# BREEDING CONDITIONS AND NUMBERS OF BIRDS ON TAIMYR, 2009

*Report of the Wader Monitoring Project on Taimyr*


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Front cover photo: male Grey Plover *Pluvialis squatarola*.

# 1. Introduction

Arctic terrestrial ecosystems are remarkable for pronounced fluctuations in the abundance and/or productivity at their high trophic levels, in birds and mammals. These unstable systems could have been expected to show quick response to increasing temperatures and precipitation across most of the Arctic during the recent decades (ACIA 2005). However, by the current time the results of observations on the impacts of climate change in terrestrial ecosystems were less alarming compared with melting of sea-ice and impacts on marine animals (Richter-Menge & Overland 2009). Apparently, this is partly due to a limited current understanding of the response of Arctic wildlife and ecosystems to both natural and human-induced changes. The latter gap in knowledge makes difficult establishing causal links between changing conditions for migratory waterbirds on their Arctic breeding grounds and the observed declines of migratory and wintering populations on flyways, for example in the Wadden Sea (Reineking & Sudbeck 2007). Hence, reinforcement and international coordination of the monitoring of waterbirds on their Arctic breeding grounds, including studies of relevant factors for the population dynamics of waterbirds, e.g. predator-prey systems and weather, have been identified as a top priority for waterbird conservation (Recommendations of the International Workshop "Seriously Declining Trends in Migratory Waterbirds in the Wadden Sea" (Wilhelmshaven, Germany, 31 August 2006), in: Reineking & Sudbeck 2007).

Several activities implemented in the framework of the International Polar Year 2007–2008 were aimed at filling gaps in the knowledge about Arctic terrestrial ecosystems, for example Arctic Wildlife Observatories Linking Vulnerable EcoSystems (ArcticWOLVES), the project building a network of circumpolar wildlife observatories in order to assess the current state of Arctic terrestrial food webs over a large geographical range (http://www.cen.ulaval.ca/arcticwolves/index.html). However, the level of research activities related to ornithology decreased in 2008 compared with several previous years in the Russian Arctic, which situation became a matter of discussion at the workshop "Monitoring waders in the Siberian Arctic", held within a framework of the annual conference of the International Wader Study Group (Texel, Netherlands, 18-21 September 2009).

In 2008-2009 "Wader monitoring project on Taimyr" (WMP) has remained the only active program of intensive monitoring of waders in the entire Russian Arctic. WMP was initiated in 1994 on south-eastern Taimyr in a framework of scientific cooperation between the National Park Schlezvig-Holstein Wattenmeer and the State Nature Reserve

“Taimyrsky”, and implemented in 1994–2009 with the primary goal to relate among-year variation of abundance and nest success of waders to environmental factors in the tundra. The long-term intensive studies proved successful, also because regularities that had emerged after the first several years of research, turned out considerably more complex when more seasons have been added to the time series. WMP has represented a unique for the whole circumpolar region example of contiguous collection of wader monitoring data for 16 years in a row with constant protocols of field data collection and processing through the whole period of monitoring. Since the start of WMP in 1994 we independently developed and employed in the project double sampling methodology (Bart & Earnst 2002), which has appeared the only reliable method to evaluate absolute densities of tundra breeding birds, and which had not been used for wader monitoring elsewhere in the Arctic before the 2000s.

Outline of the “Wader monitoring project on Taimyr”, selected presentations and reports are available at the project page at the website of the Working Group on Waders (http://www.waders.ru/taimyr.asp?lang=2 (English) and http://www.waders.ru/taimyr.asp?lang=1 (Russian)). Information about breeding conditions, environmental factors, numbers and breeding status of birds in the study areas for years 1994-2009 can be also obtained on websites of the Arctic Birds Breeding Conditions Survey (http://www.arcticbirds.ru, http://www.arcticbirds.net). Project reports in the Russian language appeared in the “Archives of nature” of the Reserve “Taimyrsky”, and are available electronically at the reserve website for years 2002-2008 (http://www.taimyrsky.ru/letopis/letopis.htm).

This reports presents information about the research activities carried out in summer 2009 at the study site in the lower reaches of the Khatanga River and preliminary results of the conducted studies.

# 2. Study site and methods

## *2.1. Study site*

Observations were carried out from 11.06 to 25.07.2009 in the area of approximately 65 km$^2$, located in the lower reaches of the Khatanga River, where studies had been carried out in the framework of the Wader monitoring project in 1994-2003 and 2008 (Fig. 1). The field camp with coordinates 72°51' N, 106°02' E was located at a distance of 3 km from the Khatanga River and 7.5 km from the Novorybnoe settlement, inhabited by the Dolgan people.

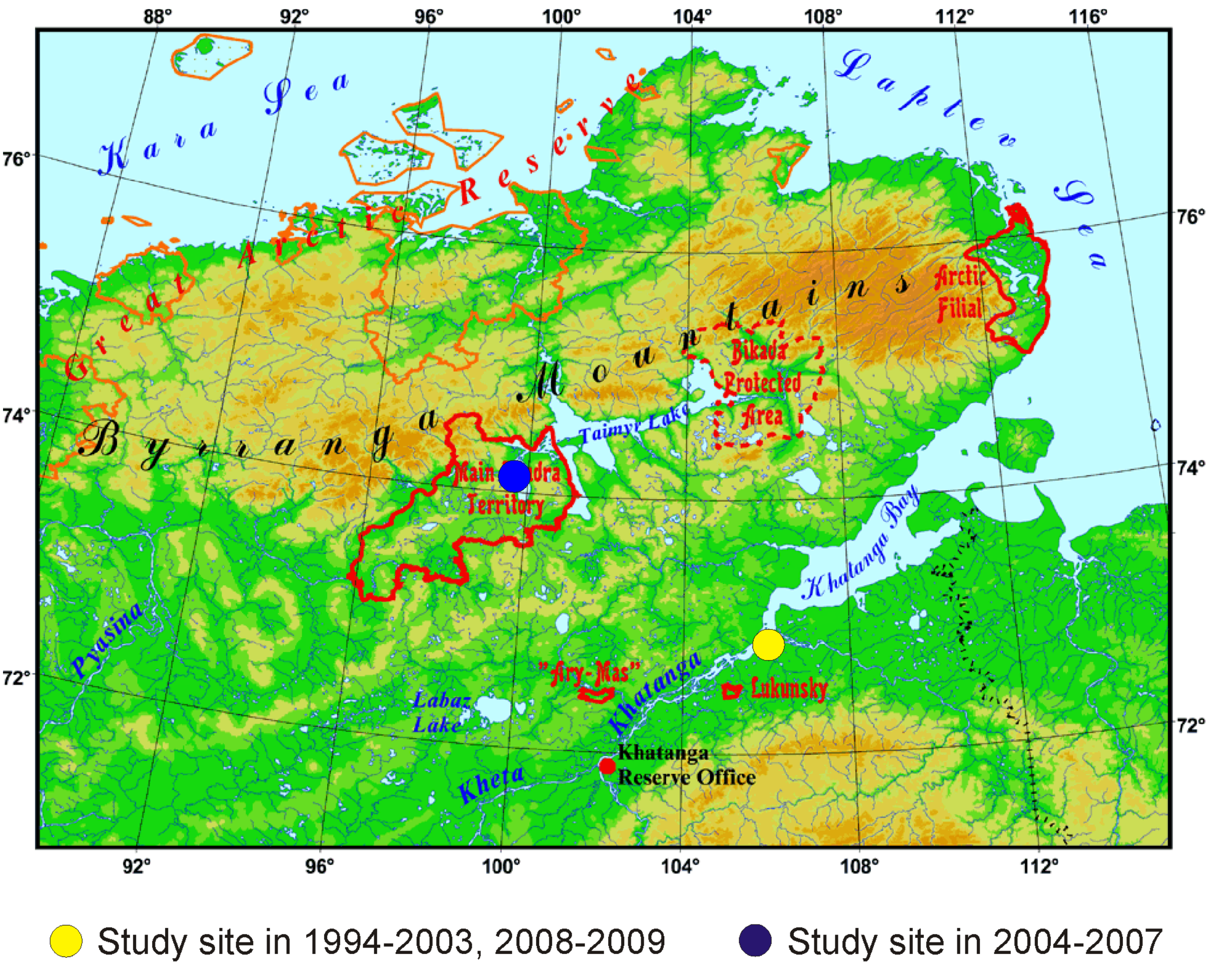



Figure 1. Study sites of the Wader Monitoring Project on Taimyr. Base map was obtained from the website of the "Taimyrsky" Nature Reserve (http://www.taimyrsky.ru/ENG/frame.htm), which territories are shown with solid red line.

The study area is situated near the southern border of the typical tundra subzone with the southern tundra subzone. We used Landsat-7 image acquired on 5 August 2000 to create habitat map of the study area (Fig. 2).

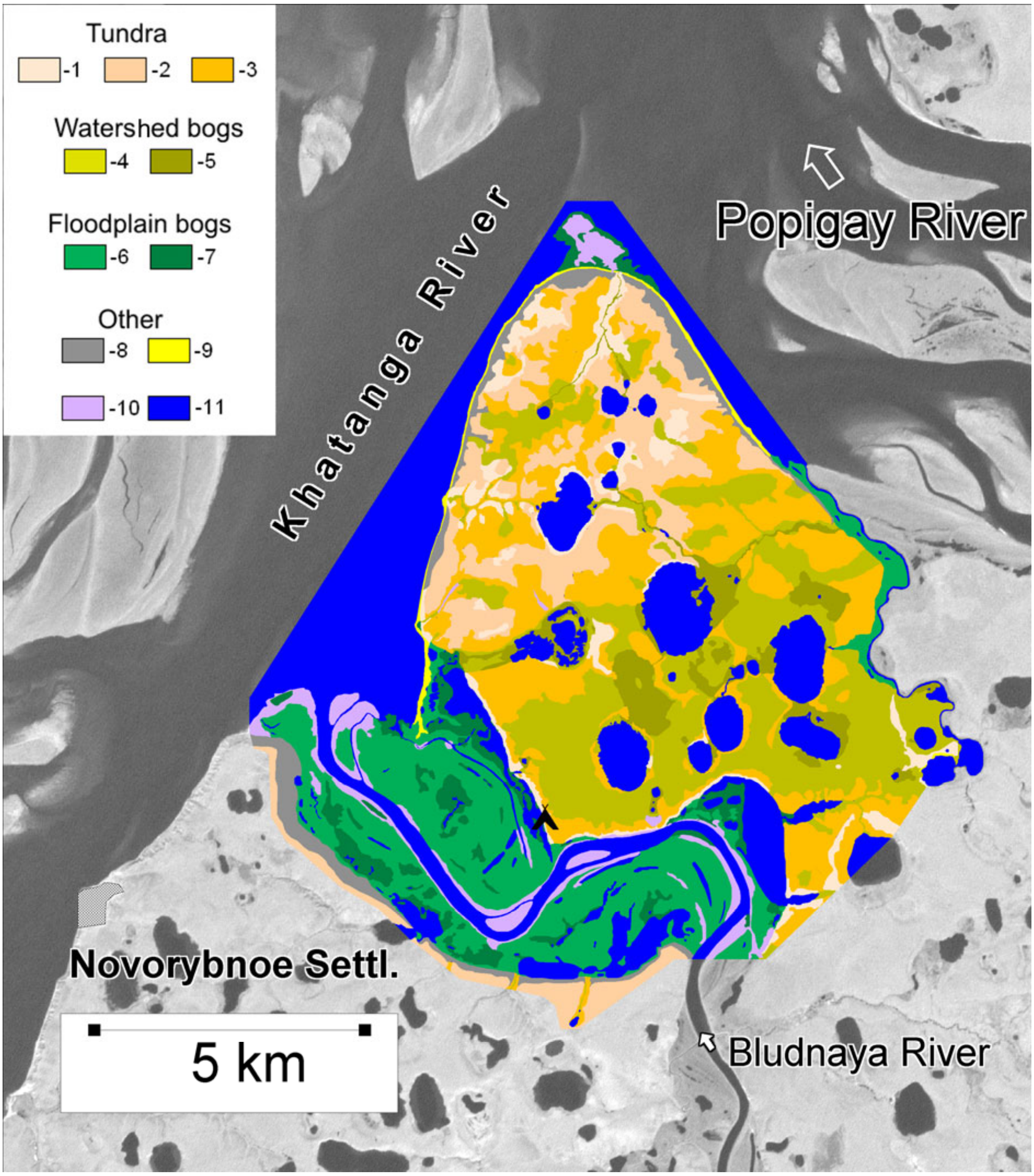



Figure 2. Principal habitats of the study area: 1 – dry dryas- tundra; 2 – watershed moss tundra; 3 – tussock sedge tundra; 4 – flat-hillock bogs; 5 – sedge bog; 6 – polygonal floodplain bog; 7 – sedge floodplain bog; 8 – bedrock river bank; 9 – sand and gravel spit; 10 – willow stands; 11 – water bodies. Panchromatic channel (15 m resolution) of the Landsat image was used as a gray-scale background. Hut symbol indicates field camp location.

