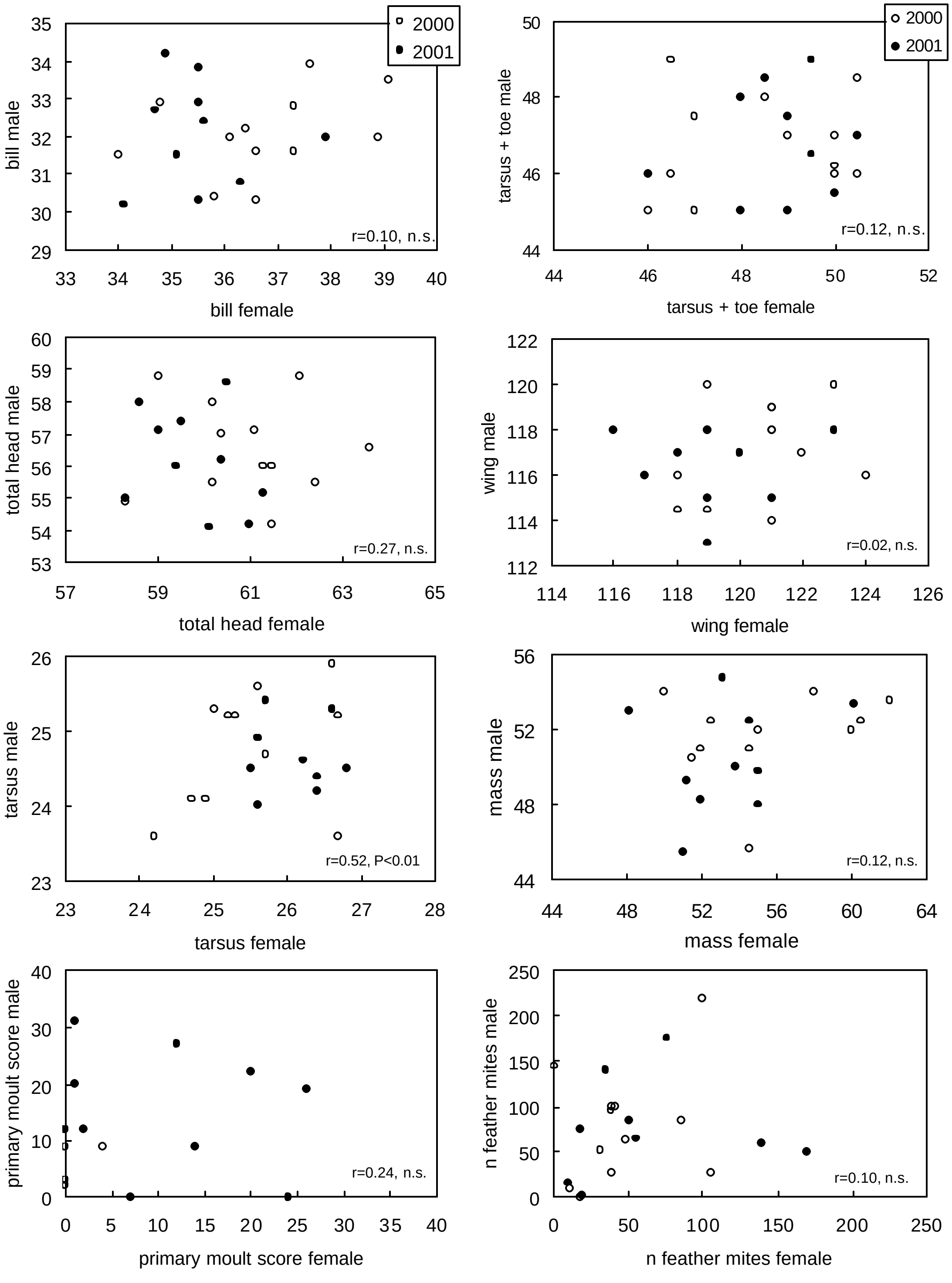


Figure 10.2. Relationships between body size measurements of Dunlin pair mates for the combined data from 2000 and 2001. Correlation coefficients are shown in bottom right corner of graphs.

Male Dunlin brooding chicks

Digging holes for pitfall traps in the permafrost

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 (∅ 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 additionally used to analyse variation in arthropod abundance related to season and weather. These lines were situated close to camp and emptied daily between 22:00 and 24:00 between 10 June and 9 August. Pitfalls could not be dug in earlier because of the permafrost. One line (dry) was situated on top of a hill close to the station in relatively dry, frost-heaved tundra. The other (wet) line was placed in a depression, where snow melt was late, in a marshy area with sedges and grass. Each day the samples were sorted to family level in the station and the length of each individual was estimated 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

From the very first sample day, arthropods were present in the pitfalls. In 2001 the numbers (and total dry mass) increased gradually and reached a peak in the second week of July (fig. 11.1). Numbers declined thereafter and by the end of the season daily numbers caught were similar to early in the season. This pattern is very unlike that found in 2000 (fig. 11.2), when numbers increased very slowly and still did not seem to have reached a peak in early August. In the pattern for arthropod biomass, the mid-summer maximum is even more pronounced than in total numbers, indicating that in early July not only the number, but also the mean size of arthropods caught is larger than at the beginning and the end of the season. As expected and known from other years/studies (Maclean & Pitelka, 1971, Tulp *et al.*, 1997, 1998, 2000) numbers were strongly correlated with temperature and the occurrence of precipitation (rain in most cases, fig. 11.1). In periods of prolonged rain (around 16 June, early July and late July through to early August) numbers of arthropods caught were strongly reduced.

In a loglinear regression analysis investigating seasonal and weather effects on the number and dry mass of arthropods, date + date^2 (together describing a parabolic curve) and mean temperature and precipitation were significant predictors (table 11.1). Wind speed did not contribute significantly to the model. As seasonal effects and weather effects are highly correlated it is difficult to distinguish between them. After correction for season, the remaining variation can partly be explained by weather variables and vice versa (fig. 11.3). The models describing variation in dry mass and numbers both resulted in a peak on 7 July.

The arthropod numbers in the dry series show a more clear cut seasonal pattern than the numbers in the wet series (fig. 11.4). On average numbers in both lines were comparable but the distribution over groups was different (fig. 11.6). Spiders (Araneae) and flies (Diptera: Brachycera & Cyclorrapha) were more abundant in the wet than in the dry series, while midges (Nematocera, including Craneflies (Tipulidae)), wasps (Hymenoptera), beetles (Coleoptera) and) occurred in higher numbers in the dry series. For most groups the timing in the wet series was slightly later than in the dry series.

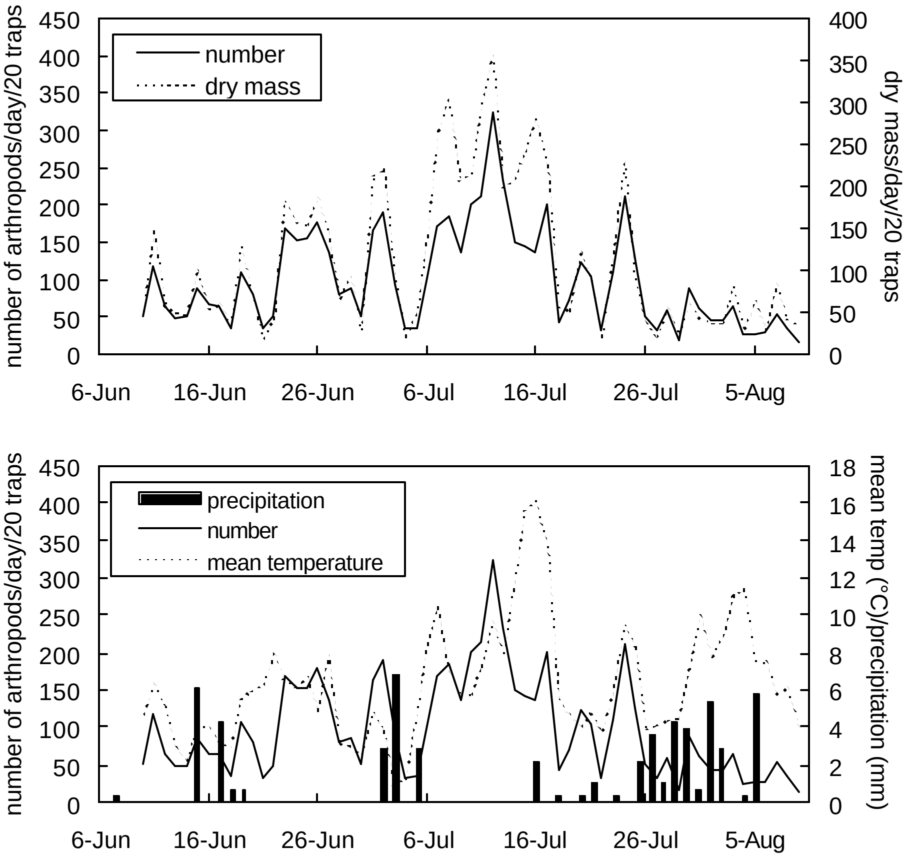


Figure 11.1. Seasonal pattern in total number and dry mass of arthropods (upper) and mean temperature, precipitation and total number of arthropods (lower).

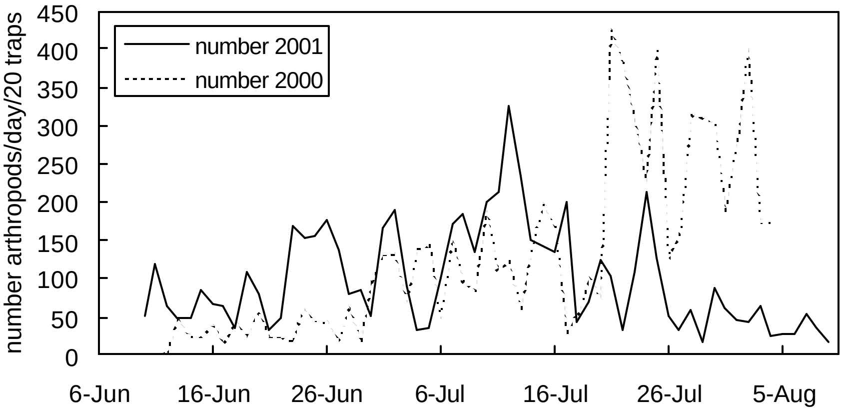


Figure 11.2. Seasonal pattern in total number of arthropods in 2000 and 2001.

If the supply of arthropods that emerge in one summer is finite, the cumulative number of arthropods plotted against the cumulative temperature should become asymptotic. This is true for 2001 but not for 2000. Despite the later season and lower total temperature sum of 2000, the cumulative number of arthropods over the season was higher than in 2001. When the wet and dry series are considered separately, the cumulative number of arthropods was higher in the wet series than in the dry series in 2000 but the pattern was reversed in 2001. The increase with temperature was highest in the dry series in 2001 and in the wet series in 2000.

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 using the SELECT directive. The variables tested included: day since 1 June (date and date^2, together describing a parabolic curve), mean air temperature (°C), mean wind speed (m/s) and the amount of precipitation (prec). Date + date^2 were included first, where after the weather data were included.

response variable	model	(change in) deviance	(change in) df	P	coefficient	se
number/	null model	2531	60			
20 pitfall traps/day	final model	1511	4			
	constant				3.625	0.229
	date	64	1	0.066	0.035	0.008
	date^2	1016	1	<0.001	-0.14×10^{-6}	0.24×10^{-7}
	temp	233	1	<0.001	0.053	0.016
	prec	197	1	<0.001	-0.132	0.043
total dry mass/	null model	3831	60			
20 pitfall traps/day	final model	2330	4			
	constant				3.548	0.266
	date	51	1	<0.001	0.035	0.009
	date^2	1404	1	<0.001	-0.14×10^{-6}	0.29×10^{-7}
	temp	635	1	<0.001	0.083	0.018
	prec	238	1	<0.001	-0.140	0.051

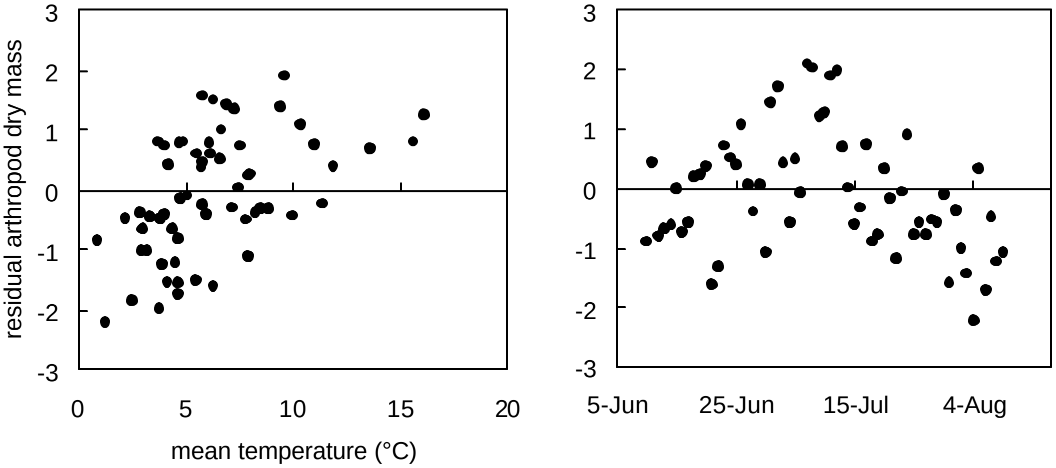


Figure 11.3. Residuals of the regression of dry mass of arthropods caught in pitfalls with residuals of the regression of dry mass with date and date^2 *as explanatory variables in relation to mean temperature and precipitation (left) and temperature and precipitation as explanatory variables in relation to date (right).*

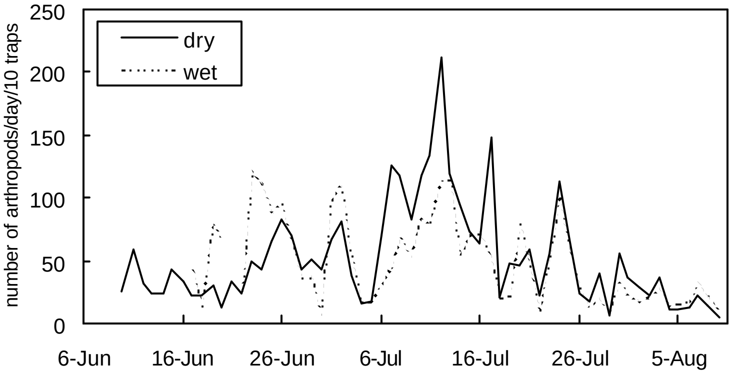


Figure 11.4. Seasonal pattern of arthropods for the dry and the wet series separately.