We used Viewfinder Panoramas - unofficial Shuttle Radar Topography Mission (SRTM) data with voids corrected using topographic maps (http://www.viewfinderpanoramas.org/dem3.html) as a source of Digital Elevation Model (DEM) for the study area. A terrain of the study area was characterized by heights ranging from 0 to 50 m above the sea level and gentle slopes across most of the area (Fig. 3).

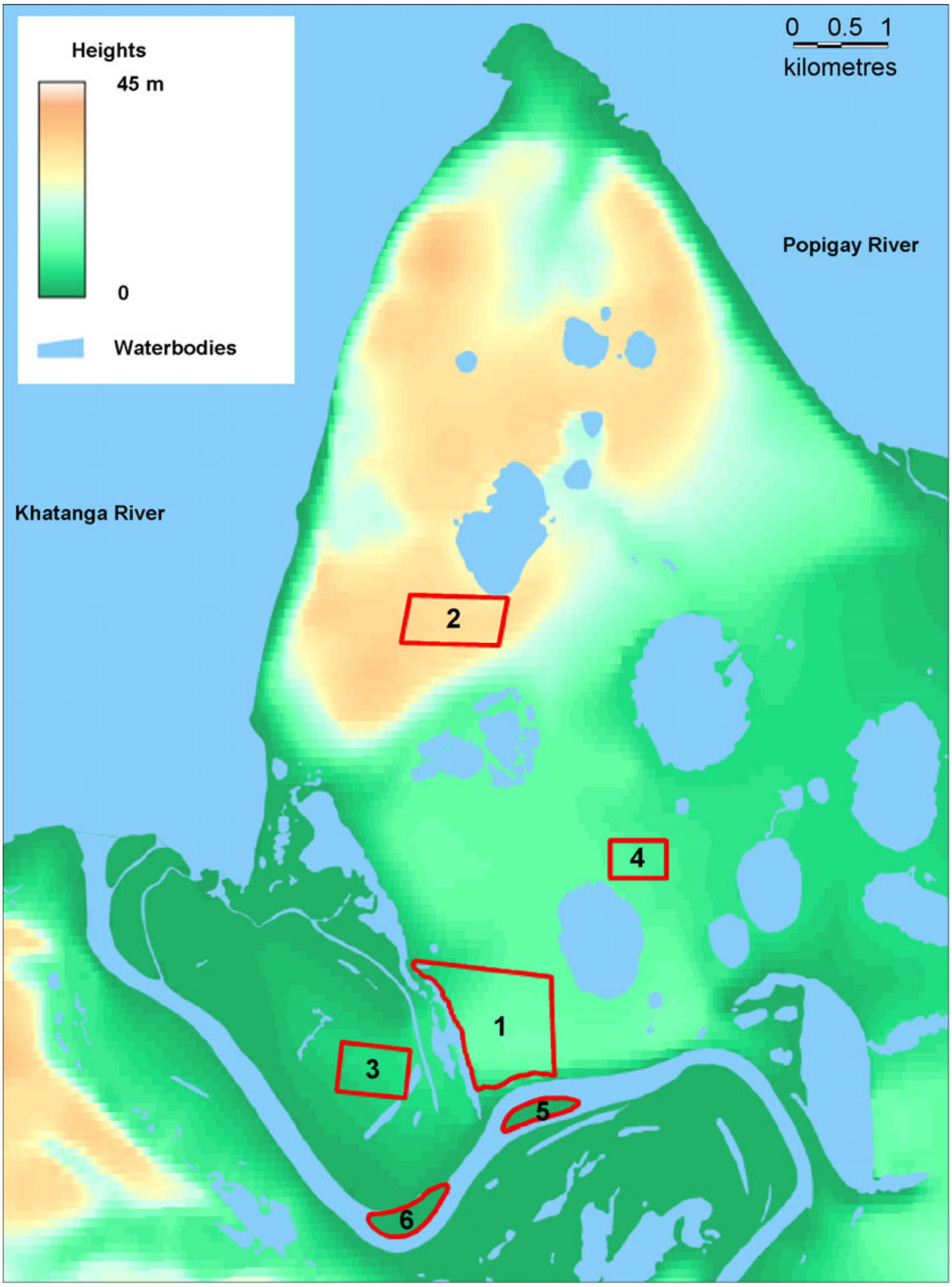



Figure 3. Plots for bird surveys overlaid with the DEM of the study area.

## *2.2. Collection of ornithological data*

A majority of quantitative data on fauna, distribution and numbers of birds were collected on 6 study plots with a total area of 269 hectares (Fig. 3 & 4, Table 1).

The main plot for nest counts and territory mapping was staked on the first river terrace adjacent to floodplain in 1994 at an area of 1.22 km$^2$ with 1 to 1.5 m high stakes, placed in lines 100 m apart. Two addition plots established in 1998 in the habitats, absent on the main plot – on hilly watershed (52 ha) and in the floodplain (37 ha) were surveyed in all the following years of studies at this site. The fourth plot (24 ha) was established in 2002 in sedge bog of near-lake depression, and surveyed in 2002-2003, and partially in 2008, as well as two small islands of the Bludnaya River (13 and 20 ha). The plots on islands were not staked, because it was not necessary on so small and narrow territories. Estimates of plot areas were corrected in 2009, when boundaries and habitat maps of the plots created in the 1990s in non-earth coordinates were georegistered using Manifold System Rel. 8 GIS software (http://www.manifold.net).

**Table 1. Plots for bird counts**

| Plot # | Area, ha | Heights (m), mean (min-max) | Years surveyed | Description |
|---|---|---|---|---|
| 1 | 122.3 | 9.5 (2-12) | 1994-2003, 2008-2009 | Oligotrophic flat-hillock bog (60.1% of the plot area), wet tussok moss tundra (28.0%), dry patchy moss tundra (2.5%), complex of lichen dryas tundra on convex ridges and shrub moss tundra in concave depressions (8.5%), stream valley with convex hillock bog (0.9 %) |
| 2 | 52.4 | 30.9 (26-33) | 1998-2003, 2008-2009 | Watershed area with 2 types of moss tundra |
| 3 | 37.4 | 4.4 (3-6) | 1998-2003, 2008-2009 | Polygonal hypnum bog in central floodplain of the Bludnaya River |
| 4 | 23.8 | 8.6 (8-9) | 2002-2003, 2008 (partly) | Wet sedge bog of the terrace |
| 5 | 13.1 | 1.0 (1-1) | 2002-2003, 2008-2009 | Willow stands (70.3% of the plot area), forb habitats (14.0%), mud-sandy shores (15.7%). |
| 6 | 20.2 | 1.0 (1-1) | 2002-2003, 2008-2009 | Willow stands (75.8% of the plot area), forb habitats (16.8%), mud-sandy shores (7.3%). |

Intensive nest searches on the plots were started in the study area on 13 June, when many clutches of early breeding species (e.g., Dunlin *Calidris alpina*) were not complete yet.

Nests were marked with wooden sticks 15–25 cm long placed 5–8 m away from the nest (larger distance for larger species). Location of each nest was determined using Garmin GPS 12 and GPSMAP 60CSx. Nest searches with the rope were carried out on plots #1–3 from 28.06–2.07 and involved dragging a 54 m long synthetic rope (blue and 6 mm thick) along the staked lines. Seven 250 ml tins with a few small stones in each were attached to the rope at regular intervals. Nests were also found occasionally in the course of ringing and other activities during the whole nesting period. In total 340 nests were found, including 129 nests of waders, 161 of passerines and 50 of other birds. The plot # 4 was not surveyed in 2009, because nest search activities would inevitably result in a loss of a nest of Bewick's Swans *Cygnus bewickii*, established in this plot in a close vicinity to a nest of Arctic Skuas *Stercorarius parasiticus*.

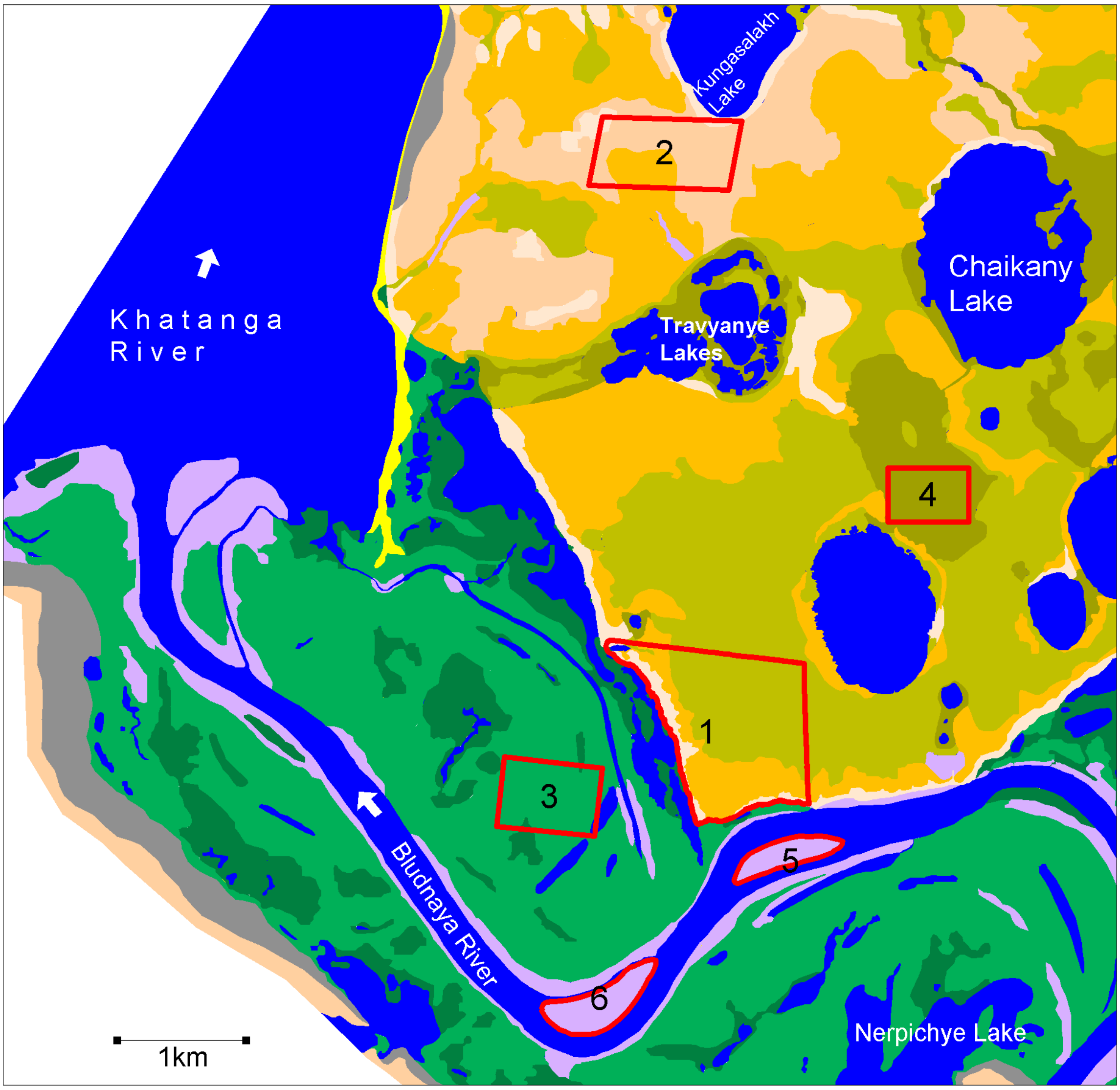



Figure 4. Plots for bird surveys in the study area. See Fig. 2 for habitat legend.

We conducted flotation tests for wader eggs with view of estimating their incubation stage according to Liebezeit et al. (2007). Egg angle, or floating egg angle and float height were measured for 2 eggs from every clutch.