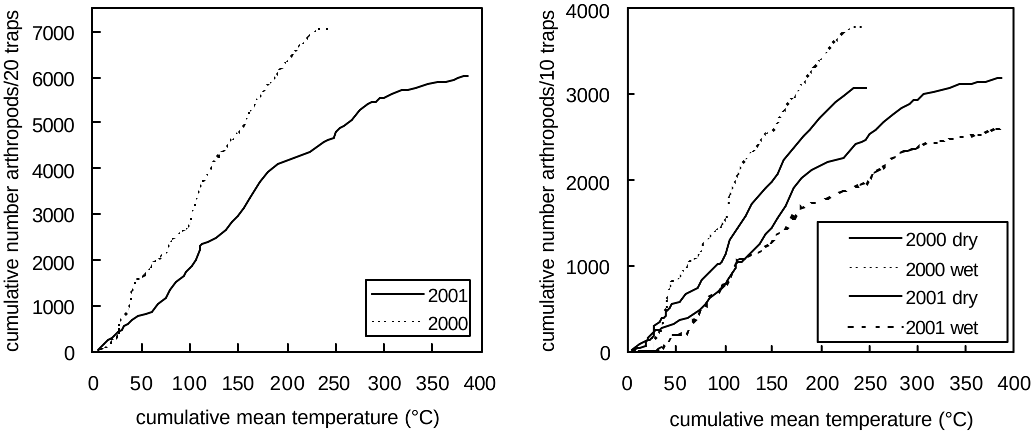


Figure 11.5. Cumulative total number of arthropods in 2000 and 2001 plotted against cumulative mean temperature for the two series combined (left) and for the wet and dry series separately (right).

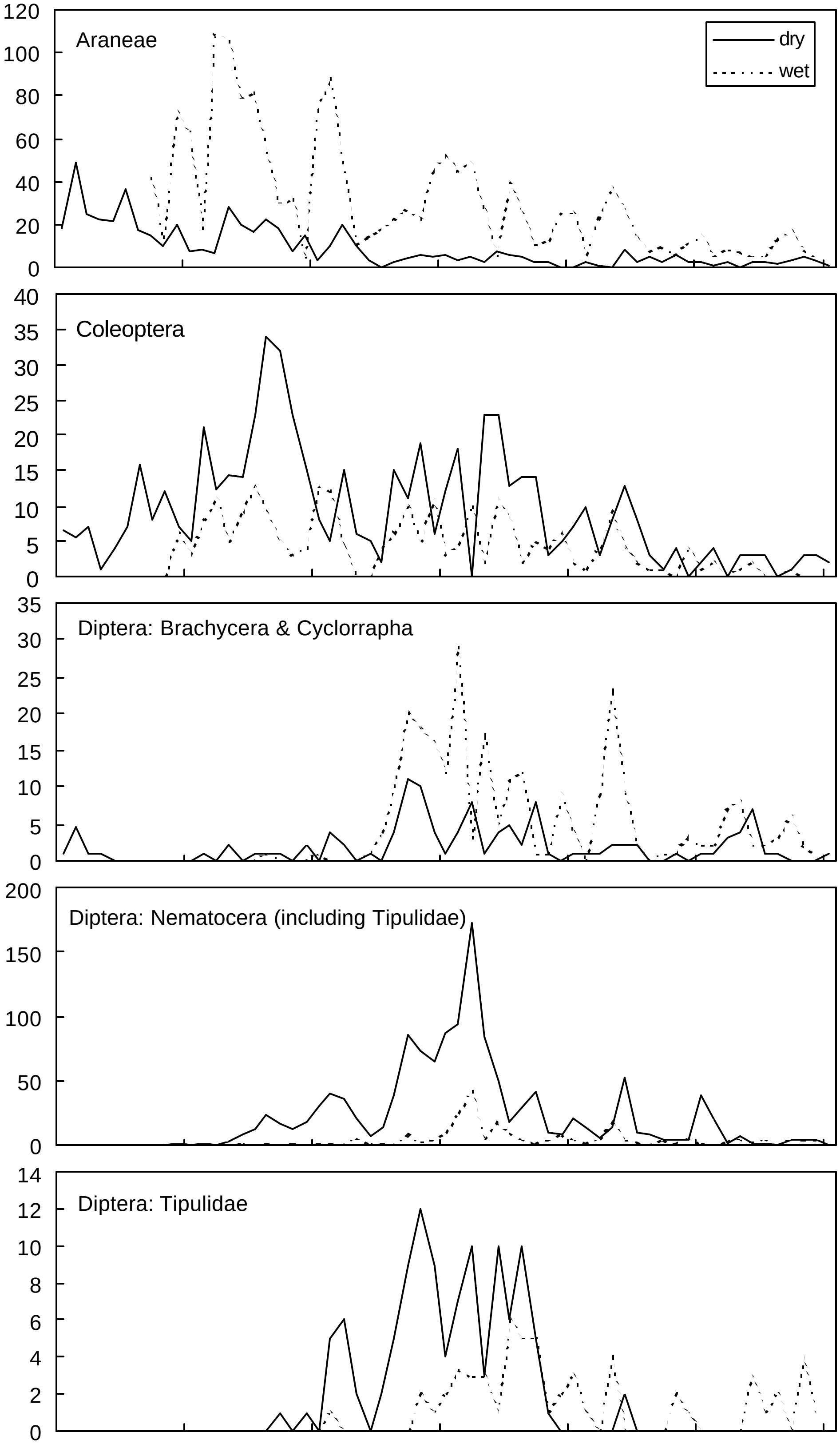


Figure 11.6. Seasonal pattern (numbers per 10 traps per day) of several groups of arthropods for the dry and the wet series separately.

11.3 Reduced wings in craneflies

The occurrence of craneflies without wings or with reduced wings is typical of arctic regions (Chernov, 1985). In the analyses of the arthropod samples we made distinctions between male and female craneflies *Tipula carinifrons* and recorded whether they had wings or were wingless. Winglessness (or reduced wings) appeared nearly exclusively in females. Strikingly in the dry series nearly all females were wingless, while in the wet series one third of the females caught had wings. The reduction of wings in females has been explained as an energy-saving adaptation. Males, however do need wings to take them to the females to fertilize them. Why a relatively large proportion of the females in wet areas had wings is unclear.

Table 11.2. The occurrence of winglessness (%) in Tipulida carinifrons caught in the two different series in the total sampling period.

	females no wings	wings	% wingless	males no wings	wings	%wingless
dry	56	7	89	1	41	2
wet	19	10	65	0	26	0
total	75	18	81	2	73	1

The majority of females with wings only occurred only occurred early August in the wet series (fig. 11.7). This influx of females with wings was not seen in the dry series.

A female cranefly laying eggs

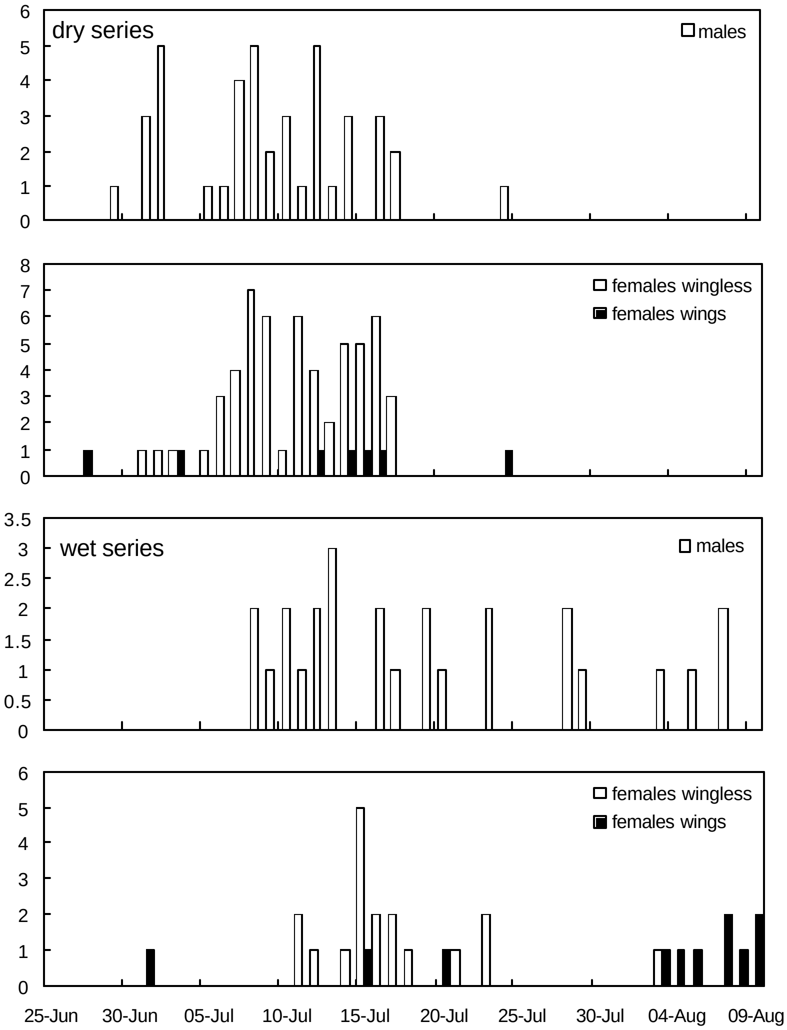


Figure 11.7. Daily number or male and female (wingless and with wings) Tipula carinifrons *the dry and wet pitfall trap series.*

11.4 Wader breeding phenology in relation to arthropod availability and snow melt

Upon their arrival in the tundra in the first two weeks of June, shorebirds generally find the largest part of the tundra surface still covered in snow. However, the year-to-year variation in snow cover exactly in the period when most birds need to start choosing territories in order to attract a mate is very large (fig. 11.8). For instance on 5 June 2000 not even half of the study area was snow-covered, while in 2001 over 80% was covered on the same date. Also the rate at which snow disappeared was different, with rapid snow melt in 2001 due to warm weather, resulting in a practically snow-free tundra by 15 June. In contrast, in 2000, characterised by a very cold June, this stage was only reached in the last week of June, and in 1996 only in the last days of June (Tulp et al., 1997). Even comparing only these few years it is striking how large variation in arrival conditions is.

As the occurrence of surface-active arthropods is highly correlated with weather conditions, the summer peak in abundance also shows variation between years (fig. 11.8). Despite this variation, the timing of shorebird breeding was highly similar between the two years. The median hatching date was two and three days earlier for Curlew Sandpipers and Dunlin respectively in 2001 compared to 2000. In Pacific Golden Plovers the median hatching date was exactly the same, while it was two days earlier for Little Stints. The larger proportion of replacement clutches in Dunlin and Little Stint in 2000 could be causing this difference. As a result of the relatively late peak in arthropod abundance in 2000 most chicks were born when food was abundant. In 2001 however, numbers of arthropods were already declining by the time that the first chicks hatched. Especially since chicks need most food from their second week of life onwards, food might become limited for the growing chicks. The relationships found between growth and food availability, and between ringing date of new broods and their chances of being recaptures in a later stage, indicates that late hatching chicks indeed have problems in finding enough food (chapter 9).

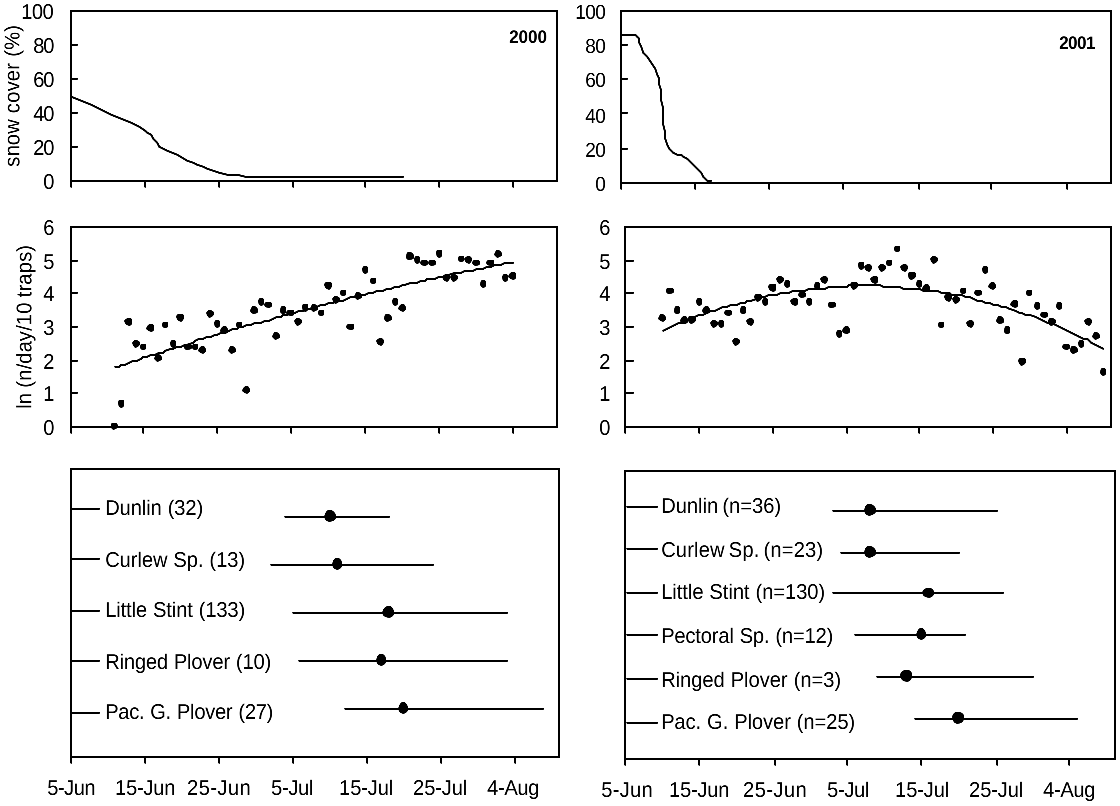


Figure 11.8 Breeding phenology (bottom) in relation to snow melt (top) and arthropod abundance (middle) in 2000 and 2001. In the lower graph lines indicate ranges of hatching dates and dots represent median hatching dates.

12 The larger picture: where do we go from here?

The research program as carried out in 2000 and 2001 (and to be continued in 2002) aims at investigating the constraints waders face in the arctic breeding season. Time is limited due to the short arctic summer. Energetic bottlenecks within the season may be different for species with different breeding systems. The selective forces acting upon the timing may also be different for adults and chicks. As far as they emerge from the data collected in the first two years, these selective forces are illustrated in figure 12.1.

Upon arrival of the birds, the tundra is still largely covered in snow and nesting can only begin once the first snow-free patches appear. Also, because the waders seem to collect the nutrients needed to produce eggs locally (Klaassen *et al* 2001), they are in need of feeding sites as soon as they arrive. In this period adult birds feed on soil invertebrates such as (tipulid) larvae and lumbricids along the edges of the melting snow fields. Although in territorial species competition for the best sites may lead to a selection for early arrival (Kokko, 1999), there may also be a severe (survival) cost in years when snow melts late or the tundra surface freezes up for several days after arrival of the birds. This would press the optimal arrival date backwards.

Soon after snow melt the first arthropods emerge from the soil and availability of this food source increases. By the end of June, most clutches have been laid and adults that spend most of their time on the nest in this period may benefit from the increasing abundance of surface-active invertebrates. When the first chicks are born in the first or second week of July, in many years the abundance of surface-active arthropods reaches its maximum. This means that a large proportion of chicks is in fact born too late: food is already declining again when energy requirements of the growing chicks are highest. On the other hand, adults of species that take care of the clutch and brood alone (Little Stint, Pectoral and Curlew Sandpipers, phalaropes) may face a feeding time contraint due to the incubation requirements of the clutch, and they might want to synchronise incubation with the insect peak. Their feeding time is likely to be less constrained in the chick period: they can feed whenever the chicks feed. For species in which both parents incubate the eggs (Dunlin, Turnstone, plovers), this might be different.

After the chicks fledge they are left by the parents. Brood desertion by one sex (Dunlin), and rapid migration of the remaining parent after fledging of the chicks point to a premium on leaving the tundra early. In Dunlin however, adults (males) finish their wing moult before departing. Depending on the migration strategy (long continuous flights that require extensive fattening versus short hops that require only short refuelling bouts) waders need more or less time and food for preparation. For both and any intermediate strategies they need sufficient food at a time when surface-active arthropods start to become depleted. For fattening, a surplus of food would be required. Alternatives in coastal habitats, streams or pools are likely to be of importance at this stage, but are not found everywhere in the arctic tundra range.

If there is a benefit of an early arrival on moulting or migratory stopover sites or the wintering grounds (competition), birds might be in a hurry to leave the breeding grounds in autumn. Juveniles start their southward journey even later than adults, and especially for slow-growing species such as Pacific Golden Plover, an early onset of winter may interfere with leaving the tundra in time.

In different stages of the breeding cycle, different selective forces seem to operate that work in different directions for adults and chicks. During early spring the snow cover and food availability forces the starting date further into the season, while for the feeding condition for the majority of chicks in many years it would be better if they are born earlier. On the other hand, early in the season temperatures are lower on average, which can be disadvantageous for chicks: in colder conditions they need to be brooded longer and less time remains for feeding. The different time trade-offs in the nesting and chick-rearing period might balance in different directions for species with different breeding systems. An indication for this is that monogamous waders tend to breed earlier than polygamous ones, which typically have uniparental incubation (Whitfield & Tomkovich, 1996). In autumn, selective pressures seem to be working that make the birds leave as soon as possible.

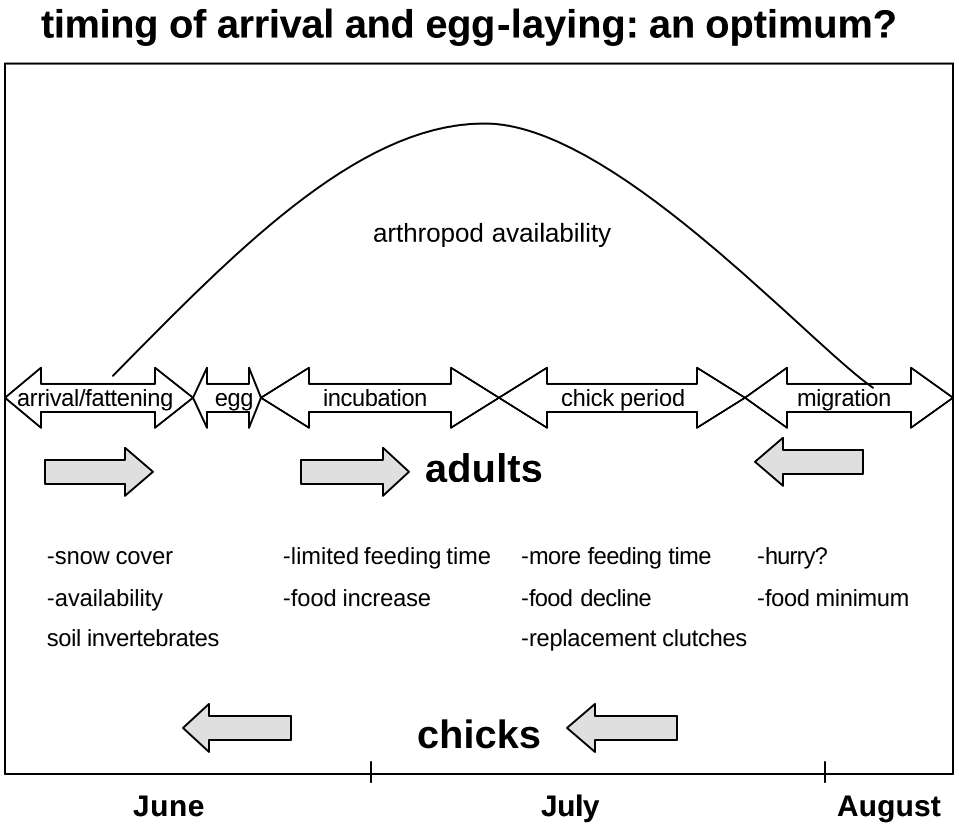


Figure 12.1. Trade-offs in timing of breeding. White arrows indicate the different periods in the breeding season. Availability of surface-active arthropods (line) has an optimum in July. Arrows indicate the opposing directions of selective pressures acting on adults and chicks. While snow cover and food conditions for adults pushes the start of breeding season forwards, the chick requirements forces this date backwards.

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Vezdekhod tracks in the study area: breeding habitat of Dunlin and Pectoral Sandpiper

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Appendix 1 Biometrics of waders caught

Biometrics of Pacific Golden Plovers caught on the nest. 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. Colour ring posittions: left tibia/left tarsus;right tibia/right tarsus.

status	ring	date	colour code (l/r)	age ky	sex	nest	bill	total head	tarsus	tars +toe	wing	mass	primary moult
nest	HS008773	15-Jul	w/bk;r/km	>2	F	IT66GP	21.3	54.7	42.4	71.5	166	122.0	0000000000
nest	HS008729	23-Jul	w/ww;y/km	>2	F	IT90GP	23.2	56.9	44.4	74.0	166	125.0	5500000000
nest	HS004611	26-Jul	y/by;m/kk	>2	F	IT92GP	22.9	57.2	44.2	76.0	169	144.0	4000000000
nest	**HS004676**	**15-Jul**	**y/ry;y/km**	**>2**	**M**	**IT66GP**						**130.0**	**5500000000**
nest	**Helgoland 7696854**	**23-Jul**	**r/by;y/km**	**>2**	**M**	**IT90GP**	**22.1**	**55.6**	**42.6**	**74.0**	**169**	**125.0**	**0000000000**
nest	HS004650	25-Jul	w/yr;y/km	>2	M	IT65GP	21.0	56.6	43.4	74.0	169	126.0	0000000000
nest	HS008774	31-Jul	w/kk;w/km	>2	M	IT95GP	23.1	56.1	42.3	73.5	136	136.0	5550000000

Biometrics of Dotterel caught during spring migration and on the nest. Bill length, total head length, tarsus length, tarsus + toe length and wing are all in mm, mass is in g.

status	ring	date	age ky	sex	nest	bill	total head	tarsus	tars +toe	wing	mass	primary moult
spring migr.	HS008708	15-Jun	>2	F		15.7	48.3	34.3	59.0	153	114.0	0000000000
spring migr.	HS008709	15-Jun	>2	F		16.5	49.0	38.7	65.0	162	127.0	0000000000
spring migr.	HS008710	16-Jun	>2	F		16.8	50.8	40.0	64.0	159	135.0	0000000000
spring migr.	HS008703	11-Jun	>2	F?		16.0	50.4	37.7	59.0	156	127.5	0000000000
spring migr.	HS008704	11-Jun	>2	F?		16.9	52.2	39.8	65.0	162	126.5	0000000000
spring migr.	HS008711	16-Jun	>2	F?		17.3	50.6	37.9	64.0	161	129.0	0000000000
spring migr.	HS008762	18-Jun	>2	F?		16.1	48.6	37.0	63.0	158	123.0	0000000000
spring migr.	HS008763	18-Jun	>2	F?		15.8	50.6	36.1	61.0	156	116.0	0000000000
spring migr.	HS008764	19-Jun	>2	F?		17.2	51.1	40.0	65.0	159	133.0	0000000000
spring migr.	HS008768	19-Jun	>2	F?		16.2	51.8	38.9	64.0	152	129.0	0000000000
spring migr.	HS008769	19-Jun	>2	F?		16.7	50.4	39.5	66.0	158	127.0	0000000000
spring migr.	HS008713	22-Jun	>2	F?		16.1	50.6	38.8	65.0	160	116.0	0000000000
spring migr.	HS008702	11-Jun	>2	M		16.2	50.5	36.2	60.0	156	127.0	0000000000
spring migr.	HS008705	15-Jun	>2	M		15.0	49.4	37.5	63.0	157	113.0	0000000000
spring migr.	HS008706	15-Jun	>2	M?		18.0	51.3	39.3	65.0	157	130.0	0000000000
spring migr.	HS008707	15-Jun	>2	M?		17.3	50.0	38.9	63.5	149	112.0	0000000000
spring migr.	HS008761	18-Jun	>2	M?		17.2	51.7	39.3	65.0	160	140.0	0000000000
spring migr.	HS008765	19-Jun	>2	M?		17.3	49.5	37.0	60.5	155	116.0	0000000000
spring migr.	HS008766	19-Jun	>2	M?		15.5	48.9	38.8	64.5	159	122.0	0000000000
spring migr.	HS008767	19-Jun	>2	M?		17.1	52.6	38.0	64.0	160	124.0	0000000000
spring migr.	HS008712	22-Jun	>2	M?		17.1	51.6	38.2	63.0	161	126.0	0000000000
nest	HS008714	08-Jul	>2	M	HS35DO	15.9	50.2	37.6	59.5	150	111.0	3320000000

Biometrics of Turnstones during spring migration, chick rearing and autumn migration.. Bill length, total head length, tarsus length, tarsus + toe length and wing length are all in mm, mass is in g. Colour codes: m= metal, r= red, w= white, k =pink, b= blue, y= yellow. Colour ring posittions: left tibia/left tarsus;right tibia/right tarsus.

status	ring	date	colour	age ky	sex code	nest (l/r)	bill	total head	tarsus	tarsus +toe	wing	mass
spring migr.	HS008751	7-Jun	y/rb;w/km	>2	F		21,8	50,7	27,3	53,5	154	109,0
spring migr.	HS008759	14-Jun	w/ww;k/km	>2	F		23,1	53,1	24,6	52,0	158	104,0
spring migr.	HS008760	14-Jun	k/yb;y/km	>2	F		22,4	50,6	25,3	52,0	156	123,0
spring migr.	HS008755	7-Jun	k/km;k/kk	>2	F?		24,2	50,0	26,0	50,0	154	95,0
spring migr.	HS008752	7-Jun	y/rr;y/km	>2	M		21,1	48,9	26,1	51,0	159	97,0
spring migr.	HS008753	7-Jun	y/bk;y/km	>2	M		21,8	49,5	24,8	50,0	156	100,0
spring migr.	HS008754	7-Jun	k/bw;b/km	>2	M		22,3	50,9	26,4	51,0	152	101,0
spring migr.	HS008758	14-Jun	r/rr;w/km	>2	M		22,2	50,5	25,8	51,0	154	100,0
spring migr.	HS008756	7-Jun	k/yk;y/km	>2	M?		22,8	50,5	25,9	51,0	159	95,0
brood	HS008716	10-Jul	r/ww;w/km	>2	M	HS09TU	19,3	46,2	23,7	50,0	148	100,0
brood	HS008722	15-Jul	y/by;k/km	>2	M	unknown	20,8	50,1	25,6	52,0	151	94,0
autumn migr.	HS008724	21-Jul		>2	F		20,4	48,0	26,6	51,0	147	92,0
autumn migr.	HS008723	21-Jul		>2	M?		22,8	49,7	25,2	50,5	151	92,0
autumn migr.	HS004678	9-Aug		1			20,0	45,6	25,6	50,5	141	76,0
autumn migr.	HS004679	9-Aug		1			21,8	49,7	26,0	52,0	152	92,0
autumn migr.	HS004680	10-Aug		1			19,0	47,5	25,1	50,0	144	79,0
autumn migr.	HS004681	10-Aug		1			20,3	48,8	25,9	51,0	150	86,0
autumn migr.	HS008773	10-Aug		1			20,9	49,6	24,5	52,0	149	93,0

Biometrics of phalaropes during spring migration and incubation. Bill length, total head length, tarsus length, tarsus + toe length and wing length are all in mm, mass is in g.

status	ring	date	age	sex	nest	bill	total head	tarsus	tarsus +toe	wing	mass
Red Phalarope											
nest	KS07440	09-Jul	>2	M	HS29PH	21.2	45.7	24.5	48.5	135	55.8
nest	KS07430	10-Jul	>2	M	OL60PH	22.0	44.1	23.7	45.0	135	59.0
autumn migr.	victim	10-Aug	1			20.2	43.8	21.9	45.5	132	43.0
Grey Phalarope											
spring migr.	KS07267	18-Jun	>2	M		24.8	48.6	23.4	49.0	136	

Biometrics of Red Knots during spring migration and incubation.. Bill length, total head length, tarsus length, tarsus + toe length and wing length are all in mm, mass is in g.

status	ring	date	age	sex	bill	total head	tarsus	tarsus +toe	wing	mass
spring migr.	KS07251	07-Jun	>2	?	32.7	62.7	32.3		169	120.0
spring migr.	KS07252	07-Jun	>2	?	35.0	64.7	33.0	59.0	174	135.0
spring migr.	HS008757	09-Jun	>2	M	33.5	64.9	34.6	63.0	168	123.0

Biometrics of Sanderling during spring migration, incubation and autumn migration. Bill length, total head length, tarsus length, tarsus + toe length and wing length are all in mm, mass is in g..

status	ring	date	age	sex	bill head	total	tarsus +toe	tarsus	wing	mass
spring migr.	KS07261	14-Jun	>2	M	23.7	48.7	25.8	45.0	128	52.0
spring migr.	KS07217	15-Jun	>2	M	23.6	49.6	25.5	45.5	126	45.0

Biometrics of Little Stints during spring migration, incubation, brood rearing and autumn migration. Bill length, total head length, tarsus length, tarsus + toe length and wing length are all in mm, mass is in g. Colour codes: m= metal, r= red, w= white, k =pink, b= blue, y= yellow. Birds ringed and recaptured in 2000 are printed in italics. Colour ring posittions: left tibia/left tarsus;right tibia/right tarsus.