Waders were caught by 'luchok'-traps (Priklonski 1960), a variation of the bow net (Bub 1991), on nests and near broods, ringed with steel rings, and colour-marked with Darvic flags and bands. Ringing results are summarised in Table 4. Captured waders were weighed to the nearest 0.1 g (stints) or 0.5 g (other species) with Pesola spring balances. We measured flattened and straightened wing (Svensson 1984) with a stopped ruler to the nearest 0.5 mm, bill length from the bill tip to the feather-line on the forehead, total head length, and tarsus length with callipers (±0.1 mm). Stage of primary moult in Dunlin and plovers was determined according to Ginn & Melwille (1983).

## *2.3. Collection of environmental data*

Weather conditions during the study period were accessed using Oregon Scientific WMR200 weather station, with its outdoor sensors taking readings at one minute interval of maximal, minimal and actual air temperatures, wind direction, average speed and gust. We recorded these values daily at 9:00 AM, and the whole log of data was saved in the station build-in datalogger.

RTV-2 datalogger (http://www.interpribor.ru/rtv.php) was installed in a sun-protected box at the height of approximately 0.15 m above the ground in the camp. This device recorded air temperature once an hour.

Precipitation was collected using plastic bottle 9 cm in diameter and 20 cm high. Total daily precipitation was measured at midnight, and its amount was later converted to mm. Strong wind could have resulted in evaporation of a substantial amount of water from the bottle, and we used occurrence of any precipitation events during a day as a qualitative measure of precipitation.

Our field weather data, however, were not very suitable for general assessment of long-term climatic trends due to considerable variation in duration and moment of initiation of our field studies, and we used weather station data to compensate for gaps. From the web-site of the World Meteorological Organization (National Climatic Data Center, USA, http://www.ncdc.noaa.gov/oa/climate/climatedata.html#daily) we obtained the mean daily air temperatures for all days in May, June and July for the period 1990-2009 for each weather station located to the north of 50°N latitude in Russia. These values were interpolated across the whole Taimyr Peninsula on a grid with a cell size of 50 km using gravity method (implementation of the inverse distance interpolation in the Manifold GIS).

A regression of mean daily air temperature values interpolated for the lower Khatanga study area from the mean daily values measured using dataloggers in 2001-2003 and 2008-2009 was highly significant ($P<0.000001$), and we used regression equations to estimate air temperature values for days with missing datalogger measurements.

Our assessment of snow cover dynamics in the study area was incomplete due to relatively late arrival to the field in many years, so we decided to use satellite imagery for this assessment. The MODIS/Terra Snow Cover Daily L3 Global 500m Grid (MOD10A1) contains snow cover, snow albedo, fractional snow cover, and Quality Assessment (QA) data in compressed Hierarchical Data Format-Earth Observing System (HDF-EOS) format along with corresponding metadata (http://nsidc.org/data/docs/daac/modis_v5/mod10a1_modis_terra_snow_daily_global_500m_grid.gd.html). MOD10A1 consists of 1200 km by 1200 km tiles of 500 m resolution data gridded in a sinusoidal map projection. The Moderate Resolution Imaging Spectroradiometer (MODIS) snow cover data are based on a snow mapping algorithm that employs a Normalized Difference Snow Index (NDSI) and other criteria tests (Hall et al. 2006).

We downloaded tiles for all days from 15 May to 15 July 2009, and then used MODIS Reprojection Tool (ver. 4, February 2008; https://lpdaac.usgs.gov/lpdaac/tools/modis_reprojection_tool) to extract a spatial subset of image, change image projection from sinusoidal to Lambert Azimuthal, and to increase image resolution to 250 m using nearest neighbour resampling. Increasing resolution aimed at increasing number of pixels falling within small study plots on days with extensive cloudiness. Average fraction of snow cover within study plots was then estimated using Manifold GIS (Fig. 5) for all days from 15 May to 15 July.

General statistical estimates and graphs were made using SYSTAT 7.01 for Windows (SPSS Inc., 1997). Ordination estimated and graphs were made using Brodgar software 2.6.0 (http://www.brodgar.com); their interpretation was based on Zuur et al. (2007).

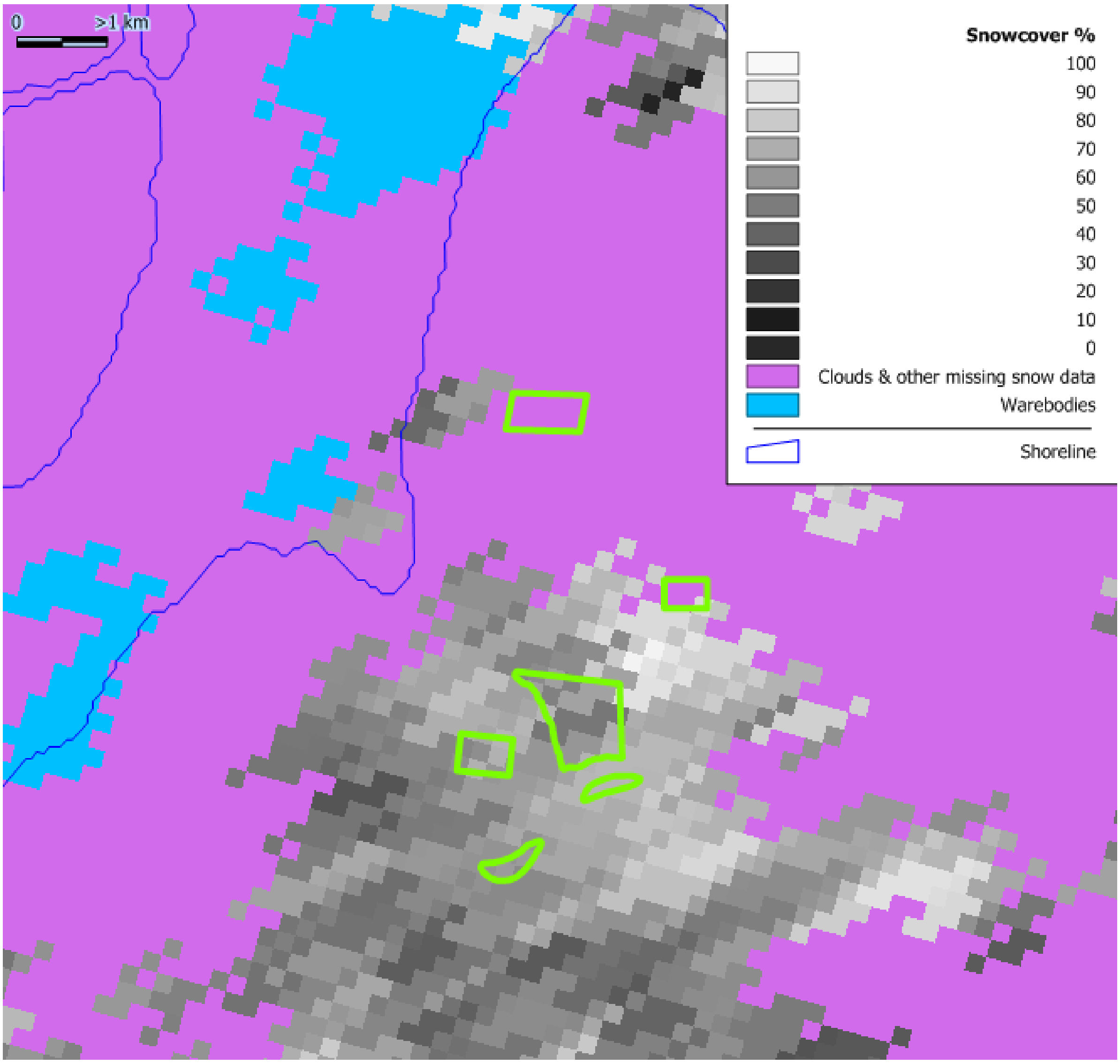



Figure 5. Plots for bird surveys overlaid with the MODIS snow product (fractional snow cover, reprojected and resampled) on 9 June 2009.

# 3. Breeding conditions for birds

## *3.1. Weather*

In the study area on south-eastern Taimyr mean monthly air temperature was –3.8°C, +7.8°C and +12.4°C in May, June and July in 2009, with the average –4.2°C, +5.7°C and +10.7°C for the respective months in the period 1990-2009. Thus, May was slightly warmer than average, June and July considerably warmer in 2009 (Fig. 6).

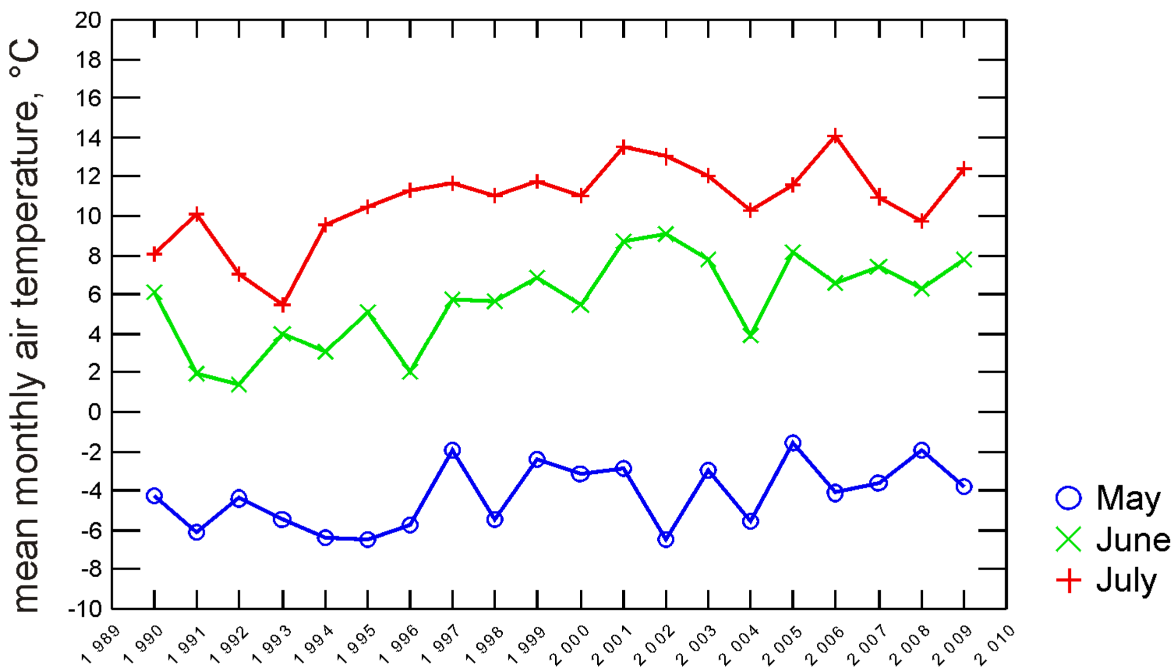



Figure 6. Dynamics of mean monthly air temperature in 1990-2009 in the study area on south-eastern Taimyr.

Mean monthly air temperatures showed significant increasing trend in May, June and July during the last 20 years ($P<0.05$) at the study site on south-eastern Taimyr.

The beginning of the study period in June was characterized by cold weather (Fig. 7) with rains and two snowfalls. Air temperatures were increasing from 17 June to 25 June, and then dropped to relatively low values several times until the end of the study period on 25 July, but never reached the freezing point.

The total amount of precipitation in the study area during the period of surveys from 11 June to 25 July in 2009 was 3.6 mm, which is the lowest value on record; median was 22.5 mm and range 11.8-30.9 mm for the same period in years 2003-2008 when quantitative assessment of precipitation was conducted. However, the number of days with precipitation was slightly above average in the study period in 2009 (22 days), with the median 20 days in 1994-2008 (range 8-26 days). Hence, precipitation occurred relatively often during the period of studies in 2009, but its amount was very low (Fig. 7). Low amount of precipitation in June resulted in drying out of most habitats on terrace and watershed by early July, and they remained dry until the middle of the month. Extreme weather events were not recorded during the study period.