status	ring	date	colour code (l/r)	age	sex	nest	bill	total head	tarsus	tarsus +toe	wing	mass
spring migr.	FS10704	16-Jun	w/yb;w/km	>1	?		16.9	37.5	21.7	40.0	97	25.7
spring migr.	FS10701	08-Jun	b/rk;k/km	>1	F		19.0	40.4	22.5	41.0	100	27.0
spring migr.	FS10755	19-Jun	w/bb;k/km	>1	F		18.1	39.7	21.4	40.0	99	26.4
spring migr.	FS10758	19-Jun	k/by;w/km	>1	F		18.3	39.2	21.2	41.0	97	26.4
spring migr.	FS10763	19-Jun		>1	F		19.9	40.3	20.1	37.0	99	25.9
spring migr.	FS10761	19-Jun	b/kr;r/km	>1	F?		19.1	39.6	21.6	39.6	100	26.1
spring migr.	victim	19-Jun		>1	F?		18.5	39.5	21.9	40.5	100	31.6
spring migr.	FS10703	16-Jun	r/by;w/km	>1	M		19.4	41.0	22.0	44.0	101	31.3
spring migr.	FS10752	19-Jun		>1	M		18.1	38.5	21.2	42.5	99	22.9
spring migr.	FS10753	19-Jun		>1	M		16.4	37.0	21.5	40.0	98	22.9
spring migr.	FS10754	19-Jun	b/ky;y/km	>1	M		18.7	39.9	21.4	40.0	99	24.9
spring migr.	FS10756	19-Jun	b/rw;r/km	>1	M		18.7	38.6	19.1	40.0	92	21.9
spring migr.	FS10757	19-Jun	r/bk;b/km	>1	M		18.5	40.8	23.1	43.0	98	24.4
spring migr.	FS10759	19-Jun	k/wk;k/km	>1	M		16.5	36.8	20.8	39.0	97	28.9
spring migr.	FS10760	19-Jun		>1	M		17.4	37.7	21.2	40.0	98	22.9
spring migr.	FS10762	19-Jun	r/br;r/km	>1	M		17.9	37.8	23.0	40.0	96	24.7
spring migr.	FS10702	11-Jun	r/kb;y/km	>1	M?		18.1	38.6	22.8	42.0	98	26.2
spring migr.	FS10751	13-Jun	k/by;y/km	>1	M?		17.5	37.1	20.9	39.0	95	22.2
nest	FS10975	20-Jul	r/rb;k/km	>1	?	HS54LS	20.4	41.1	21.3	41.0	98	24.9
nest	FS10712	01-Jul	r/yr;k/km	>1	F	IT60LS	18.1	38.7	22.9	40.0	98	26.6
nest	FS10766	01-Jul	y/ry;y/km	>1	F	IT61LS	19.2	39.5	23.0	41.0	99	29.6
nest	FS10715	03-Jul	w/wb;r/km	>1	F	IT36LS	18.8	38.7	21.2	39.0	102	26.6
nest	FS10718	05-Jul	w/ry;k/km	>1	F	HS42LS	18.7	39.3	22.3	40.5	97	26.8
nest	FS10716	05-Jul	r/br;r/km	>1	F	HS41LS	18.2	40.1	23.7	43.0	101	27.5
nest	FS10769	06-Jul	y/yb;w/km	>1	F	IT69LS	20.0	41.1	22.6	40.5	102	33.9
nest	FS10774	07-Jul		>1	F	IT73LS	19.7	40.0	21.3	49.0	99	27.5
nest	FS10781	08-Jul	w/bk;k/km	>1	F	IT45LS	17.5	34.3	20.7	39.5	99	34.1
nest	FS10782	08-Jul	y/by;k/km	>1	F	LP15LS	19.2	38.1	22.4	41.0	96	31.4
nest	FS10783	08-Jul	k/ky;y/km	>1	F	IT75LS	18.9	38.3	21.5	40.0	100	32.0
nest	FS10785	09-Jul	r/bb;w/km	>1	F	OL65LS	18.8	41.1	21.1	39.5	101	37.0
nest	FS10740	11-Jul	k/wk;w/km	>1	F	HS32LS	20.1	41.4	21.6	41.5	101	29.1
nest	FS10738	11-Jul	y/wy;w/km	>1	F	OL66LS	19.5	40.3	23.1	42.0	98	35.2
nest	FS10750	13-Jul	y/bw;b/km	>1	F	HS55LS	18.0	39.9	21.6	40.5	103	29.4
nest	FS10901	13-Jul	r/yr;r/km	>1	F	HS56LS	17.5	39.1	23.0	42.5	101	31.0
nest	FS10909	15-Jul		>1	F	HS58LS	18.8	39.6	21.3	40.0	102	31.7
nest	FS10919	16-Jul	y/bk;b/km	>1	F	HS59LS	19.2	40.0	21.9	39.5	100	30.9
nest	FS10922	17-Jul	w/wk;w/km	>1	F	IT74LS	19.9	42.1	22.1	42.0	105	34.5
nest	FS10838	18-Jul	r/ry;r/km	>1	F	IT89LS	18.4	39.3	21.1	39.5	99	32.5
nest	FS10940	19-Jul	y/wb;b/km	>1	F	OL67LS	18.0	38.9	19.8	38.0	103	31.1
nest	FS10976	20-Jul	y/rw;r/km	>1	F	IT87LS	19.1	40.2	22.6	41.0	101	30.7
nest	FS10711	29-Jun	y/ky;r/km	>1	F?	HS28LS	18.7	37.1	21.9	40.5	96	27.3
nest	FS10713	02-Jul	k/yr;y/km	>1	F?	OL39LS	17.9	38.9	21.0	39.0	97	25.1
nest	FS10717	05-Jul	k/br;r/km	>1	F?	LP13LS	19.1	38.8	20.4	39.0	100	25.8
nest	FS10719	05-Jul	w/yk;b/km	>1	F?	IT68LS	17.2	38.4	22.6	41.5	99	27.8
nest	FS10732	10-Jul	y/kr;y/km	>1	F?	OL59LS	18.8	40.7	21.7	40.0	102	33.8
nest	FS10821	16-Jul	r/ry;k/km	>1	F?	IT88LS	19.9	39.1	21.9	41.0	101	29.7
nest	FS10706	24-Jun	w/kk;y/km	>1	M	IT19LS	16.9	38.0	21.6	39.0	95	27.7
nest	*FS10707*	*26-Jun*	*k/yy;y/km*	*>1*	*M*	*HS21LS*	*17.0*	*37.8*	*20.6*	*39.0*	*97*	*28.0*
nest	FS10708	26-Jun	y/yr;y/km	>1	M	IT05LS	17.7	39.2	22.1	40.0	98	28.0
nest	FS10709	26-Jun	y/ry;r/km	>1	M	HS23LS	17.6	37.0	22.1	41.0	95	30.0
nest	FS10710	29-Jun	b/rw;k/km	>1	M	HS16LS	16.9	36.8	20.9	40.0	97	26.5
nest	FS10764	29-Jun	k/wr;y/km	>1	M	IT53LS	17.1	37.8	22.0	41.0	96	27.7
nest	FS10765	01-Jul	b/wy;y/km	>1	M	IT26LS	17.4	37.8	19.8	39.5	95	30.2
nest	FS10767	02-Jul	w/rr;k/km	>1	M	HS37LS	17.5	38.1	21.0	38.5	95	37.3
nest	FS10707	03-Jul	k/yy;y/km	>1	M							26.0
nest	FS10720	06-Jul	b/kb;r/km	>1	M	IT70LS	19.2	40.0	21.6	40.0	96	29.6

Little stint continued

status	ring	date	colour code (l/r)	age	sex	nest	bill	total head	tarsus	tarsus +toe	wing	mass
nest	FS10721	06-Jul	y/wr;w/km	>1	M	IT71LS	18.7	39.4	22.2	41.5	97	29.8
nest	FS10722	06-Jul	k/rb;k/km	>1	M	IT72LS	18.6	39.0	22.3	41.0	97	30.1
nest	FS10723	07-Jul	w/rk;k/km	>1	M	HS50LS	18.5	39.4	21.8	40.0	97	30.3
nest	FS10780	08-Jul	y/kb;r/km	>1	M	IT31LS	17.5	37.8	21.1	38.5	92	27.7
nest	FS10784	08-Jul	w/rw;r/km	>1	M	IT64LS	18.6	36.3	21.9	41.0	95	31.8
nest	FS10786	09-Jul	w/bw;y/km	>1	M	OL58DU	19.3	38.6	21.1	38.0	96	33.5
nest	FS10729	09-Jul	y/bw;w/km	>1	M	LP17LS	20.0	37.9	21.8	41.0	99	34.3
nest	FS10730	10-Jul	k/kk;w/km	>1	M	LP12LS	18.5	39.7	22.0		101	27.0
nest	*FS10759*	*10-Jul*	*k/wk;k/km*	*>1*	*M*	*IT42LS*						*32.0*
nest	FS10741	11-Jul	b/yw;r/km	>1	M	IT43LS	19.4	41.3	22.3	40.0	101	34.5
nest	FS10787	11-Jul	y/kw;k/km	>1	M	IT80LS	17.3	37.7	20.7	40.0	96	32.5
nest	FS10791	12-Jul	y/br;b/km	>1	M	IT63LS	17.5	38.1	21.1	40.0	94	28.0
nest	FS10792	12-Jul	w/wb;b/km	>1	M	OL63LS	17.6	39.0	22.0	41.0	98	32.4
nest	FS10793	12-Jul	y/yw;y/km	>1	M	IT83LS	18.5	38.0	20.1	38.5	98	32.3
nest	FS10745	12-Jul	k/rw;w/km	>1	M	HS52LS	17.0	39.2	21.4	39.5	98	30.7
nest	FS10748	12-Jul	w/br;r/km	>1	M	HS54LS	19.3	40.2	24.1	44.5	102	32.1
nest	FS10749	12-Jul	y/kk;b/km	>1	M	LP16LS	19.0	41.4	22.0	41.0	101	34.3
nest	FS10888	20-Jul	w/br;y/km	>1	M	LP19LS	19.2	38.5	23.1	41.5	98	34.9
nest	FS10714	02-Jul	k/ry;r/km	>1	M?	HS38LS	16.7	38.3	20.4	40.5	100	28.9
nest	FS10768	03-Jul	y/by;r/km	>1	M?	IT25LS	16.6	37.7	21.8	41.0	97	29.2
brood	FS10955	14-Jul	w/bk;b/km	>1	?	OLLS01	18.0	36.8	21.7	39.0		26.4
brood	FS10960	14-Jul	y/bb/b/km	>1	?	OLLS02	18.3	38.5	21.5	41.0	96	29.2
brood	FS10981	20-Jul	r/rw;y/km	>1	?	ITLS15	18.2	39.2	23.0	41.0	99	27.0
brood	FS10989	21-Jul	w/bb;w/km	>1	?	LPLS02	18.6	39.8	23.5	42	104.0	28.4
brood	XD261306	21-Jul	w/yy;b/km	>1	?	OLLS05	18.3	39.1	21.2	40.0	99	26.0
brood	XD261315	26-Jul	w/by;k/km	>1	?	OLLS07	18.8	39.7	21.0	41.0	101	25.5
brood	FS10885	19-Jul	w/yy;y/km	>1	?	ITLS12	17.6	37.9	22.0	40.5	101	27.4
brood	FS10892	20-Jul	r/yb;w/km	>1	?	ITLS16	20.7	41.2	22.4	40.5	101	25.8
brood	FS10742	11-Jul	b/yr;r/km	>1	F	HSLS05	19.0	40.1	22.5	42.0	101	28.5
brood	FS10848	19-Jul	r/by;b/km	>1	F	LP16LS	20.9	41.7	23.0	43.0	104	29.2
brood	FS10979	20-Jul	w/ky;w/km	>1	F	LPLS01	18.0	38.3	20.9	40.0	102	27.7
brood	FS10779	07-Jul	k/wb;w/km	>1	M	HSLS02	17.2	38.4	22.0	40.5	97	25.6
brood	FS10736	10-Jul	b/bw;y/km	>1	M	HSLS01	18.3	39.9	22.3	42.5	97	27.5
brood	FS10801	13-Jul	w/kw;y/km	>1	M	ITLS05	16.4	36.0	20.9	39.0	93	27.3
brood	FS10914	15-Jul	y/kw;y/km	>1	M	HSLS07	18.8	39.6	21.6	40.0	97	28.7
brood	*FS10749*	*19-Jul*	*y/kk;b/km*	*>1*	*M*	*LP16LS*						*28.2*
brood	FS10851	23-Jul	b/by;m/bk	>1	M	ITLS19	17.7	37.5	21.1	40.0	99	25.0
brood	FS10806	14-Jul	r/bb;r/km	>1	M?	ITLS06	19.4	39.6	21.5	41.0	97	25.3
brood	FS10811	14-Jul	w/kb;y/km	>1	M?	ITLS07	19.0	40.3	22.7	39.5	97	33.5
brood	FS10817	15-Jul	y/wk;r/km	>1	M?	ITLS08	18.3	37.8	19.6	38.0	96	25.5
brood	FS10847	19-Jul	r/wk;y/km	>1	M?	ITLS11	18.9	38.6	20.0	37.0	96	23.2
brood	FS10993	23-Jul	b/kk;k/km	>1	M?	LPLS03	18.8	39.4	21.2	39.0	95	22.9
autumn migr.	XD261031	21-Jul		>1			18.9	38.7	21.6	40.0	104	24.8
autumn migr.	XD261307	23-Jul	y/rk;r/km	>1			18.6	40.0	21.2	39.0	102	27.5
autumn migr.	XD261308	23-Jul	r/rr;k/km	>1			18.0	37.5	21.2	37.0	94	21.5
autumn migr.	XD261309	23-Jul	w/bw;k/km	>1			18.3	39.1	21.3	39.0	97	22.5
autumn migr.	XD261310	23-Jul		>1	M		18.5	39.5	20.9	39.0	96	23.7
autumn migr.	XD261030	24-Jul		>1	M?		20.4	40.7	21.1	40.0	103	24.7
autumn migr.	XD261029	24-Jul		>1	M?		18.6	39.2	22.8	42.0	95	24.1
autumn migr.	XD261028	24-Jul		>1	M		19.4	39.7	20.8	39.5	101	25.1
autumn migr.	XD261027	24-Jul		>1	M?		18.8	38.8	22.1	40.5	102	25.7
autumn migr.	XD261026	24-Jul		>1	M		16.7	37.4	21.7	40.0	95	25.6
autumn migr.	FS10897	24-Jul		>1	M		20.9	41.0	21.5	41.0	98	25.3
autumn migr.	FS10898	24-Jul		>1	M		18.3	39.3	21.1	38.0	94	23.9
autumn migr.	FS10899	24-Jul		>1	M		19.1	40.2	22.2	40.0	98	25.8
autumn migr.	FS10900	24-Jul		>1	F		20.3	40.9	22.5	41.0	101	27.0
autumn migr.	FS10852	24-Jul		>1	?		15.8	37.2	19.8	39.0	91	24.8
autumn migr.	FS10853	24-Jul		>1	F?		17.5	38.0	20.8	41.5	99	21.9
autumn migr.	FS10854	24-Jul		>1	M		18.5	39.9	20.5	39.0	98	25.2
autumn migr.	FS10855	25-Jul		>1	?		16.9	37.5	20.0	39.0	95	22.8