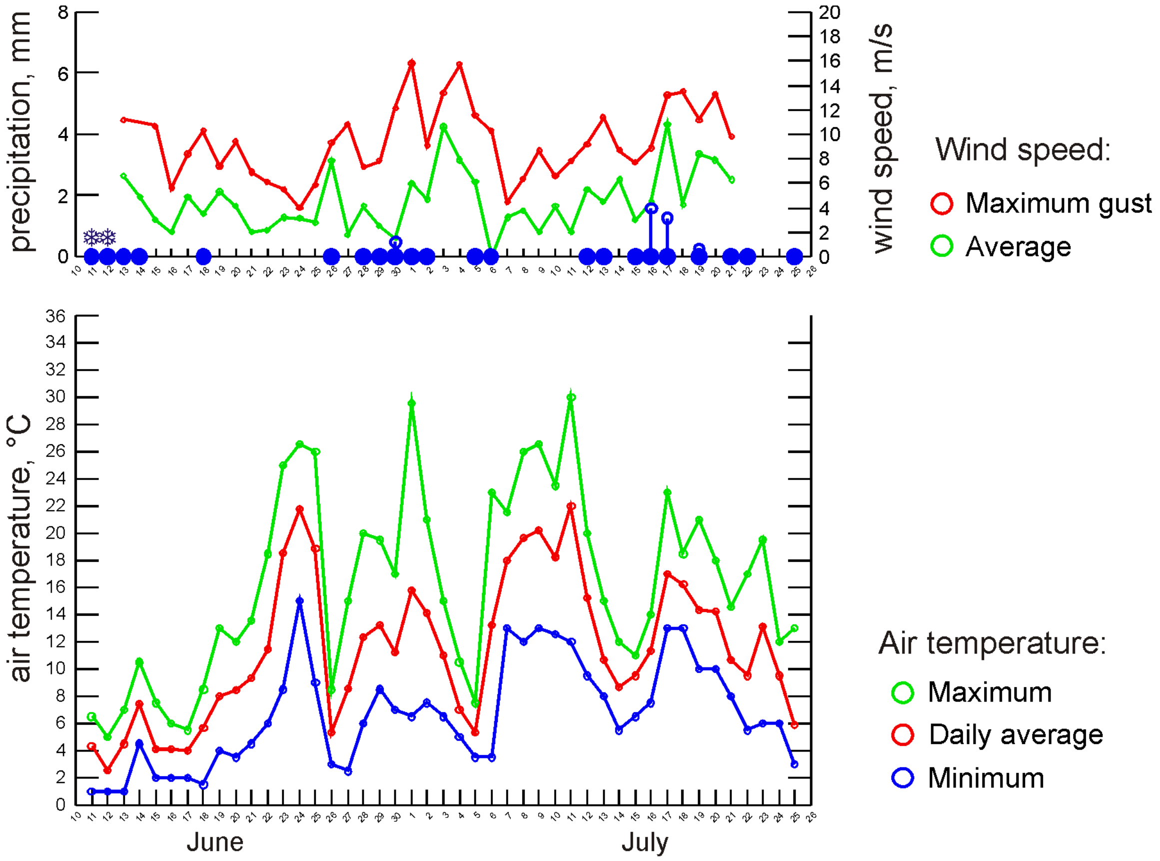



Figure 7. Dynamics of principal weather parameters during the period of studies in 2009 in the study area on south-eastern Taimyr. On the upper graph blue spikes indicate precipitation events that resulted in collection of measurable amounts of water in the rain gauge; blue filled circles indicate other precipitation events; snowflake symbols indicate snowfalls.

All study plots were completely snow-covered on 2 June, judging by the estimates of average fractional snow based on the MODIS snow product (Fig. 8), and the only plot visible on 5 June was still completely under snow. Snow cover reduced to 59-74% on 4 visible plots on 9 June, and then dropped below 10% on plot #1 on 12 June. At arrival to the study area on 11 June we evaluated below 30% snowcover on the plot #1, which tallies well with the regression line that can be constructed for this plot based on MODIS data. Snow melted quicker on plot #1 compared with other plots. Relatively high values of snow cover on plots 4 & 5 (river islands) on 18-20 June require future investigation; a probable explanation is that they were due to accumulation of snow in willow stands, a dominant habitat on the islands.

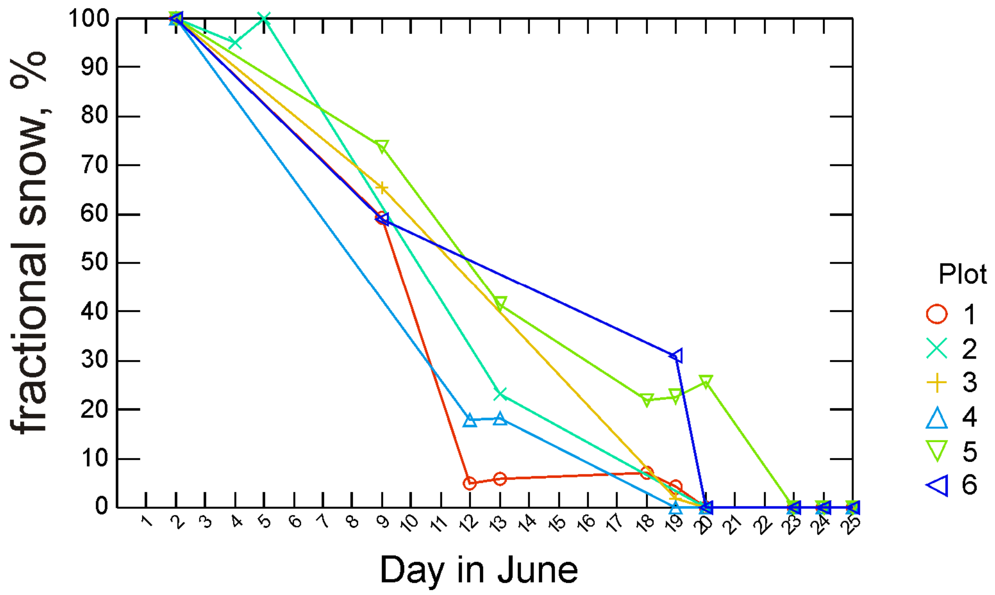



Figure 8. Dynamics of snow melt on study plots in 2009 based on the MODIS snow product.

Estimated date of 50% of snow cover on flat surface in 2009 was 10 June, which was closer to the median date for south-eastern Taimyr (12 June) than to several early seasons with these dates on 4-6 June (Fig. 9). Dates of flowering of early plants and emergence of insects were also earlier than average for the area which was in good agreement with above-average air temperatures in May and June 2009.

Flood was very low in 2009 for the second year in a row, and most of the middle floodplain of the Bludnaya River was not covered by water. Water table was maximal on 18 June in the Bludnaya River.

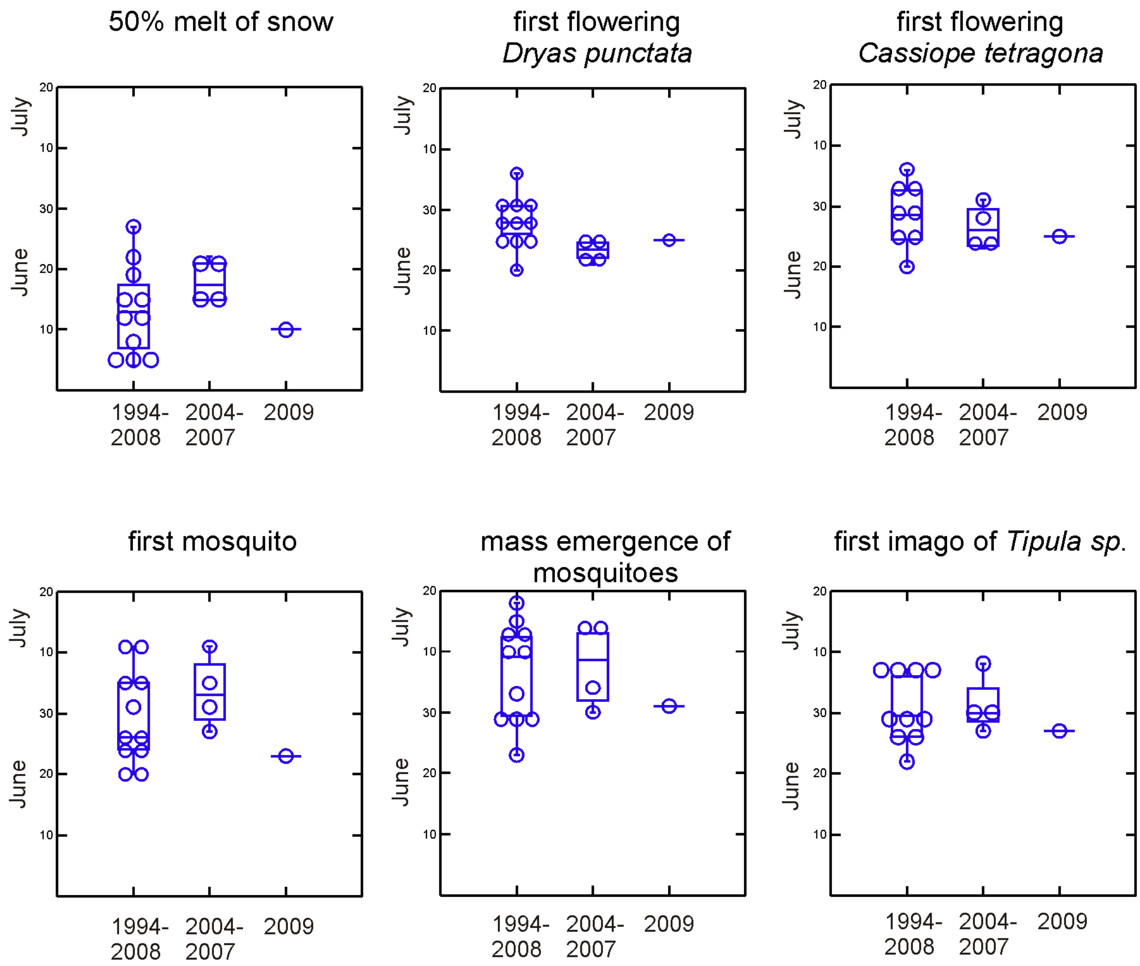



Figure 9. Dates of phenological events in the study area on south-eastern Taimyr in 1994-2003, 2008-2009, and in the study area on central Taimyr in 2004-2007.

### *3.2. Lemming abundance*

Lemming abundance was very low in 2009 (Fig. 10), and only 4 lemmings (two Siberian Lemmings *Lemmus sibiricus* and two Collared Lemmings *Dicrostonyx torquatus*) were recorded by three observers during the study period. The number of lemming undersnow nests was also low, which indicated that there was no attempts of intensive undersnow reproduction. Low lemming populations on the south-eastern Taimyr in 2001-2003 and 2008-2009 indicate that there was no regular cyclicity during this period of time, regardless of what was happening in 2004-2007 when monitoring was carried out in another area. A “regular” peak could had been anticipated in 2004, but in this case the next peak should have occurred in 2008, and this did not happen. An increase in lemming numbers can be expected in 2010, based on the dynamics observed in 1994-1999.

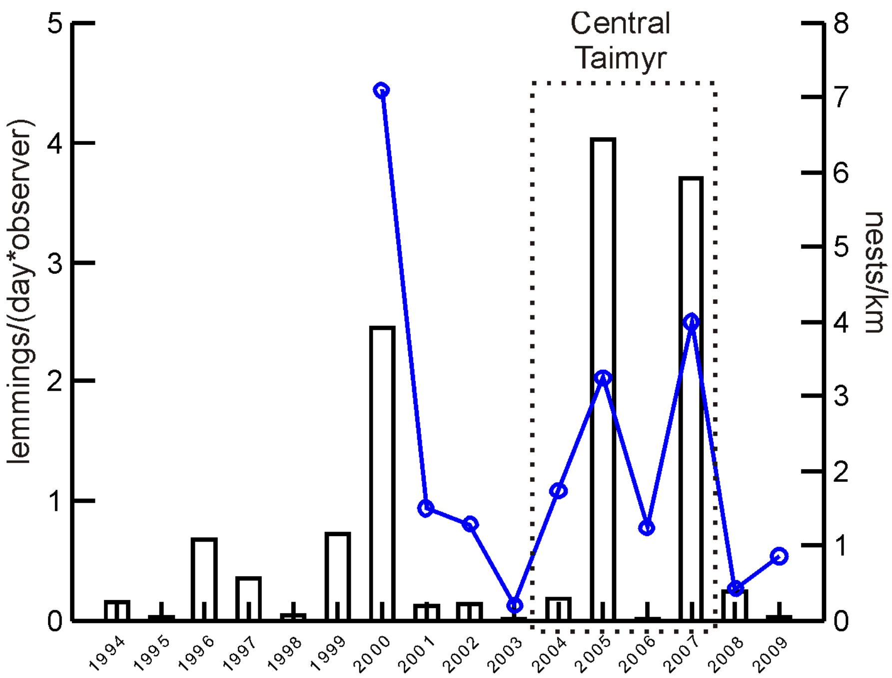



Figure 10. Number of lemmings observed during one day in the field per observer (bars, left axis) and number of undersnow nests of lemmings per km (line, right axis).

### *3.3. Numbers and reproductive performance of predators*

Similarly to 2008 Arctic Foxes *Alopex lagopus* did not breed in the study area in 2009, but their abundance was still high, for the second year in a row (Fig. 11). Of 30 observations of Arctic Foxes 23 were made in the period from 11 to 30 June, and only 7 from 1 to 25 July.

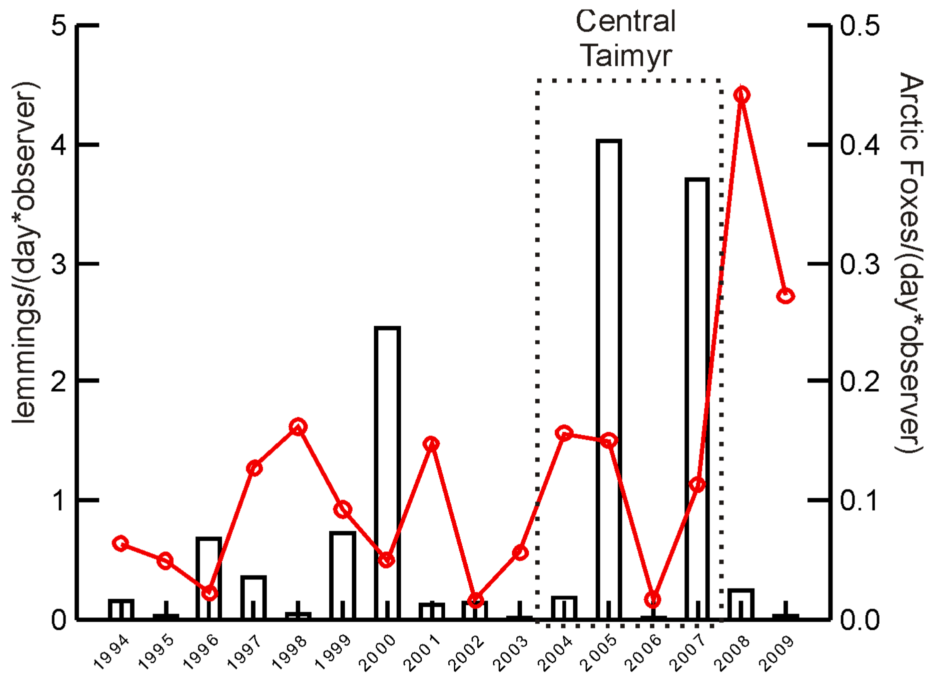



Figure 11. Number of lemmings observed during one day in the field per observer (bars, left axis) and number of Arctic Foxes observed during one day per observer (line, right axis).

According to the report of Dolgan people a Brown Bear *Ursus arctos* was observed in the study area in spring 2009. A Muskrat *Ondatra zibethicus* was recorded on 9 July swimming in a floodplain lake, which record is probably close to the northern limit of the species distribution.

Reindeers *Rangifer tarandus* appeared on 20 June, and were common from 22 June to 29 June, moving mostly to the north or north-east. Several small flocks were recorded in early July, which were mostly moving to the south. Although we did not conduct formal counts of Reindeers, according to the general impression their numbers were lower than in the previous years of studies on the south-eastern Taimyr.

Numbers of avian predators were very low in 2009. Long-tailed Skuas *Stercorarius longicaudus* were rare breeders in the area with only 2 nests found, of which both failed. Two pairs of Arctic Skuas occupied their traditional territories in the vicinity of plot # 3 (floodplain) and on plot # 4 (wet sedge bog on the terrace). Chicks hatched in both clutches, consisting of 2 and 1 egg. Pomarine Skuas *St. pomarinus* were common in June on westward migration, which was most intensive on 16 June.

A brood of Herring Gulls *Larus argentatus* and a brood of Glaucous Gulls *L. hyperboureus* were observed in the vicinity of nests of these species used in the previous years.

Rough-legged Buzzards *Buteo lagopus* were rare non-breeders in the study area. A single Short-eared Owl *Asio flammeus* was seen on 14 June flying to the south-west.

A nest of Peregrine Falcons *Falco peregrinus* with 3 eggs was found on 15 July on the bluffs of the Popigay River 70 m to the south-east of the nest in 2008. One egg had stars which indicated approaching hatching. Two adult and two juvenile Ravens *Corvus corax* were observed on 15 July in the vicinity of the nest occupied by Ravens in 2008.

Siberian Lemming

# 4. Breeding numbers and nest success of birds

## *4.1. Breeding phenology of birds*

Employment of the egg-flotation technique for evaluation of incubation stage allowed to increase samples of wader nests with known breeding dates by a factor of 2.2 in 2008 and 2.8 in 2009. This was particularly important in the case of 2009 sample, as low nest success resulted in low numbers of clutches surviving until hatching (see below), and in the case of relatively rare species with small numbers of nests usually found.

Distribution of dates of clutch initiation for 8 species of waders and 2 species of passerines is shown on Fig. 12–14 and Fig. 15, respectively, along with dates of 50% snowmelt on flat surfaces. Distribution of breeding dates of waders in 2009 was typical for a season with average timing of snowmelt; median dates were very close in most species to the dates in 2002 when 50% snowmelt occurred one day later than in 2009. Mass egg-laying in Lapland Buntings *Calcarius lapponicus* started on the next day after the date of 50% snowmelt in 2009, which was also similar to the situation in 2002-2003, but different from the previous seasons on the south-eastern Taimyr, when longer delay occurred between snow-melt and the onset of mass breeding. In 2009 for the first time a considerable sample of breeding dates was collected for the Common Redpoll *Acanthis flammea*, an extremely late breeder, with most clutches initiated already in July. Apparently late breeding of this species is partially explained by a preferred breeding habitat, willow stands on river islands and on river banks, because another abundant species of this habitat, the Temminck's Stint *Calidris temminckii*, has bred very late compared to other species of waders. Late breeding of birds in this habitat can be explained either by late snowmelt (Fig. 8), or by a threat of flooding in spring. Additional observations are required to find out which explanation is more appropriate.

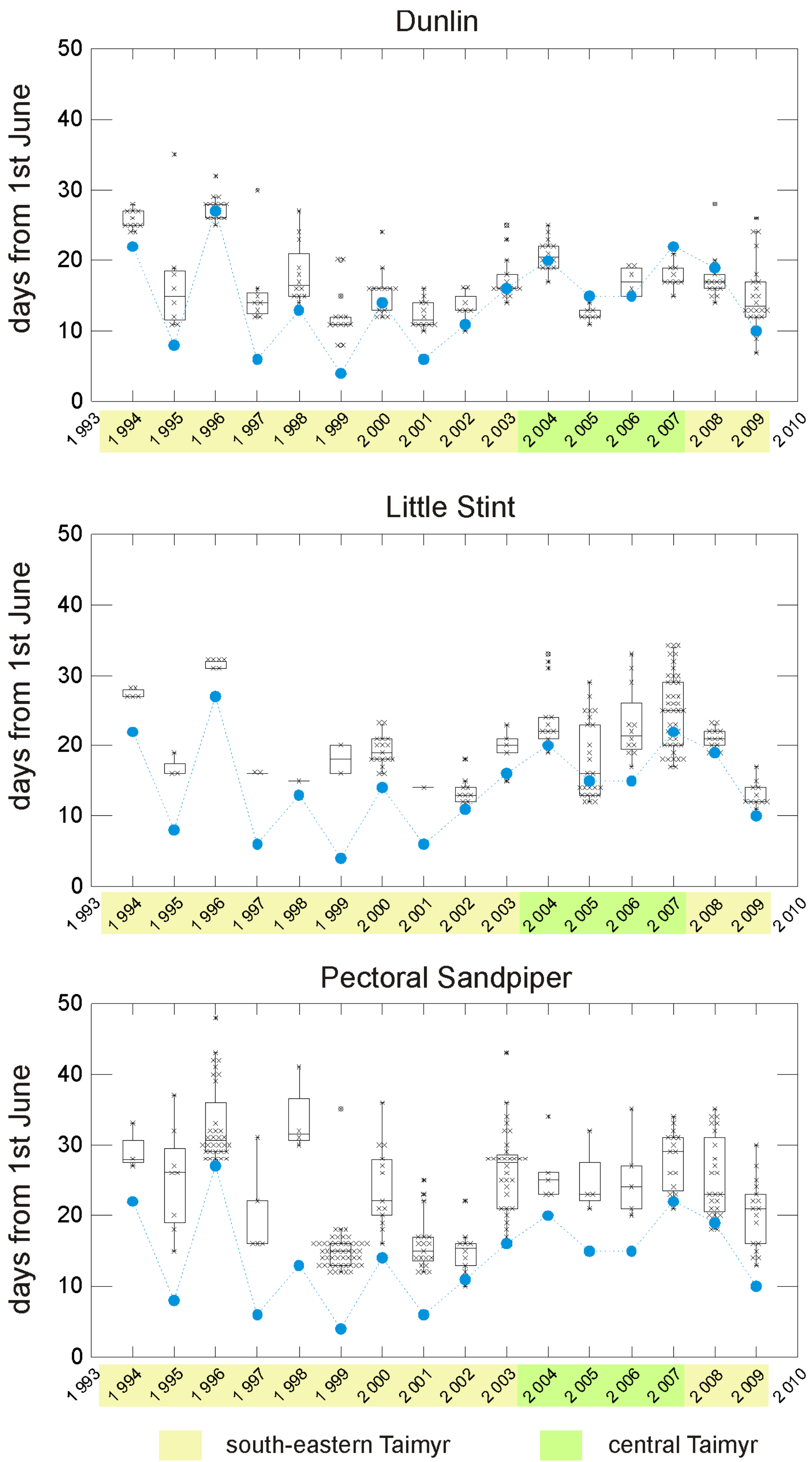



Figure 12. Dates of clutch initiation by selected species of waders in 1994–2003, 2008-2009 on south-eastern Taimyr, and in 2004-2007 on central Taimyr. Crosses show actual date values; box plots show non-parametric statistics: central horizontal line marks the median of a sample, edges of box (hinges) mark quantiles, whiskers show range of values that fall within 1.5 interquartile range of the hinges. Blue circles show dates of 50% snow melt.

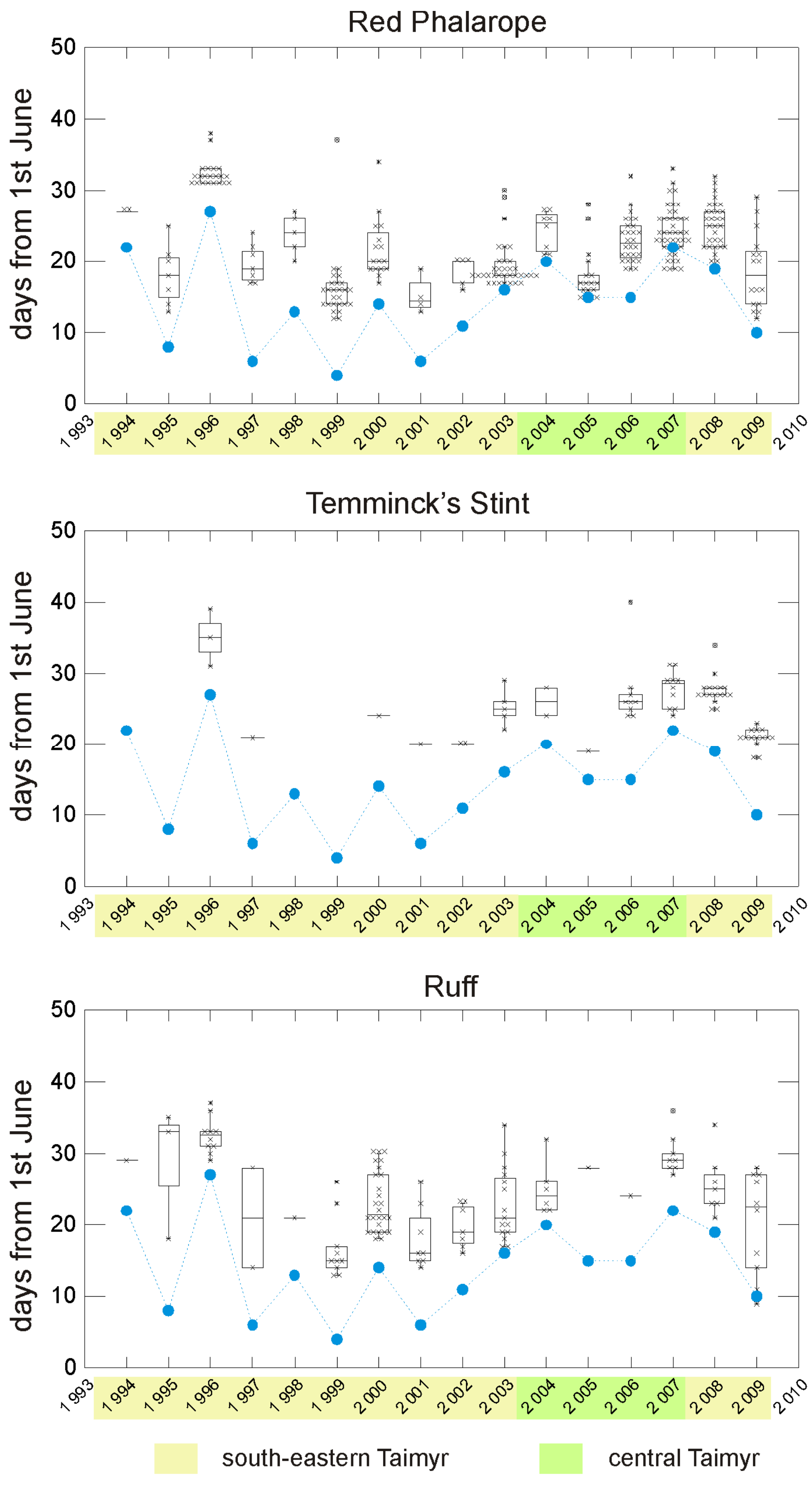



Figure 13. Dates of clutch initiation by selected species of waders in 1994–2003, 2008-2009 on south-eastern Taimyr, and in 2004-2007 on central Taimyr (continued). Legend the same as on Fig. 12.