Little stint continued

status	ring	date	colour code (l/r)	age	sex	nest	bill	total head	tarsus	tarsus +toe	wing	mass
autumn migr.	FS10856	25-Jul		>1	?		20.4	40.5	23.5	41.5	102	25.7
autumn migr.	FS10857	25-Jul		>1	M		19.2	39.6	21.8	41.0	99	25.8
autumn migr.	XD261340	26-Jul		>1	F		19.1	38.7	21.9	40.0	99	24.2
autumn migr.	XD261025	26-Jul		>1	M		19.6	39.6	21.1	39.0	101	24.5
autumn migr.	XD261024	26-Jul		>1	M		19.0	39.4	23.0	42.0	96	21.7
autumn migr.	XD261023	26-Jul		>1	F		20.5	41.1	23.4	42.0	105	23.8
autumn migr.	FS10858	30-Jul		>1	?		19.5	40.0	23.6	42.0	101	26.7
autumn migr.	FS10860	30-Jul		>1	F		19.0	39.2	21.2	39.5	94	24.0
autumn migr.	FS10861	30-Jul		>1	M		19.8	39.1	21.2	38.5	91	22.0
autumn migr.	FS10862	30-Jul		>1	M		17.8	39.2	20.6	38.0	96	19.7
autumn migr.	FS10863	30-Jul		>1	F		19.6	40.3	22.2	41.0	104	26.0
autumn migr.	FS10864	30-Jul		>1	F		18.6	40.2	22.3	40.5	102	27.7
autumn migr.	FS10865	30-Jul		>1	M		18.6	39.1	21.1	39.0	95	22.5
autumn migr.	FS10866	30-Jul		>1	M		18.8	36.3	21.2	38.5	96	26.6
autumn migr.	FS10867	30-Jul		>1	F		18.3	39.6	22.1	40.5	101	25.1
autumn migr.	XD261367	31-Jul		>1			18.1	39.1	20.7	41.0	96	30.0
autumn migr.	XD261368	31-Jul		>1			19.3	39.3	21.9	40.0	100	33.0
autumn migr.	XD261370	31-Jul		>1			17.2	37.3	20.9	40.0	99	25.5
autumn migr.	XD261371	31-Jul		>1	M		17.4	39.0	21.0	40.0	91	30.5
autumn migr.	XD261372	31-Jul		>1			18.3	38.3	20.5	41.0	95	21.5
autumn migr.	XD261373	31-Jul		>1			17.5	38.2	21.5	40.0	96	27.1
autumn migr.	XD261375	31-Jul		>1			18.6	39.6	21.3	40.0	104	29.5
autumn migr.	FS10868	31-Jul		>1	M		17.6	38.7	22.2	40.5	96	23.0
autumn migr.	FS10869	31-Jul		>1			18.2	37.8	20.3	40.0	98	24.6
autumn migr.	FS10873	31-Jul		>1	M		18.1	39.4	21.0	41.0	99	27.2
autumn migr.	FS10874	31-Jul		>1	M?		19.7	39.9	21.4	39.0	101	26.4
autumn migr.	FS10875	31-Jul		>1			17.6	38.7	21.6	40.0	97	24.2
autumn migr.	FS10876	31-Jul		>1	F?		18.8	40.0	21.5	42.0	101	27.2
autumn migr.	FS10878	31-Jul		>1	F?		19.1	40.2	21.0	40.0	98	24.2
autumn migr.	FS10879	31-Jul		>1	M?		18.4	39.1	21.6	40.0	98	25.2
autumn migr.	XD261382	31-Jul		>1	M		18.6	38.3	20.1	40.0	97	20.5
autumn migr.	XD261379	31-Jul		>1	M		19.0	40.0	21.5	42.0	95	24.2
autumn migr.	XD261362	31-Jul		>1	?		18.8	38.8	21.0	40.0	96	31.2
autumn migr.	XD261363	31-Jul		>1	?		18.3	38.4	20.8	42.0	101	25.2
autumn migr.	XD261364	31-Jul		>1	?		19.1	38.6	21.9	45.0	100	25.7
autumn migr.	XD261365	31-Jul		>1	?		17.9	37.5	19.6	37.0	96	21.7
autumn migr.	XD261366	31-Jul		>1	?		18.8	39.2	22.2	40.0	103	28.0
autumn migr.	XD261080	01-Aug		>1			18.6	40.4	21.8	41.0	97	23.5
autumn migr.	XD261079	01-Aug		>1			21.3	41.6	21.9	42.0	102	30.5
autumn migr.	XD261078	01-Aug		>1			19.4	38.9	22.7	42.0	101	27.0
autumn migr.	XD261077	01-Aug		>1			18.9	38.9	20.4	39.0	96	24.0
autumn migr.	XD261073	03-Aug		>1	M		17.3	37.3	21.0	39.0	94	23.5
autumn migr.	XD261071	03-Aug		>1			19.9	38.3		40.0	98	25.0
autumn migr.	victim	03-Aug		>1	M		16.5	36.4	20.7	40.0	95	24.5
autumn migr.	XD261068	03-Aug		>1	?		19.1	39.8	20.9	39.0	101	26.5
autumn migr.	XD261064	03-Aug		>1	?		19.4	39.7	22.6	40.0	102	28.3
autumn migr.	XD261347	03-Aug		>1	?		18.0	38.9	22.5	41.5	100	26.1
autumn migr.	XD261021	03-Aug		>1	M		17.6	37.6	22.3	41.0	98	24.7
autumn migr.	FS10949	04-Aug		>1	?		18.7	39.4	22.6	42.0	98	30.0
autumn migr.	FS10950	04-Aug		>1	F		20.3	40.8	23.4	41.5	99	29.1
autumn migr.	FS11000	04-Aug		>1	F		19.0	38.6	21.9	40.0	100	24.3
autumn migr.	XD261331	04-Aug		>1	M		17.0	36.8	21.1	39.0	96	21.5
autumn migr.	XD261353	04-Aug		>1			17.6	37.9	21.4	39.5	97	23.8
autumn migr.	XD261011	04-Aug		>1			19.7	40.8	21.5	39.0	99	28.0
autumn migr.	XD261010	04-Aug		>1			18.3	39.4	21.6	40.0	101	27.8
autumn migr.	XD261009	04-Aug		>1			19.2	40.5	22.2	40.0	95	23.0
autumn migr.	XD261328	05-Aug		>1	M		19.0	40.0	21.5	39.0	99	24.9
autumn migr.	XD261321	05-Aug		>1	?		escaped					
autumn migr.	XD261393	06-Aug		>1	?		16.4	36.1	20.2	37.0	100	23.2
autumn migr.	XD261091	09-Aug		>1	?		17.4	37.7	20.5	40.0	103	27.0

Little stint continued

status	ring	date	colour code (l/r)	age	sex	nest	bill	total head	tarsus	tarsus +toe	wing	mass
autumn migr.	FS10859	30-Jul		1	?		16.5	36.2	21.7	40.0	94	21.0
autumn migr.	XD261369	31-Jul		1			19.1	37.4	20.9	39.0	92	22.0
autumn migr.	FS10870	31-Jul		1			18.4	38.4	21.1	40.0	96	
autumn migr.	FS10871	31-Jul		1			18.7	38.9	21.7	41.0	98	22.7
autumn migr.	FS10872	31-Jul		1			17.6	37.8	20.1	39.0	96	20.6
autumn migr.	FS10877	31-Jul		1	?		18.5	38.2	21.5	40.0	99	23.2
autumn migr.	FS10880	31-Jul		1	?		16.2	36.3	22.2	41.5	101	22.7
autumn migr.	XD261381	31-Jul		1	?		16.4	38.3	20.5	39.0	95	21.7
autumn migr.	XD261361	31-Jul		1			18.4	38.2	21.4	43.0	104	23.7
autumn migr.	XD261076	03-Aug		1			17.5	40.0	22.0	41.0	103	24.0
autumn migr.	XD261075	03-Aug		1			18.3	38.0	22.4	41.0	96	23.0
autumn migr.	XD261074	03-Aug		1			18.5	38.1	22.1	42.0	98	24.0
autumn migr.	XD261072	03-Aug		1			18.3	38.3	21.7	40.0	98	23.5
autumn migr.	XD261070	03-Aug		1			18.5	38.9	22.2	40.5	89	23.1
autumn migr.	XD261069	03-Aug		1			18.2	37.8	22.4	41.0	98	21.0
autumn migr.	XD261067	03-Aug		1			19.6	40.1	22.3	41.5	104	23.6
autumn migr.	XD261066	03-Aug		1			19.1	40.3	22.3	42.0	102	27.0
autumn migr.	XD261065	03-Aug		1			17.7	38.4	23.6	41.5	104	23.7
autumn migr.	XD261063	03-Aug		1			20.3	41.1	22.0		103	24.0
autumn migr.	XD261062	03-Aug		1			18.5	38.6	21.4	38.5	98	22.4
autumn migr.	XD261061	03-Aug		1			19.8	40.4	22.9	42.0	101	21.8
autumn migr.	XD261378	03-Aug		1			18.6	37.6	20.5	38.0	98	22.4
autumn migr.	victim	03-Aug		1			18.3	37.4	21.3	40.0	100	24.2
autumn migr.	XD261377	03-Aug		1			18.1	37.3	20.8	40.0	95	21.5
autumn migr.	XD261342	03-Aug		1			18.9	39.0	20.8	40.0	99	23.9
autumn migr.	XD261343	03-Aug		1			19.0	39.2	23.8	43.0	103	23.1
autumn migr.	XD261344	03-Aug		1			16.3	36.8	21.7	39.0	104	21.9
autumn migr.	XD261345	03-Aug		1			18.0	38.7	23.1	41.0	102	23.8
autumn migr.	XD261346	03-Aug		1			18.5	37.0	21.9	40.0	97	20.3
autumn migr.	XD261348	03-Aug		1			17.7	38.8	23.1	41.0	96	24.5
autumn migr.	XD261022	03-Aug		1			18.3	37.7	22.0	41.0	97	22.4
autumn migr.	victim	03-Aug		1			19.4	39.3	22.5	41.0	100	24.6
autumn migr.	XD261001	04-Aug		1			19.2	39.7	22.7	41.0	99	25.6
autumn migr.	XD261002	04-Aug		1			17.0	36.0	20.8	40.0	96	21.5
autumn migr.	FS10947	04-Aug		1			19.5	39.3	22.2	39.0	103	24.0
autumn migr.	FS10948	04-Aug		1			18.1	38.9	22.9	42.0	102	24.9
autumn migr.	FS10997	04-Aug		1			19.5	39.8	22.3	41.5	102	24.3
autumn migr.	FS10998	04-Aug		1			18.8	38.2	22.5	39.5	97	22.7
autumn migr.	FS10999	04-Aug		1			18.3	39.7	22.4	41.0	103	24.0
autumn migr.	XD261327	04-Aug		1			18.9	38.8	22.4	42.0	101	27.3
autumn migr.	XD261349	04-Aug		1			19.4	39.5	21.9	40.5	104	24.8
autumn migr.	XD261350	04-Aug		1			18.6	38.6	21.4	40.0	96	23.9
autumn migr.	XD261351	04-Aug		1			18.7	38.6	23.1	42.5	101	23.4
autumn migr.	XD261352	04-Aug		1			17.9	38.1	21.7	40.5	97	22.9
autumn migr.	XD261354	04-Aug		1			18.4	39.1	21.5	39.5	95	23.1
autumn migr.	XD261355	04-Aug		1			17.8	38.6	21.8	40.0	97	22.3
autumn migr.	XD261356	04-Aug		1			17.9	38.5	22.2	40.5	100	21.8
autumn migr.	XD261357	04-Aug		1			19.5	40.1	22.4	40.5	105	25.7
autumn migr.	XD261358	04-Aug		1			18.7	38.6	22.1	39.5	95	
autumn migr.	XD261360	04-Aug		1			17.2	38.0	21.2	39.5	97	23.0
autumn migr.	XD261359	04-Aug		1			19.2	39.8	23.0	41.0	99	23.8
autumn migr.	XD261020	04-Aug		1			18.0	38.7	22.8	41.3	98	23.7
autumn migr.	XD261019	04-Aug		1			18.8	38.2	22.1	40.5	101	26.3
autumn migr.	XD261018	04-Aug		1			19.7	39.6	22.2	40.0	101	24.0
autumn migr.	XD261017	04-Aug		1			18.7	39.0	22.3	40.0	97	22.5
autumn migr.	XD261016	04-Aug		1			19.5	39.9	23.1	42.0	100	26.3
autumn migr.	XD261015	04-Aug		1			20.0	40.4	22.4	40.0	101	25.0
autumn migr.	XD261014	04-Aug		1			18.7	39.7	22.0	40.0	102	24.3
autumn migr.	XD261013	04-Aug		1			17.8	38.3	22.3	40.0	101	22.8
autumn migr.	XD261012	04-Aug		1			18.2	38.4	22.6	42.0	97	23.6

Little stint continued

status	ring	date	colour code (l/r)	age	sex	nest	bill	total head	tarsus	tarsus +toe	wing	mass
autumn migr.	XD261008	04-Aug		1			17.9	38.3	21.9	40.0	98	23.0
autumn migr.	XD261007	04-Aug		1			17.2	38.0	22.0	39.0	96	22.5
autumn migr.	XD261006	04-Aug		1			18.4	37.8	22.1	40.0	102	24.5
autumn migr.	XD261005	04-Aug		1			19.7	39.1	22.1	39.5	98	24.4
autumn migr.	XD261004	04-Aug		1			17.9	39.2	21.8	39.0	104	24.0
autumn migr.	XD261003	04-Aug		1			17.5	37.4	22.1	41.0	97	21.2
autumn migr.	XD261325	05-Aug		1			17.1	37.5	21.1	40.0	98	24.8
autumn migr.	XD261324	05-Aug		1			18.1	38.7	22.3	41.0	98	23.9
autumn migr.	XD261322	05-Aug		1			19.5	38.7	21.6	40.0	101	26.4
autumn migr.	XD261323	05-Aug		1			18.4	38.7	21.6	40.0	101	
autumn migr.	XD261399	06-Aug		1			17.9	38.5	23.1	41.0	98	24.0
autumn migr.	XD261397	06-Aug		1			19.7	39.6	21.7	40.5	103	24.3
autumn migr.	XD261400	06-Aug		1			18.0	37.7	22.0	40.5	100	21.9
autumn migr.	XD261398	06-Aug		1			18.1	38.3	22.7	40.0	96	22.2
autumn migr.	XD261396	06-Aug		1			18.9	39.9	21.9	40.0	100	23.7
autumn migr.	XD261395	06-Aug		1			18.2	37.8	21.3	38.5	97	21.3
autumn migr.	XD261392	06-Aug		1			17.1	37.8	21.1	39.5	99	22.1
autumn migr.	XD261394	06-Aug		1			17.9	38.1	23.1	42.0	98	21.3
autumn migr.	XD261032	06-Aug		1			17.7	38.0	22.3	41.5	100	21.9
autumn migr.	XD261044	07-Aug		1			16.9	37.6	22.1	41.0	98	
autumn migr.	XD261045	07-Aug		1			17.5	37.3	21.4	39.5	97	21.7
autumn migr.	XD261046	07-Aug		1			17.0	35.9	22.2	40.0	95	20.2
autumn migr.	XD261047	07-Aug		1			17.6	37.4	20.9	39.0	97	21.7
autumn migr.	KS06195	07-Aug		1			16.7	36.7	21.2	39.5	97	22.5
autumn migr.	XD261033	07-Aug		1			18.2	38.6	22.0	41.5	99	23.4
autumn migr.	XD261034	07-Aug		1			18.0	38.7	22.6	40.5	98	23.7
autumn migr.	XD261035	07-Aug		1			18.5	38.9	20.8	38.0	98	20.6
autumn migr.	XD261036	07-Aug		1			17.8	38.6	22.6	40.5	103	23.6
autumn migr.	XD261037	07-Aug		1			18.8	38.6	22.3	40.0	100	23.8
autumn migr.	XD261038	07-Aug		1			17.8	37.9	22.3	41.0	103	21.5
autumn migr.	XD261039	07-Aug		1			18.7	38.4	22.6	41.0	97	24.5
autumn migr.	XD261040	07-Aug		1			18.6	39.6	22.8	40.5	101	22.5
autumn migr.	XD261041	07-Aug		1			17.6	37.6	22.4	40.0	92	21.0
autumn migr.	XD261042	07-Aug		1			17.2	37.7	22.6	40.0	97	23.0
autumn migr.	XD261043	07-Aug		1			18.7	39.5	21.9	40.0	101	23.2
autumn migr.	XD261048	08-Aug		1			18.0	37.0	20.3	39.0	97	20.1
autumn migr.	XD261049	08-Aug		1			18.4	38.3	22.1	42.0	101	23.5
autumn migr.	XD261050	08-Aug		1			17.9	37.2	21.3	39.5	92	21.3
autumn migr.	XD261051	08-Aug		1			18.2	37.2	21.4	41.0	98	22.1
autumn migr.	XD261052	08-Aug		1			18.4	39.2	23.4	42.0	101	26.4
autumn migr.	XD261053	08-Aug		1			18.8	39.2	21.0	40.0	99	22.3
autumn migr.	XD261054	08-Aug		1			17.5	37.4	22.6	41.0	98	23.8
autumn migr.	XD261055	08-Aug		1			17.0	36.9	22.0	39.5	101	22.1
autumn migr.	XD261056	08-Aug		1			17.5	37.4	21.8	40.0	94	21.8
autumn migr.	XD261057	08-Aug		1			17.7	37.8	20.5	38.0	96	21.0
autumn migr.	XD261058	09-Aug		1			18.0	38.5	23.4	41.5	98	22.5
autumn migr.	XD261059	09-Aug		1			17.5	37.2	21.8	39.0	99	21.9
autumn migr.	XD261060	09-Aug		1			20.4	40.7	22.1	41.0	101	25.4
autumn migr.	XD261081	09-Aug		1			17.1	37.3	22.7	40.5	99	24.6
autumn migr.	XD261082	09-Aug		1			18.6	38.2	22.1	40.5	101	21.8
autumn migr.	XD261083	09-Aug		1			17.2	39.1	20.4	38.0	104	27.0
autumn migr.	XD261084	09-Aug		1			17.2	38.9	20.6	38.5	103	27.0
autumn migr.	XD261085	09-Aug		1			17.7	38.6	22.1	41.0	101	26.0
autumn migr.	XD261086	09-Aug		1			18.5	37.9	21.9	39.0	97	23.2
autumn migr.	XD261087	09-Aug		1			17.9	36.9	20.9	39.0	97	24.0
autumn migr.	XD261088	09-Aug		1			17.6	37.8	21.8	41.5	100	22.0
autumn migr.	XD261089	09-Aug		1			17.4	37.3	19.6	39.5	97	21.1
autumn migr.	XD261090	09-Aug		1			17.7	37.9	21.0	39.0	100	21.5
autumn migr.	XD261092	09-Aug		1			17.2	38.0	21.4	38.0	97	21.0
autumn migr.	XD261093	09-Aug		1			18.0	38.0	20.2	40.0	102	21.5

Little stint continued

status	ring	date	colour code (l/r)	age	sex	nest	bill	total head	tarsus	tarsus +toe	wing	mass
autumn migr.	XD261094	09-Aug		1			18.2	39.1	21.8	42.0	100	23.5
autumn migr.	XD261095	09-Aug		1			18.8	39.0	21.1	38.0	97	23.0
autumn migr.	XD261096	10-Aug		1			17.5	38.4	20.1	39.5	96	24.3
autumn migr.	XD261097	10-Aug		1			17.7	38.3	20.6	39.0	100	22.3
autumn migr.	XD261098	10-Aug		1			18.2	38.2	21.6	41.0	95	23.0
autumn migr.	XD261099	10-Aug		1			18.1	38.3	22.8	40.0	97	22.3
autumn migr.	XD261100	10-Aug		1			18.0	38.9	22.3	39.0	98	24.9
autumn migr.	XD261101	10-Aug		1			16.2	36.4	21.5	41.0	94	21.3
autumn migr.	XD261326	05-Aug		1			escaped					

Biometrics of Temminck's Stints and a Red-necked Stint during spring migration, incubation and autumn migration. Bill length, total head length, tarsus length, tarsus + toe length and wing length are all in mm. mass is in g. Birds ringed and recaptured in 2000 are printed in italics.

status	ring	date	age	sex	nest	bill	total head	tarsus	tarsus +toe	wing	mass
Temminck'c Stint											
spring migr.	FS10705	22-Jun	>1	F?		18.0	38.2	18.6	36.0	100	26.5
nest	FS10731	10-Jul	>1	M?	OL56TS	18.8	37.2	17.8	36.5	102	27.3
nest	FS10921	17-Jul	>1	F?	SK01TS	18.0	37.4	18.2	36.5	102	32.1
autumn migr.	*FS10921*	*30-Jul*	*>1*	*?*							*28.9*
Red-necked stint											
autumn migr.	KS07479	10-Aug	1			18.5	39.8	19.8	39.0	109	33.3

Biometrics of Pectoral Sandpipers during incubation and chick rearing. Bill length, total head length, tarsus length, tarsus + toe length and wing length are all in mm. mass is in g. Birds ringed and recaptured in 2000 are printed in italics.

status	ring	date	age	sex	nest	bill	total head	tarsus	tarsus +toe	wing	mass
nest	KS07221	24-Jun	>2	F	OL14PS	26.3	50.7	28.3	54.5	133	62.0
nest	KS07234	29-Jun	>2	F	OL08PS	27.6	52.7	29.8	57.0	133	59.0
nest	KS07243	06-Jul	>2	F	IT68PS	29.1	53.5	28.1	54.0	138	60.0
nest	KS07244	06-Jul	>2	F	IT50PS	27.2	51.0	27.8	53.0	129	69.0
nest	KS07245	06-Jul	>2	F	IT51PS	29.4	54.7	28.8	55.0	132	67.5
nest	KS07435	09-Jul	>2	F	HS44PS	26.1	48.7	25.6	50.0	130	63.2
nest	KS06173	21-Jul	>2	F	HS46PS	28.1	52.2	27.1	52.0	125	55.5
brood	*KS06243*	*19-Jul*	*>2*	*F*	*IT68PS*						*55.5*

Biometrics of Dunlin caught on the nest. 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, recoveries of birds ringed in 2001 in italics. Colour codes: m= metal, r= red, w= white, k =pink, b= blue, y= yellow.

status	ring	date	colour code (l/r)	age	sex	nest	bill	total head	tarsus	tars +toe	wing	mass	primary moult
spring migr.	KS07201	08-Jun	r/yy:w/km	>2	F		37.0	62.0	26.2	49.0	122	53.0	0000000000
spring migr.	KS07253	07-Jun	y/ky;y/km	>2	M		33.0	57.6	24.6	44.0	116	48.0	0000000000
spring migr.	KS07255	07-Jun	r/wb;b/km	>2	M		32.0	56.8	24.5	45.0	119	48.0	0000000000
spring migr.	KS07202	08-Jun	r/rr;w/km	>2	M		29.3	54.6	24.6	45.5	119	47.5	0000000000
spring migr.	KS07258	09-Jun	y/ry;y/km	>2	M		29.7	54.4	24.5	48.0	117	52.0	0000000000
spring migr.	KS07204	10-Jun	r/yb;w/km	2	M		32.8	57.7	25.8	47.0	114	45.0	0000000000
spring migr.	KS07257	07-Jun	k/bk;k/km	>2	M?		31.2	49.9	25.0	46.5	116		0000000000

Dunlin continued

status	ring	date	colour code (l/r)	age	sex	nest	bill	total head	tarsus +toe	tars	wing	mass	primary moult
nest	KS07223	24-Jun	r/bb;w/km	>2	F	TKO4DU	39.1	63.6	26.8	50.0	120	55.5	1100000000
nest	KS07227	25-Jun	r/ww;k/km	>2	F	IT23DU	37.9	61.3	26.2	49.0	117	51.0	1000000000
nest	KS07228	27-Jun	y/kw;w/km	>2	F	IT39DU	35.2	60.4	26.7	50.0	116	57.8	4443321000
nest	KS07230	27-Jun	w/ww;k/km	>2	F	IT08DU	35.5	60.1	25.6	48.0	123	55.0	0000000000
nest	KS07231	27-Jun	r/yy;r/km	>2	F	OL05DU	36.3	61.0	26.4	49.0	119	55.0	2221000000
nest	KS07232	28-Jun	k/kk;k/km	>2	F	IT20DU	35.5	60.4	26.6	49.5	121	51.2	3332210000
nest	**KS06141**	**28-Jun**	**b/yk;y/km**	**>2**	**F**	**IT13DU**	**35.1**	**59.4**	**25.5**	**46.0**	**119**	**48.2**	**3332100000**
nest	KS07242	06-Jul	r/bb;r/km	>2	F	OL40DU	34.9	58.6	25.6	49.5	116	53.1	4444310000
nest	**KS06106**	**08-Jul**	**r/yb;w/km**	**>2**	**F**	**IT41DU**	**35.5**	**60.5**	**26.4**	**50.0**	**119**	**53.8**	**5555420000**
nest	KS07226	25-Jun	k/by;y/km	>2	F?	HS02DU	34.7	59.5	25.6	48.5	119	52.0	1100000000
nest	KS07235	01-Jul	r/kk;k/km	>2	F?	IT57DU	34.1	58.3	26.8	50.5	118	60.1	1000000000
nest	KS07224	24-Jun	w/wy;k/km	>2	M	HS12DU	32.9	57.6	25.7	48.5	118	54.0	1100000000
nest	**KS06207**	**26-Jun**	**w/yk;y/km**	**>2**	**M**	**OL05DU**	**30.8**	**54.2**	**24.4**	**47.5**	**118**	**49.8**	**0000000000**
nest	**KS06212**	**26-Jun**	**r/yy;k/km**	**>2**	**M**	**IT20DU**	**32.9**	**56.2**	**25.3**	**46.5**	**115**	**49.3**	**2222100000**
nest	KS06121	27-Jun	y/yw;y/km	>2	M	IT23DU	32.0	55.2	24.6	45.0	116	45.5	4444310000
nest	**KS06220**	**28-Jun**	**w/rw;w/km**	**>2**	**M**	**HS02DU**	**32.7**	**57.4**	**24.9**	**48.5**	**113**	**48.2**	**3332100000**
nest	**KS06115**	**28-Jun**	**r/rr;k/km**	**>2**	**M**	**OL32DU**	**32.2**	**57.2**	**25.7**	**47.0**	**119**	**53.2**	**0000000000**
nest	KS07233	28-Jun	b/wk;w/km	>2	M	IT08DU	30.3	54.1	24.0	45.0	118	48.0	3332100000
nest	KS07236	01-Jul	r/bb;k/km	>2	M	OL40DU	34.2	58.0	24.9	49.0	118	54.7	5443321000
nest	KS07237	06-Jul	k/wk;w/km	>2	M	IT57DU	30.2	55.0	24.5	47.0	117	53.4	5554443100
nest	**KS06218**	**06-Jul**	**w/yr;w/km**	**>2**	**M**	**IT13DU**	**31.5**	**56.0**	**24.5**	**46.0**	**115**	**53.0**	**5554431000**
nest	**KS07236**	**08-Jul**	**r/bb;k/km**	**>2**	**M**	**OL40DU**							**0000000000**
nest	**KS06204**	**10-Jul**	**w/yr;k/km**	**>2**	**M**	**IT41DU**	**33.8**	**58.6**	**24.2**	**45.5**	**118**	**50.0**	**4443310000**
nest	**KS06209**	**20-Jul**	**w/yw;w/km**	**>2**	**M**	**HS51DU**	**30.0**	**54.7**	**24.2**	**46.0**	**119**	**58.0**	**5551000000**
brood	KS07445	08-Jul	r/kk;r/km	>2	F	HSDU01	35.6	59.0	25.7	48.0	120	54.5	5554320000
brood	KS07454	18-Jul		>2	F	ITDU10	31.7	56.0	26.5	48.0	116	45.5	5555541000
brood	KS07446	08-Jul	k/yw;y/km	>2	M	HSDU01	32.4	57.1	25.4	48.0	117	52.5	0000000000
brood	*KS07233*	*11-Jul*	*b/wk;w/km*	*>2*	*M*	*IT08DU*						*47.0*	*5544430000*
brood	*KS07233*	*14-Jul*	*b/wk;w/km*	*>2*	*M*	*IT08DU*						*45.0*	*5554431000*
brood	KS07428	15-Jul	w/bb;b/km	>2	M	HSDU06	32.4	57.2	24.4	46.0	118	46.3	4443100000
brood	**KS06300**	**16-Jul**	**b/ww;k/km**	**>1**	**M**	**IT30DU**	**31.8**	**57.1**	**25.2**	**48.0**	**115**	**50.0**	**4442000000**
brood	KS07427	16-Jul	w/yy;w/km	>1	M	HSDU08	32.1	56.7	25.4	47.0	117	47.5	5555441000
brood	KS07459	19-Jul	y/wy;/km	>2	M	ITDU13	31.2	54.1	25.0	49.5	116	47.9	5555541000
brood	KS07418	20-Jul	r/br;w/km	>2	M	HSDU11	33.6	57.7	26.2	49.5		47.0	5555555311
brood	KS07471	23-Jul	w/by;y/km	>2	M	OL68DU	30.0	53.8	24.9	47.5	114	43.0	5555555310
autumn migr.	KS07426	17-Jul		2	F		36.6	61.6	27.3	50.5	122	49.0	5544330000
autumn migr.	KS06271	20-Jul		>1	F?	HS54LS	37.7	63.2	27.8	49.0	117	52.0	5555554100
autumn migr.	KS06274	23-Jul		>1	F?		35.2	59.5	25.3	48.0	116	46.5	5555555200
autumn migr.	KS06182	24-Jul		>1	M		34.0	57.7	26.2	46.0	117	47.0	5555554310
autumn migr.	KS06183	24-Jul		>1	M		31.3	54.9	24.9	45.0	110	40.0	5555554100
autumn migr.	KS06188	05-Aug		>1	M		34.5	59.9	25.3	47.0		50.5	5555555544
autumn migr.	KS06273	23-Jul		>1	M?		32.4	57.0	25.6	47.0	114	46.5	5555555200
autumn migr.	victim	17-Jul		>2	F		38.3	62.8	27.1	51.0	121	54.0	5555531000
autumn migr.	KS07474	03-Aug		>2	M		32.1	55.9	26.4	47.5	111	47.0	5555555554
autumn migr.	KS06193	07-Aug		>2	M		31.8	55.6	24.6	45.0		44.2	5555555544
autumn migr.	KS06194	07-Aug		>2	M		34.2	58.0	26.1	47.0	116	45.2	5555555554
autumn migr.	KS06196	07-Aug		>2	M		33.9	58.1	25.6	48.0		45.8	5555555544
autumn migr.	KS06285	08-Aug		>2	M		31.6	55.6	24.7	46.5	109	48.5	5555555554
autumn migr.	KS06296	10-Aug		>2	M		32.4	55.7	25.7	46.5	115	49.5	5555555555
autumn migr.	KS06298	10-Aug		>2	M		31.2	54.9	23.4	45.5	116	43.5	5555555554
autumn migr.	KS06187	26-Jul		2?	M?		33.3	55.6	24.2	47.0	112	44.0	5555543200
autumn migr.	KS06197	07-Aug		1			31.3	55.3	27.3	49.0	117	48.6	0000000000
autumn migr.	KS07437	08-Aug		1			29.0	52.0	25.7	46.5	118	45.1	0000000000
autumn migr.	KS06291	08-Aug		1			33.0	56.5	25.4	48.0	123	46.7	0000000000
autumn migr.	KS06292	09-Aug		1			34.1	59.0	26.9	50.5	125	52.0	0000000000
autumn migr.	KS06294	09-Aug		1			31.6	55.7	25.3	49.0	119	46.5	0000000000
autumn migr.	KS06295	09-Aug		1			30.0	55.4	25.7	48.5	120	46.6	0000000000
autumn migr.	KS06297	10-Aug		1			31.1	54.3	25.2	46.0	120	42.5	0000000000
autumn migr.	KS06299	10-Aug		1			32.3	56.7	25.6	47.0	122	44.0	0000000000