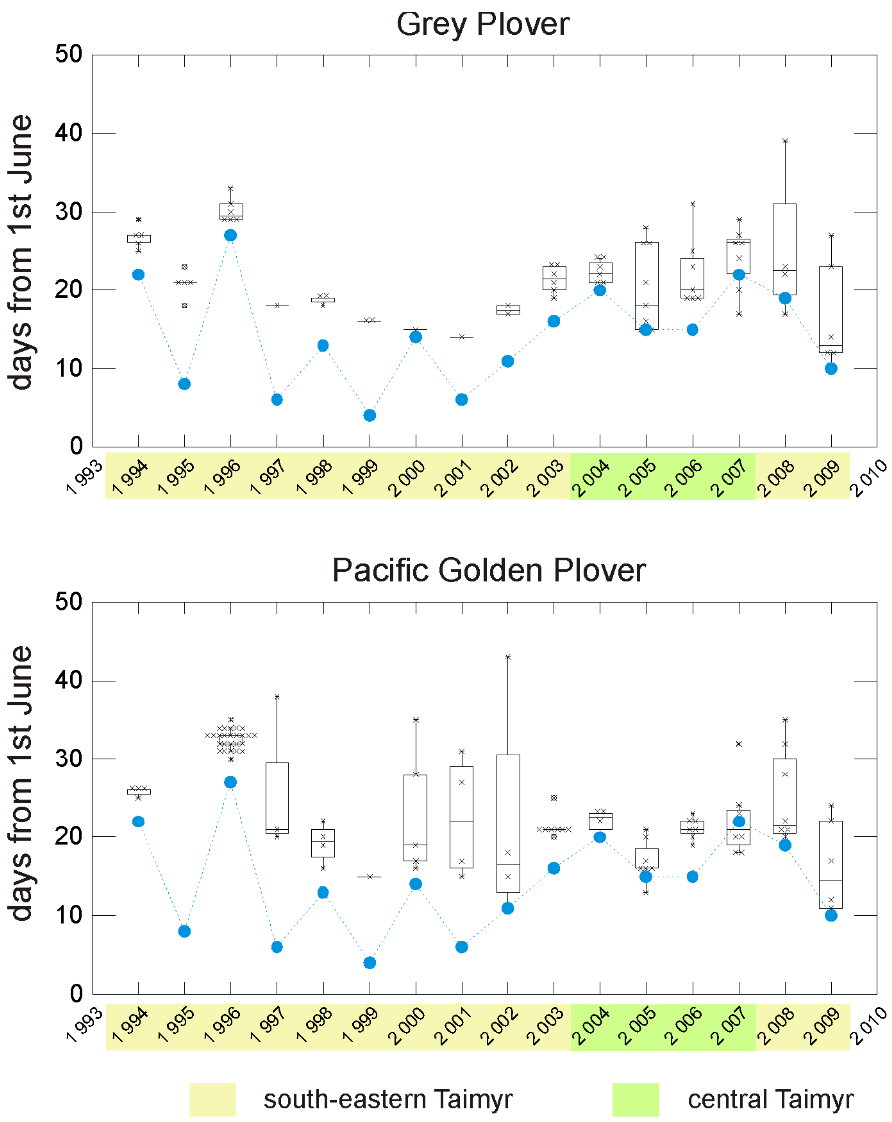



Figure 14. Dates of clutch initiation by selected species of waders in 1994–2003, 2008–2009 on south-eastern Taimyr, and in 2004–2007 on central Taimyr (continued). Legend the same as on Fig. 12.

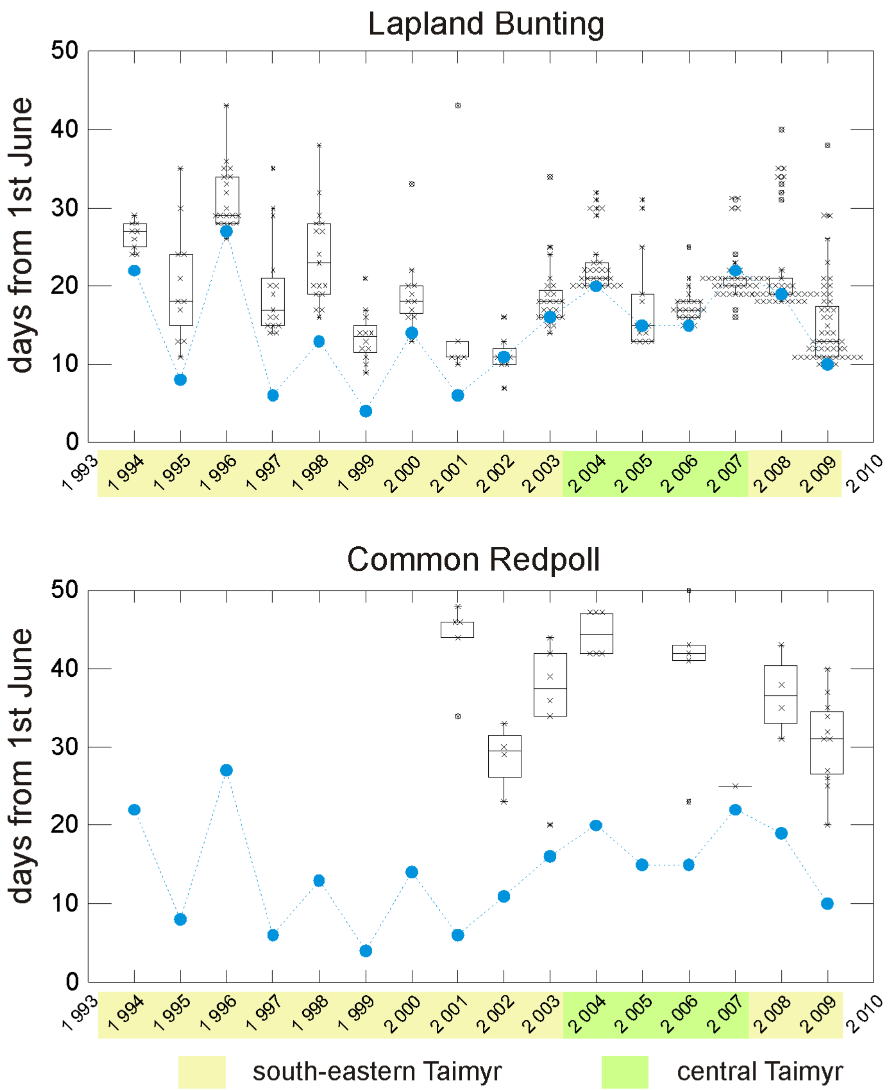



Figure 15. Dates of clutch initiation by selected species of passerines in 1994–2003, 2008–2009 on south-eastern Taimyr, and in 2004–2007 on central Taimyr. Legend the same as on Fig. 12.

Larger samples of nests with known dates of clutch initiation in 2008–2009 allowed to compare breeding phenology of several common species between different habitats. Still it was necessary to aggregate habitats into three broader groups to obtain interpretable results (Fig. 16, 17), namely, a group of tundra habitats ("tundra"), a group of floodplain bogs ("flplbogs") and a group of bogs on the terrace and watershed ("wshdbogs"). In the Dunlin no difference in breeding phenology was found between nests in tundra and in terrace/watershed, while clutches in floodplain bogs were initiated significantly later (Fig. 16).

A significant difference was not found in breeding dates of Lapland Buntings between different habitats in 2009 and between habitats outside of the floodplain in 2008. An apparent absence of difference between the floodplain and other habitats in 2009 confirmed our hypothesis that all clutches in the floodplain in 2008 had been replacement. Dates of initiation of these clutches were very close to those in the small second wave of breeding on the terrace, apparently represented by replacement clutches as well, while finding of a nest with probably incomplete clutch as early as 20 June 2008 indicated that nesting started at the same time on the terrace and in the floodplain in that year.

Little Stints *Calidris minuta* showed no difference in breeding dates between habitats, which has been an anticipated result for an early breeding nomadic species, with a preference for snow-covered areas at the onset of breeding (Rakhimberdiev et al. 2007). Little Stints probably appear in the area in one synchronized wave in accordance with their migration schedule, and either stay for breeding, if there is still enough snow around, or continue migration to the north, if the advance of spring made habitats unsuitable for them. Double-clutch breeding system creates certain prerequisites for a difference in breeding dates between habitats with different timing of snow-melt, but available data are currently insufficient to test this hypothesis.

Incubating Common Redpoll.

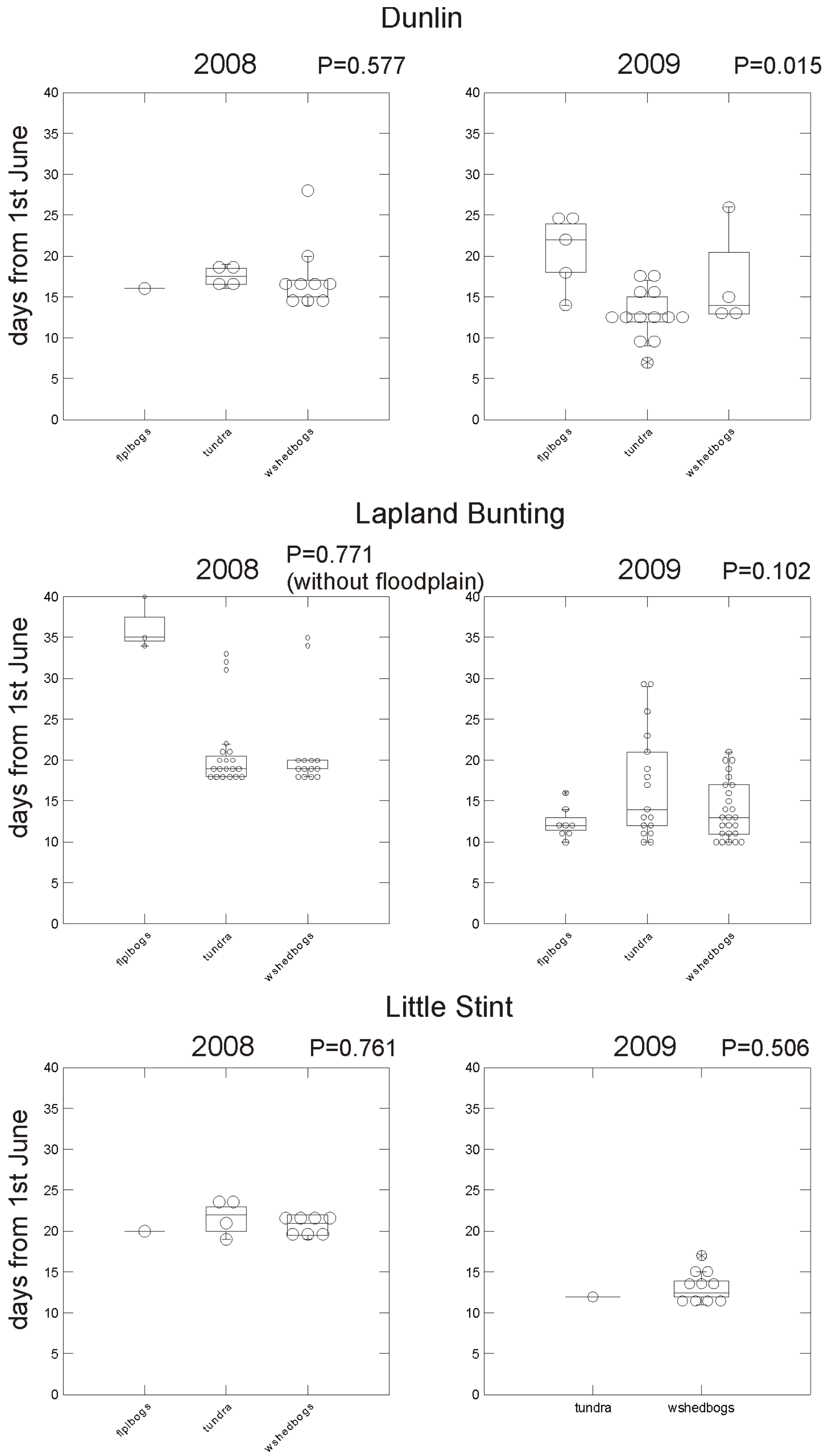



Figure 16. Dates of clutch initiation by common birds in different habitats in 2008-2009. Habitats of the study area (Fig. 2) were aggregated in the following broader groups: tundra = 1-3 on Fig.2, wshedbogs = 4-5, flplbogs = 6-7. Probabilities correspond to Kruskal-Wallis ANOVA with habitat as a grouping variable.

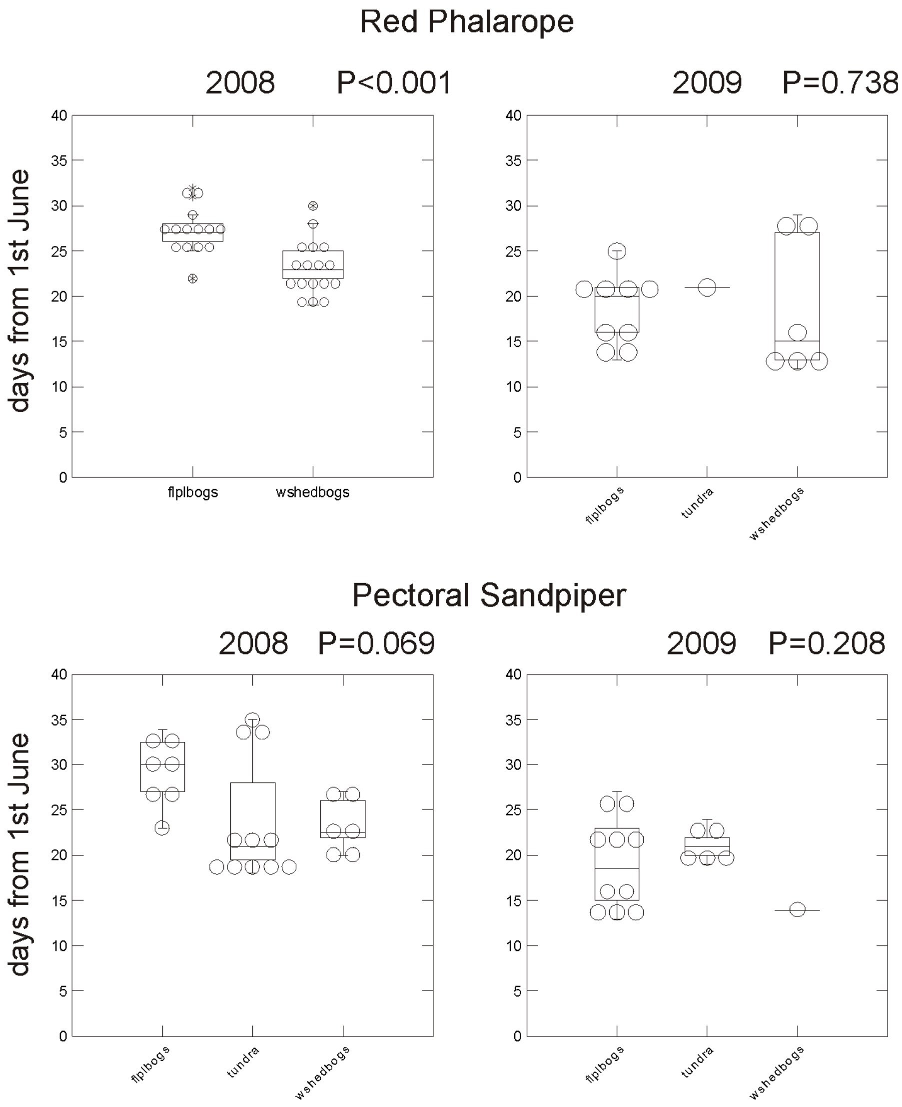
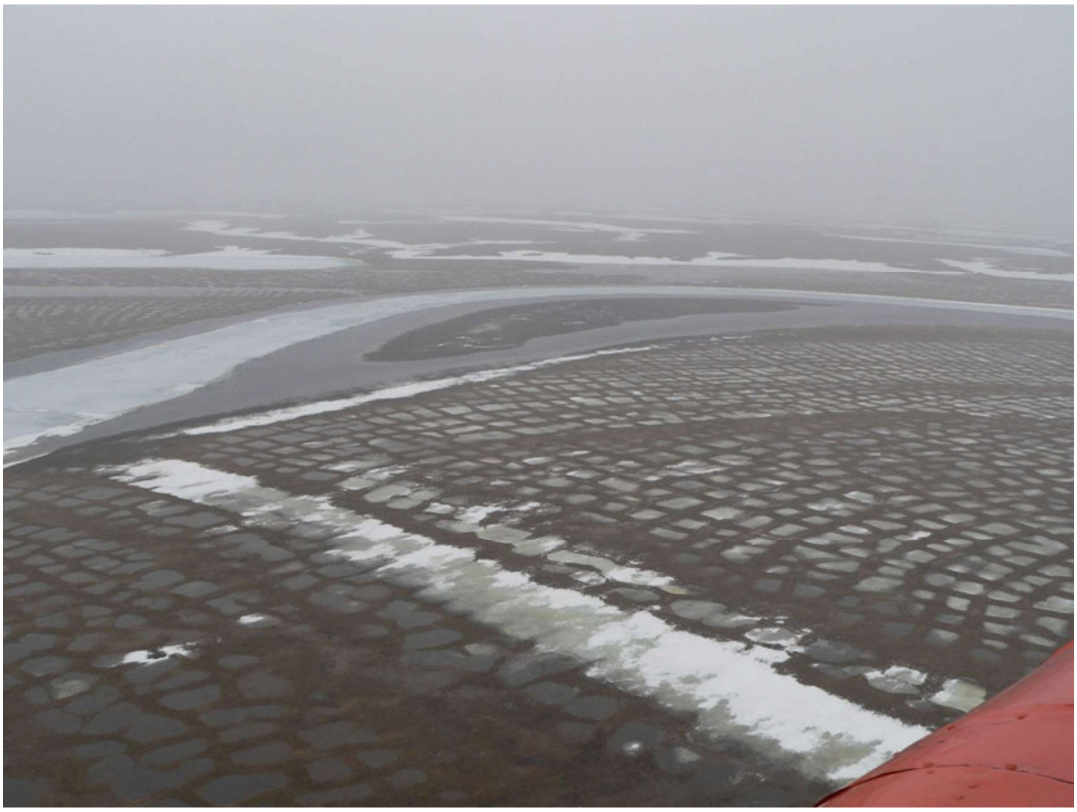



Figure 17. Dates of clutch initiation by common birds in different habitats in 2008-2009 (continued). Legend is the same as on Fig. 16.

The results for Red Phalaropes *Phalaropus fulicarius* and Pectoral Sandpipers *Calidris melanotos* are similar in that both species showed a significant (marginally in the case of the second species) delay in breeding dates in the floodplain compared with the terrace and watershed habitats in 2008 (Fig. 17), and did not show any difference in 2009. On 20 June 2008, at arrival to the study site, the snow covered less than 5% of the terrace plot, according to visual evaluation, while a respective proportion for the floodplain plot was around 20% with most snow concentrated in polygons. It is possible that in 2008 Red Phalaropes and Pectoral Sandpipers had to wait until snow melts in the floodplain before habitats became suitable for breeding, while in much earlier season 2009 all habitats were snow-free at arrival of these birds and they could start breeding immediately. Earlier breeding of both species relative to the date of 50% snowmelt in 2008 compared with 2009 (Fig. 12-13) seem to confirm this interpretation. It is interesting that the first clutch of the Dunlin, an early breeder, was initiated in 2009 in the floodplain on 14 June which coincided with the first breeding dates there by Red Phalaropes and Pectoral Sandpipers, but represented a considerable delay compared with breeding dates of Dunlins elsewhere. This tallies well with a hypothesis that a delayed snowmelt in the floodplain in the relatively early season 2009 resulted in a delay of breeding by an early-breeder (Dunlin), but had little impact on later breeding species.

Thus, breeding phenology apparently did not differ between habitats in the most abundant passerine, the Lapland Bunting, and an early breeding nomadic wader, the Little Stint. Breeding was delayed in the floodplain compared with the terrace and watershed in several other common wader species, and this delay seems to be most pronounced in relatively early seasons in an early breeder (Dunlin), and in late seasons in later breeding species (Red Phalarope and Pectoral Sandpiper).

Further investigations are required to find out which factors are actually responsible for the delayed breeding of waders in the floodplain, e.g. evaluation of snow-free areas actually available for breeding (excluding polygons filled with water or snow).



Aerial view of the plot # 6 (island) and the middle floodplain of the Bludnaya River (the habitat of plot # 3) on 11 June 2009.

## *4.2. Breeding numbers of birds in the study area*

A decline in numbers of breeding waders at the main study plot on the river terrace, which had been observed in 2008, continued in 2009, and their total density dropped to the lowest value on record (Fig. 18). This decline was marginally significant (P= 0.066, Spearman correlation between density and year). All common species of waders contributed to this decline in numbers, with the exception of the Dunlin which density was above average in 2009 (Fig 19), but the trend was significant for none of the species (P>0.2, Spearman correlation). Densities of Pectoral Sandpipers and Ruffs *Philomachus pugnax* in 2009 were the lowest on record for this habitat. Mean June temperature was significantly increasing at the study site in 1994-2009 (Fig. 6), but correlation between temperature and density was significant neither for any of the common species, nor for total densities of bird groups (P>0.1).

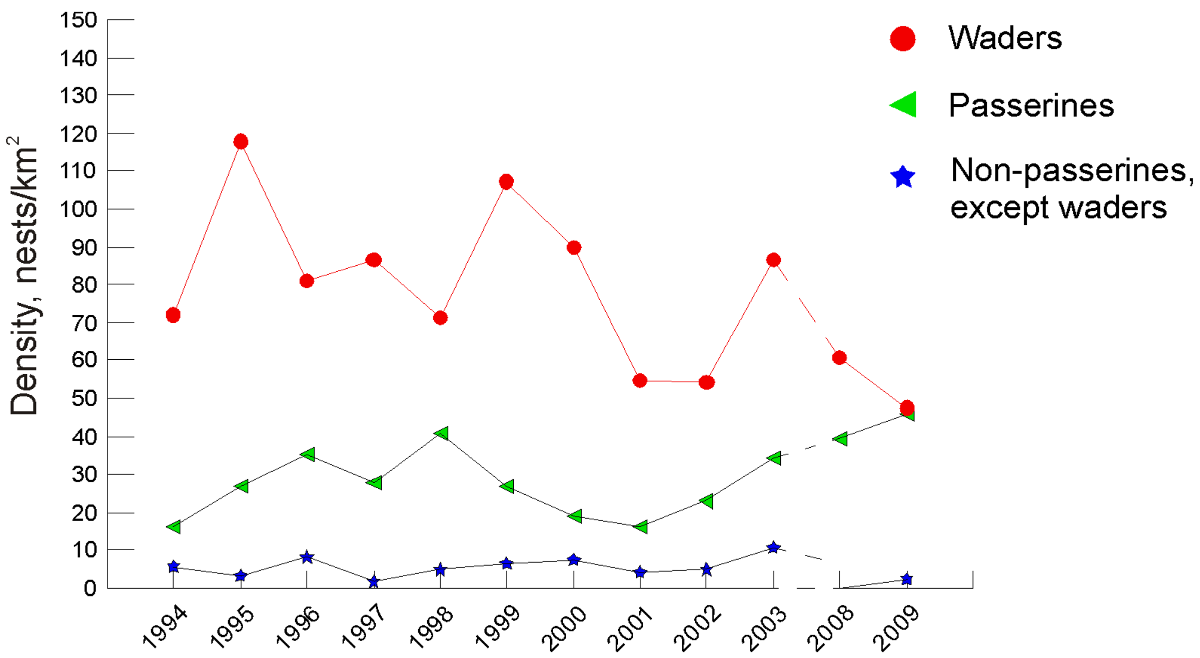



Figure 18. Densities of principal groups of birds in 1994–2003 and 2008-2009 on the main plot on the river terrace on south-eastern Taimyr.