Biometrics of Curlew Sandpipers during spring migration, incubation, brood rearing and autumn migration. Bill length, total head length, tarsus length, tarsus + toe length and wing length are all in mm, mass is in g. Colour codes: m= metal, r= red, w= white, k =pink, b= blue, y= yellow.

status	ring	date	colour	age	sex	nest code (l/r)	bill	total head	tarsus	tarsus +toe	wing	mass
spring migr.	KS07205	10-Jun	b/yy;y/km	>2	F		40,0	64,6	31,9	56,6	134	66,4
spring migr.	KS07207	10-Jun	b/yw;y/km	>2	F		37,7	62,5	31,2	52,0	132	58,5
spring migr.	KS07209	11-Jun	y/yb;k/km	>2	F		41,9	65,7	30,2	54,0	135	65,0
spring migr.	KS07210	11-Jun	y/wb;w/km	>2	F		41,8	66,9	31,6	55,0	137	57,5
spring migr.	KS07213	12-Jun	r/rr;y/km	>2	F		37,3	64,7	33,3	56,0	136	62,5
spring migr.	KS07215	12-Jun		>2	F		39,8	64,2	30,9	54,0	136	54,5
spring migr.	KS07262	14-Jun		>2	F		38,1	63,0	31,0	56,0	131	68,5
spring migr.	KS07263	14-Jun		>2	F		38,8	61,3	33,8	54,5	132	58,5
spring migr.	KS07264	14-Jun		>2	F		41,3	67,4	31,8	55,0	134	63,0
spring migr.	KS07266	14-Jun		>2	F		37,9	63,9	28,0	50,0	131	55,0
spring migr.	KS07216	15-Jun		>2	F		38,2	62,5	30,3	51,0	125	61,4
spring migr.	KS07218	15-Jun		>2	F		37,0	61,0	30,4	53,0	132	53,0
spring migr.	KS07268	18-Jun		>2	F		37,0	62,2	31,4	55,0	135	57,5
spring migr.	KS07206	10-Jun	b/wr;b/km	>2	M		35,4	59,4	30,8	52,5	131	53,4
spring migr.	KS07208	11-Jun	r/rr;w/km	>2	M		36,0	60,6	32,3	53,0	134	60,0
spring migr.	KS07211	11-Jun	y/rr;w/km	>2	M		35,7	60,5	31,3	54,0	134	58,5
spring migr.	KS07212	11-Jun	y/wy;w/km	>2	M		35,0	60,0	31,0	55,0	132	57,5
spring migr.	KS07214	12-Jun		>2	M		37,2	61,8	30,5	53,0	131	55,5
spring migr.	KS07259	13-Jun		>2	M		35,7	60,7	30,6	52,0	131	56,5
spring migr.	KS07260	14-Jun		>2	M		35,4	59,0	29,3	52,0	129	53,7
spring migr.	KS07265	14-Jun		>2	M		34,1	58,4	29,8	51,0	130	51,0
spring migr.	KS07219	16-Jun		>2	M		36,9	60,7	29,9	50,0	127	59,5
spring migr.	KS07220	16-Jun		>2	M		34,8	60,0	30,4	54,0	130	57,5
spring migr.	KS07269	19-Jun		>2	M		34,4	59,0	29,7	51,0	130	58,5
spring migr.	KS07256	7-Jun	b/yk;b/km	>2	M		34,0	58,5	29,3	53,0	133	59,0
spring migr.	KS07203	8-Jun	k/kk;k/km	>2	M?		36,0	61,1	30,2	52,0	132	52,7
nest	KS07222	24-Jun	w/yr;w/km	>2	F	HS11CS	38,7	63,5	30,5	53,5	132	63,5
nest	KS07225	24-Jun	w/rr;k/km	>2	F	HS10CS	38,0	63,4	31,8	54,0	135	71,0
nest	KS07270	26-Jun	b/kb;k/km	>2	F	HS20CS	38,9	64,3	34,8	59,0	131	63,0
nest	KS07229	27-Jun	y/yk;y/km	>2	F	IT09CS	40,3	65,8	35,7	59,5	133	61,8
nest	KS07250	7-Jul	k/yb;y/km	>2	F	HS48CS	39,6	64,2	32,3	56,0	138	68,5
nest	KS07271	7-Jul	y/yy;k/km	>2	F	HS49CS	37,8	63,0	32,2	54,0	130	65,5
nest	KS07272	8-Jul	k/yy;k/km	>2	F	HS25CS	40,8	66,7	31,9	55,0	131	72,3
nest	KS07434	9-Jul	k/bw;w/km	>2	F	HS47CS	40,0	65,4	30,8	54,0	127	69,5
nest	KS07429	13-Jul	r/ww;y/km	>2	F	HS57CS	40,1	65,0	33,2	57,5	134	71,2
brood	KS07293	9-Jul	y/ww;y/km	>2	F	ITCS03	40,6	64,1	32,6	55,0	138	61,5
brood	KS07296	16-Jul	r/yr;m/k	>2	F	HSCS07	38,4	61,4	29,5	50,5	129	61,0
brood	KS07467	21-Jul	k/ww;w/km	>2	F	ITCS18	38,8	63,5	32,0	54,0	132	49,5
autumn migr.	KS07417	21-Jul		>2	F		42,3	68,0	31,7	54,0	137	55,7
autumn migr.	KS06272	23-Jul		>2	F		41,4	66,6	33,3	56,0	135	61,5
autumn migr.	KS06178	24-Jul		>2	F		38,6	63,9	30,8	55,5	129	54,5
autumn migr.	KS06179	24-Jul		>2	F		38,8	62,6	31,9	54,5	131	55,0
autumn migr.	KS06180	24-Jul		>2	F		37,6	61,6	31,2	54,0	133	51,0
autumn migr.	KS06181	24-Jul		>2	F		43,2	66,2	33,1	55,0	133	54,0
autumn migr.	KS06184	24-Jul		>2	F		42,2	66,6	33,0	56,6	127	56,0
autumn migr.	KS06185	24-Jul		>2	F		41,1	65,9	31,0	53,0	135	54,0
autumn migr.	KS06186	24-Jul		>2	F		41,8	66,0	31,2	54,5	130	51,0
autumn migr.	KS07415	25-Jul		>2	F		36,7	60,7	31,8	57,0	134	58,5
autumn migr.	KS07414	25-Jul		>2	F		42,2	66,9	32,1	58,5	135	59,5
autumn migr.	KS07413	25-Jul		>2	F		39,0	63,6	30,3	54,0	133	54,0
autumn migr.	KS07412	25-Jul		>2	F		39,4	63,9	31,0	55,0	135	56,5
autumn migr.	KS07411	25-Jul		>2	F		37,8	61,8	30,3	54,5	132	52,5
autumn migr.	KS07410	25-Jul		>2	F		40,5	65,2	31,8	57,0	129	54,5
autumn migr.	KS07409	25-Jul		>2	F		40,9	65,6	32,2	56,0	134	61,0
autumn migr.	KS06275	25-Jul		>2	F		41,3	66,7	33,2	57,0	140	61,0
autumn migr.	KS06276	25-Jul		>2	F		39,1	64,2	30,3	53,0	132	57,5
autumn migr.	KS06277	25-Jul		>2	F		39,7	63,8	32,0	55,0	128	53,5

Curlew Sandpiper continued

status	ring	date	colour	age	sex code	nest (l/r)	bill	total head	tarsus	tarsus +toe	wing	mass
autumn migr.	KS07407	30-Jul		>2	F		40,7	64,8	32,4	54,0	131	58,3
autumn migr.	KS07406	30-Jul		>2	F		38,2	62,6	32,2	56,5	132	59,0
autumn migr.	KS07405	30-Jul		>2	F		42,2	67,0	32,0	57,0	132	58,0
autumn migr.	KS07404	30-Jul		>2	F		38,2	62,6	30,6	53,0	125	53,4
autumn migr.	KS07403	30-Jul		>2	F		39,6	64,1	31,5	55,0	129	58,7
autumn migr.	KS07402	30-Jul		>2	F		39,1	63,8	32,7	56,0	134	52,3
autumn migr.	KS07401	30-Jul		>2	F		39,4	64,0	32,4	57,0	133	53,8
autumn migr.	KS06278	30-Jul		>2	F		39,2	62,8	31,1	56,0	133	57,8
autumn migr.	KS06279	30-Jul		>2	F		43,3	68,0	31,4	56,5	134	58,0
autumn migr.	KS06280	30-Jul		>2	F		38,4	62,7	33,2	56,0	136	56,5
autumn migr.	KS06281	30-Jul		>2	F		38,9	63,1	29,8	51,0	126	48,0
autumn migr.	KS06282	31-Jul		>2	F		40,1	64,5	30,4	54,0	134	53,5
autumn migr.	KS06283	31-Jul		>2	F		39,1	64,0	29,7	54,0	139	55,3
autumn migr.	KS07475	4-Aug		>2	F		44,8	67,8	30,8	54,5	133	60,7
autumn migr.	KS07476	4-Aug		>2	F		38,3	62,2	32,1	54,0	129	56,9
autumn migr.	KS06189	5-Aug		>2	F		36,6	62,5	29,9	52,0	135	64,2
autumn migr.	KS06191	5-Aug		>2	F		36,3	61,1	30,6	53,0	133	57,5
autumn migr.	KS06293	9-Aug		>2	F		43,5	67,6	32,0	56,0	132	61,0
autumn migr.	KS07477	4-Aug		1			35,4	59,7	32,7	55,0	131	53,0
autumn migr.	KS07478	4-Aug		1			40,4	64,5	31,9	55,0	134	54,0
autumn migr.	KS06190	5-Aug		1			30,3	54,6	28,7	50,5	126	49,0
autumn migr.	KS06192	5-Aug		1			31,3	61,4	34,6	55,5	136	57,0
autumn migr.	KS06198	7-Aug		1			34,9	58,2	30,9	53,0	129	47,6
autumn migr.	KS06199	7-Aug		1			35,4	57,4	32,0	53,0	131	52,4
autumn migr.	KS06200	7-Aug		1			34,6	59,0	31,0	52,5	137	49,3
autumn migr.	KS06284	8-Aug		1			34,6	58,7	31,0	54,0	128	52,1
autumn migr.	KS06286	8-Aug		1			38,8	63,4	30,2	54,0	129	52,9
autumn migr.	KS06287	8-Aug		1			34,6	58,6	30,4	53,5	131	51,4
autumn migr.	KS06288	8-Aug		1			38,8	63,3	29,6	54,5	130	53,8
autumn migr.	KS06289	8-Aug		1			38,4	62,7	31,8	56,0	131	52,0
autumn migr.	KS06290	8-Aug		1			34,7	57,6	28,9	52,0	129	48,7
autumn migr.	victim	10-Aug		1			35,1	58,3	29,6	52,0	131	49,5

Appendix 2 Egg size and start of incubation for each nest.

Egg size measurements and estimated start of incubation of Ringed Plover clutches (volume is calculated as 0.5 x length x width^2). D volume represents the difference in volume between the largest and the smallest egg of one clutch.

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	Δ volume (ml)	start of incubation
TK06RP	4	34.38	24.65	10.44	0.43	16-Jun
OL06RP	4	35.68	25.78	11.85	1.02	20-Jun
OL33RP	4	35.80	24.90	11.09	0.42	7-Jul

Egg size measurements and estimated start of incubation of Pacific Golden Plover clutches (volume is calculated as 0.5 x length x width^2). Incomplete nests that were preyed upon before nest completion are indicated (>). D volume represents the difference in volume between the largest and the smallest egg of one clutch.

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	Δ volume (ml)	start of incubation
IT14GP	4	47.75	33.30	26.48	2.88	19-Jun
IT16GP	4	49.38	33.93	28.42	2.14	19-Jun
IT24GP	4	46.13	32.30	24.06	1.26	20-Jun
IT38GP	4	51.48	33.55	28.97	1.59	20-Jun
IT66GP	4	45.50	32.60	24.17	1.14	20-Jun
IT78GP	4	47.23	33.38	26.31	2.18	20-Jun
OL17GP	>3					20-Jun
OL30GP	4	48.95	33.98	28.25	0.92	20-Jun
IT48GP	4	47.38	32.65	25.25	1.49	21-Jun
IT15GP	4	50.87	33.47	28.49	2.16	22-Jun
IT21GP	2	48.45	32.95	26.30	0.33	22-Jun
OL37GP	4	48.45	33.80	27.68	2.86	22-Jun
OL44GP	4	49.00	32.10	25.24	1.49	25-Jun
OL45GP	4	49.73	32.53	26.31	2.08	26-Jun
IT33GP	>2	46.55	33.40	25.96	0.06	27-Jun
IT82GP	4	46.68	31.78	23.57	2.20	27-Jun
IT90GP	4	47.40	33.90	27.25	1.11	28-Jun
IT65GP	4	47.23	33.03	25.75	2.22	30-Jun
IT91GP	4	46.00	31.38	22.64	1.62	30-Jun
IT92GP	4	50.03	32.50	26.41	1.83	1-Jul
HS31GP	>2	46.60	32.65	24.84	0.26	2-Jul
IT77GP	4	48.83	32.23	25.35	1.20	7-Jul
IT95GP	4	48.03	32.98	26.10	1.81	7-Jul
IT81GP	4	46.53	32.83	25.06	1.27	10-Jul
IT79GP	4	45.93	32.87	24.83	2.89	11-Jul
OL69GP	4	46.43	32.70	24.83	2.35	?

Egg size measurements and estimated start of incubation of Dotterel clutches (volume is calculated as 0.5 x length x width^2). D volume represents the difference in volume between the largest and the smallest egg of one clutch.

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	Δ volume (ml)	start of incubation
HS35DO	3	42.90	28.77	17.75	1.15	27-Jun
HS24DO	3	40.77	28.97	17.10	0.25	?

Egg size measurements and estimated start of incubation of Turnstone clutches (volume is calculated as 0.5 x length x width^2). Incomplete nests that were preyed upon before nest completion are indicated (>). D volume represents the difference in volume between the largest and the smallest egg of one clutch.

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	Δ volume (ml)	start of incubation
HS04TU	4	41.40	28.23	16.49	0.91	16-Jun
HS09TU	4	40.40	28.83	16.79	1.67	16-Jun
OL47TU	4	41.45	28.73	17.10	0.66	16-Jun
HS13TU	4	41.23	28.73	17.01	0.52	17-Jun
HS08TU	4	40.95	28.13	16.20	0.78	18-Jun
OL34TU	4	39.10	23.68	10.96	1.38	23-Jun
OL53TU	>3					

Egg size measurements and estimated start of incubation of Red Phalaropes (volume is calculated as 0.5 x length x width^2). D volume represents the difference in volume between the largest and the smallest egg of one clutch.

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	Δ volume (ml)	start of incubation
HS06PH	4	31.93	22.67	8.20	0.46	22-Jun
HS29PH	4	31.78	22.78	8.24	0.16	23-Jun
OL50PH	4	30.28	21.60	7.10	2.20	23-Jun
OL60PH	4	31.43	22.60	8.03	0.30	25-Jun

Egg size measurements and estimated start of incubation of the Red Knot clutch (volume is calculated as 0.5 x length x width^2). D volume represents the difference in volume between the largest and the smallest egg of one clutch.

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	Δ volume (ml)	start of incubation
OL52KN	4	44.18	31.78	22.30	0.69	21-Jun

Egg size measurements and estimated start of incubation of Little Stint clutches (volume is calculated as 0.5 x length x width^2). Incomplete nests that were preyed upon before nest completion are indicated (>).D volume represents the difference in volume between the largest and the smallest egg of one clutch.

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	Δ volume (ml)	start of incubation
IT17LS	4	27.23	20.40	5.67	0.47	15-Jun
IT53LS	4	30.25	19.98	6.04	0.34	16-Jun
TK05LS	4	28.75	20.00	5.75	0.75	16-Jun
HS21LS	4	20.23	29.28	5.99	0.30	17-Jun
HS23LS	4	30.50	21.10	6.79	0.33	17-Jun
HS42LS	4	29.93	21.50	6.92	0.23	17-Jun
IT05LS	4	28.63	20.45	5.99	0.66	17-Jun
IT19LS	5	29.76	19.98	5.94	0.18	17-Jun
IT28LS	4	28.88	21.03	6.38	0.13	17-Jun
IT73LS	4					17-Jun
OL23LS	4	30.40	20.35	6.30	0.43	17-Jun
HS01LS	>2					18-Jun
HS37LS	4	29.75	20.63	6.33	0.21	18-Jun
IT11LS	4	28.38	20.18	5.78	0.40	18-Jun
OL39LS	4	28.85	20.83	6.26	0.55	18-Jun
IT01LS	4	28.43	19.65	5.49	0.38	19-Jun
IT56LS	4	28.38	20.70	6.08	0.25	19-Jun
HS28LS	4	26.83	20.73	5.76	0.24	21-Jun
HS50LS	4	29.38	20.88	6.40	0.18	21-Jun
IT80LS	4					21-Jun
IT26LS	4	28.25	20.30	5.82	0.35	22-Jun
IT49LS	4	28.25	20.23	5.78	0.37	22-Jun
IT83LS	4					22-Jun
LP09LS	4	29.53	21.35	6.73	0.25	22-Jun
OL24LS	>3					22-Jun
HS16LS	4	27.93	20.43	5.82	0.26	23-Jun
HS34LS	4	28.15	20.08	5.67	0.39	23-Jun
HS38LS	4	26.88	20.68	5.74	0.32	23-Jun
HS41LS	4	29.98	21.18	6.72	0.37	23-Jun
IT25LS	4	29.73	20.33	6.14	0.22	23-Jun
HS58LS	4					24-Jun
IT34LS	4	29.45	21.03	6.51	0.24	24-Jun
IT36LS	4	29.70	20.83	6.45	0.34	24-Jun
IT44LS	4	29.80	21.13	6.65	0.69	24-Jun
OL22LS	>1					24-Jun
OL58LS	4	28.48	20.75	6.13	0.51	24-Jun
IT40LS	4	29.05	21.13	6.48	0.60	25-Jun
IT46LS	4	29.13	20.83	6.32	0.13	25-Jun
LP13LS	4	26.75	20.70	5.73	0.20	25-Jun
HS22LS	4	28.38	20.73	6.09	0.15	26-Jun
IT42LS	4	28.48	20.18	5.79	0.12	26-Jun
IT61LS	4					26-Jun
IT69LS	4	30.00	21.68	7.05	0.35	26-Jun
IT88LS	4					26-Jun
OL38LS	4	28.08	20.10	5.67	0.27	26-Jun
OL65LS	4	29.35	20.85	6.38	0.19	26-Jun
HS26LS	4	29.48	20.68	6.30	0.12	27-Jun
IT55LS	4	29.85	20.55	6.30	0.49	27-Jun
IT60LS	4	27.93	20.43	5.82	0.23	27-Jun
IT67LS	4	29.78	20.75	6.41	0.42	27-Jun

Little Stint continued

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	Δ volume (ml)	start of incubation
IT68LS	4	29.38	21.25	6.63	0.07	27-Jun
IT70LS	4	27.88	20.50	5.86	0.42	27-Jun
LP10LS	4	28.80	20.75	6.20	0.33	27-Jun
LP16LS	4	29.88	21.28	6.76	0.28	27-Jun
OL49LS	4	29.25	20.55	6.18	0.23	27-Jun
OL57LS	4	28.88	20.43	6.02	0.38	27-Jun
HS55LS	4	29.88	20.50	6.28	0.43	28-Jun
HS59LS	4	28.90	20.78	6.24	0.17	28-Jun
IT45LS	4	29.75	20.33	6.15	0.36	28-Jun
IT72LS	4	28.00	20.10	5.66	0.26	28-Jun
IT89LS	>2	28.95	20.65	6.17	0.09	28-Jun
LP14LS	4	28.60	20.23	5.85	0.62	28-Jun
LP15LS	4	29.58	21.28	6.70	0.81	28-Jun
OL42LS	4	28.73	20.85	6.24	0.24	28-Jun
OL66LS	4	28.98	20.50	6.09	0.24	28-Jun
HS33LS	4	28.33	21.05	6.28	0.29	29-Jun
HS36LS	4	29.70	20.33	6.14	0.20	29-Jun
HS52LS	4	27.83	21.23	6.27	0.38	29-Jun
HS56LS	4	27.95	19.63	5.38	0.09	29-Jun
IT43LS	4	28.83	21.35	6.57	0.18	29-Jun
IT64LS	4	29.28	21.05	6.49	0.57	29-Jun
IT71LS	4	27.68	19.48	5.25	0.67	29-Jun
OL63LS	4	29.48	20.60	6.25	0.21	29-Jun
TK08LS	4	28.65	20.68	6.12	0.17	29-Jun
HS32LS	4	28.33	21.05	6.28	0.29	30-Jun
HS54LS	4	29.25	20.45	6.12	0.34	30-Jun
IT31LS	4	29.77	20.67	6.36	0.50	30-Jun
IT52LS	>3inc	28.10	20.87	6.12	0.51	30-Jun
IT74LS	4	29.55	20.80	6.39	0.52	30-Jun
IT75LS	4	29.98	20.50	6.30	0.56	30-Jun
LP11LS	4	31.35	20.38	6.51	0.34	30-Jun
LP17LS	4	29.65	20.38	6.16	0.61	30-Jun
OL59LS	4	29.03	21.45	6.68	0.41	30-Jun
IT63LS	4	27.18	19.15	4.98	0.29	1-Jul
LP12LS	4	29.15	21.15	6.52	0.40	1-Jul
OL54LS	4	29.28	20.83	6.35	0.58	1-Jul
OL67LS	4	29.98	20.78	6.47	0.56	1-Jul
IT62LS	4	28.88	20.73	6.20	0.45	2-Jul
IT94LS	4	27.00	20.40	5.62	0.32	3-Jul
LP19LS	4	30.13	19.90	5.96	0.10	3-Jul
OL61LS	4	29.30	20.85	6.37	0.14	4-Jul
HS40LS	4	28.73	20.35	5.95	0.33	6-Jul
HS45LS	4	29.50	20.60	6.26	0.40	6-Jul
IT87LS	4	29.43	21.15	6.59	0.78	6-Jul
TK09LS	4	28.03	20.45	5.86	0.38	
OL26LS	4					
HS18LS	3inc					

Egg size measurements and estimated start of incubation of Temminck's Stint clutches (volume is calculated as 0.5 x length x width^2). D volume represents the difference in volume between the largest and the smallest egg of one clutch.

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	Δ volume (ml)	start of incubation
OL56TS	4	27.68	21.18	6.20	0.12	28-Jun
SK01TS	4	28.53	21.23	6.42	0.34	28-Jun

Egg size measurements and estimated start of incubation of Pectoral Sandpipers (volume is calculated as 0.5 x length x width^2). D volume represents the difference in volume between the largest and the smallest egg of one clutch.

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	Δ volume (ml)	start of incubation
OL08PS	4	38.13	25.68	12.57	1.51	15-Jun
OL14PS	4	37.80	26.50	13.27	0.71	19-Jun
HS27PS	4	36.75	27.35	13.74	0.17	22-Jun
OL41PS	4	35.33	25.63	11.60	0.66	23-Jun
IT50PS	4	36.90	26.35	12.81	0.36	24-Jun
IT51PS	4	37.85	27.45	14.26	0.81	24-Jun
HS44PS	4	34.95	26.25	12.04	0.51	25-Jun
IT68PS	4	34.05	24.80	10.48	1.52	25-Jun
LP08PS	4	40.00	27.38	14.99	0.84	25-Jun
HS19PS	4	37.68	26.63	13.35	0.52	26-Jun
OL64PS	4	37.73	26.70	13.45	0.63	29-Jun
HS46PS	4	35.58	25.70	11.75	0.88	30-Jun

Egg size measurements and estimated start of incubation of Dunlin clutches (volume is calculated as 0.5 x length x 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 (>). D volume represents the difference in volume between the largest and the smallest egg of one clutch.*

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	Δ volume (ml)	start of incubation
TK04DU	4	33.58	24.40	9.99	0.55	12-Jun
OL05DU	4	36.35	25.13	11.47	0.36	14-Jun
HS12DU	4	35.83	24.90	11.11	0.59	15-Jun
IT13DU	4	34.18	24.30	10.09	0.73	15-Jun
IT57DU	4	34.95	24.65	10.62	1.06	15-Jun
OL20DU	4	35.88	25.00	11.21	0.71	15-Jun
HS02DU	4	35.08	25.95	11.81	0.70	16-Jun
IT39DU	4	35.48	24.50	10.64	0.16	16-Jun
TK02DU	4	36.43	25.93	12.24	0.86	16-Jun
IT08DU	4	32.38	24.38	9.62	0.59	17-Jun
IT20DU	4	35.53	24.63	10.76	0.88	17-Jun
IT23DU	4	36.55	24.18	10.68	0.54	17-Jun
OL40DU	4	34.90	25.45	11.30	0.39	17-Jun
HS15DU	4	36.35	25.90	12.19	0.64	18-Jun
OL32DU	4	35.15	24.33	10.39	0.55	18-Jun
OL46DU	4	35.75	25.28	11.42	0.50	18-Jun
IT47DU	4	35.60	24.68	10.83	0.46	23-Jun
IT30DU	4	36.43	24.28	10.73	0.21	24-Jun
IT41DU	4	35.48	24.75	10.87	0.64	26-Jun
OL43DU	4	34.28	24.20	10.04	0.34	28-Jun
OL68DU	4	33.78	24.55	10.18	0.65	30-Jun
HS30DU	>3	35.27	25.33	11.32	0.44	1-Jul
IT86DU	>1	36.50	24.90	11.32		2-Jul
HS51DU	3	35.87	24.57	10.82	0.62	4-Jul
OL09DU	4					

Egg size measurements and estimated start of incubation of Curlew Sandpiper clutches (volume is calculated as 0.5 x length x width^2). Incomplete nests that were preyed upon before nest completion are indicated (>). D volume represents the difference in volume between the largest and the smallest egg of one clutch.

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	Δ volume (ml)	start of incubation
IT04CS	4	36.65	25.43	11.85	0.98	13-Jun
HS07CS	4	37.28	25.83	12.43	1.10	14-Jun
IT09CS	4	37.08	25.18	11.75	0.82	14-Jun
TK03CS	4	37.18	25.93	12.49	0.59	14-Jun
HS10CS	4	35.15	26.60	12.44	1.23	15-Jun
IT02CS	4					15-Jun
HS20CS	4	37.53	26.05	12.73	0.53	16-Jun
HS49CS	2	37.95	25.80	12.63	0.17	16-Jun
HS11CS	4	37.70	26.58	13.32	0.98	17-Jun
HS03CS	>1					19-Jun
IT32CS	4	36.40	25.90	12.22	0.79	20-Jun
HS05CS	4	36.57	25.20	11.61	0.67	21-Jun
HS14CS	4	37.08	26.88	13.40	2.01	22-Jun
HS57CS	3	35.00	26.37	12.17	0.73	22-Jun
LP07CS	4	35.35	25.70	11.68	0.79	25-Jun
HS48CS	4	36.98	26.28	12.77	1.02	26-Jun
TK07CS	4	36.90	25.65	12.14	0.90	26-Jun
HS25CS	3	36.77	26.10	12.52	0.62	28-Jun
HS47CS	4	36.50	25.85	12.20	0.66	28-Jun

Egg size measurements and estimated start of incubation of Ruff clutches (volume is calculated as 0.5 x length x width^2). D volume represents the difference in volume between the largest and the smallest egg of one clutch.

nest	n eggs	mean length (mm)	mean width (mm)	mean volume (ml)	Δ volume (ml)	start of incubation
IT35RU	4					21-Jun
IT58RU	4	44.50	29.73	19.65	0.93	26-Jun