The abundance of Lapland Buntings was record high in 2009 in all habitats where this species was the most common passerine, the terrace (plot #1, Fig. 18, Table 2), watershed (plot #2) and floodplain (plot #3). Density of breeding birds was record high in 2009 on the plot # 5 (Upper Island on the Bludnaya River), mostly on behalf of Common Redpolls, although densities of breeding Willow Warblers *Phylloscopus trochilus* and Pallas's Reed Buntings *Schoeniclus pallasi* were higher than previously there (Table 2).

**Table 2.**
Breeding densities of birds (nest/$km^2$) on study plots in 2009 on south-eastern Taimyr.

| Species | Plots | | | | | |
|---|---|---|---|---|---|---|
| | **#1** | **#2** | **#3** | **#4** | **#5** | **#6** |
| *Cygnus bewickii* | 0.00 | 0.00 | 0.00 | 1 nest | 0.00 | 0.00 |
| *Somateria spectabilis* | 0.00 | 0.00 | 2.67 | - | 0.00 | 0.00 |
| *Clangula hyemalis* | 0.82 | 0.00 | 0.00 | - | 0.00 | 0.00 |
| *Melanitta fusca* | 0.00 | 0.00 | 0.00 | - | 7.63 | 0.00 |
| *Pluvialis fulva* | 3.27 | 3.82 | 0.00 | - | 0.00 | 0.00 |
| *Pluvialis squatarola* | 1.64 | 0.00 | 0.00 | - | 0.00 | 0.00 |
| *Limosa lapponica* | 0.82 | 0.00 | 0.00 | - | 0.00 | 0.00 |
| *Phalaropus fulicarius* | 4.91 | 0.00 | 16.03 | - | 0.00 | 0.00 |
| *Calidris ferruginea* | 1.64 | 0.00 | 0.00 | - | 0.00 | 0.00 |
| *Calidris melanotos* | 8.18 | 0.00 | 21.37 | - | 0.00 | 0.00 |
| *Calidris minuta* | 8.18 | 0.00 | 0.00 | - | 0.00 | 0.00 |
| *Calidris ruficollis* | 0.00 | 1.91 | 0.00 | - | 0.00 | 0.00 |
| *Calidris temminckii* | 0.00 | 0.00 | 0.00 | - | 30.51 | 44.49 |
| *Calidris alpina* | 15.54 | 0.00 | 10.68 | - | 0.00 | 0.00 |
| *Philomachus pugnax* | 3.27 | 0.00 | 5.34 | - | 7.63 | 9.89 |
| *Stercorarius longicaudus* | 0.82 | 0.00 | 0.00 | - | 0.00 | 0.00 |
| *Sterna paradisaea* | 0.82 | 0.00 | 0.00 | - | 0.00 | 0.00 |
| *Eremophila alpestris* | 1.64 | 3.82 | 0.00 | - | 0.00 | 0.00 |
| *Luscinia svecica* | 0.00 | 0.00 | 0.00 | - | 15.26 | 0.00 |
| *Phylloscopus trochilus* | 0.00 | 0.00 | 0.00 | - | 30.51 | 9.89 |
| *Anthus cervinus* | 0.82 | 0.00 | 0.00 | - | 0.00 | 0.00 |
| *Acanthis flammea* | 0.00 | 0.00 | 0.00 | - | 83.91 | 64.27 |
| *Ocyris pusillus* | 0.00 | 0.00 | 0.00 | - | 30.51 | 0.00 |
| *Schoeniclus pallasi* | 0.00 | 0.00 | 0.00 | - | 22.88 | 4.94 |
| *Calcarius lapponicus* | 43.35 | 28.63 | 34.73 | - | 7.63 | 0.00 |
| **Total birds:** | **95.72** | **38.18** | **90.82** | **-** | **236.47** | **133.48** |
| **Including waders:** | **47.45** | **5.73** | **53.42** | **-** | **38.14** | **54.38** |
| **Including passerines:** | **45.81** | **32.45** | **34.73** | **-** | **190.7** | **79.1** |

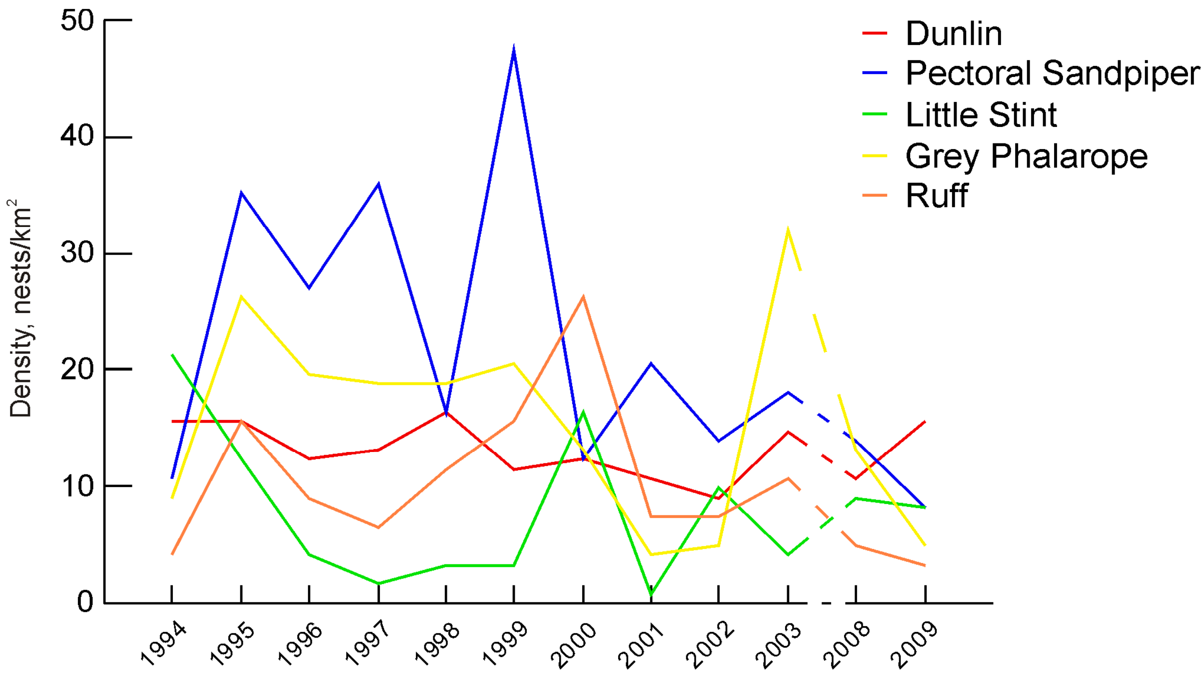



Figure 19. Densities of common species of waders in 1994–2003 and 2008-2009 on the main plot on the river terrace on south-eastern Taimyr.

Breeding density of waders declined in 2009 in other principal habitats monitored since 1998 (Fig. 20), reaching the lowest value on record on the watershed plot. The density was slightly above average in the floodplain. It is noteworthy that changes in densities of breeding waders were relatively well synchronized in the three principal habitats (Fig. 20), which became particularly evident since 2003, when the density in the floodplain for the first time became higher than the density on the terrace. An analysis of trends in different habitats makes an impression that after several years of declining numbers in 2000-2002 on the terrace waders switched since 2003 to breeding in the floodplain in much higher numbers than previously. Variations of density of waders in the floodplain cannot be explained by the regime of flooding of this habitat alone, because this density was the highest on record in 2003 with a high flood and above average in 2008-2009 with very low flood. Impacts of other factors related to spring phenology, such as temperature regime and habitat wetness, on wader breeding density in the floodplain should be further investigated.

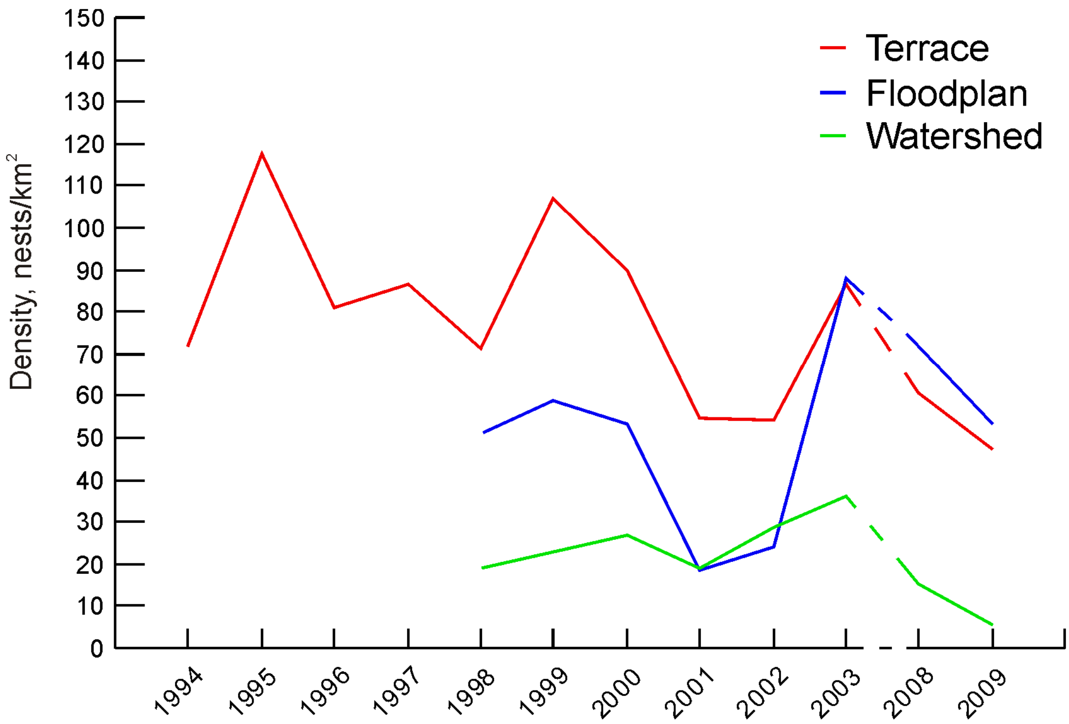



Figure 20. Abundance of waders in different habitats in 1994–2003 and 2008-2009 on south-eastern Taimyr.

A diversity of patterns of density dynamics demonstrated by different species of birds in the study area and still short duration of the time series stimulated the use of ordination techniques to explore patterns of variation in numbers and their relation to environmental factors. Redundancy analysis (RDA) was chosen as an ordination method allowing explicit modeling of response variables (species) as a function of explanatory variables (Zuur et al. 2007). RDA was preferred over canonical correspondence analysis (CCA), because relatively short environmental gradient allowed to expect linear rather than unimodal relationships between species and environmental variables. We believed that variation between the species is an important feature of the data, and accordingly used the covariance matrix rather than correlation matrix in the analysis. The main focus in ordination was on making statements about species rather than observations (years), hence correlation scaling was used to construct RDA triplot.

Figure 21 shows a triplot of the RDA for 6 common species of birds on the main study plot sampled during 12 seasons, 1994–2003 and 2008–2009. These species were chosen because in all years they accounted for at least 85% of the total density of birds, while proportion of any other species was insignificantly small. Two explanatory variables were included: mean June temperature (TempJune) was expected to account for early summer conditions when birds make decision about breeding in the study area, and the year was expected to account for a temporal trend in the community composition. The first axis of the triplot is mostly related to high density of the Lapland Bunting in two last years (2008-2009) and low density of waders (in particular, the Pectoral Sandpiper, and to lesser extent the Ruff). There is some correlation between the 1st axis and year, although it is not very strong. The second axis has very strong relation with June temperatures, which were high in years 2001-2003 and 2009, and low in 1994 and 1996. The 2nd axis has also high negative correlation with the density of Little Stints, which have bred in high numbers in late seasons.

Explanatory variables explained 25% of the variation in the species data, and neither of them explained variation larger than a random contribution (P>0.1 for Monte-Carlo permutation test for conditional effects). Hence, variation in the structure of bird community on the plot # 1 (terrace) was mostly determined by factors other than early summer temperatures or a temporal trend.

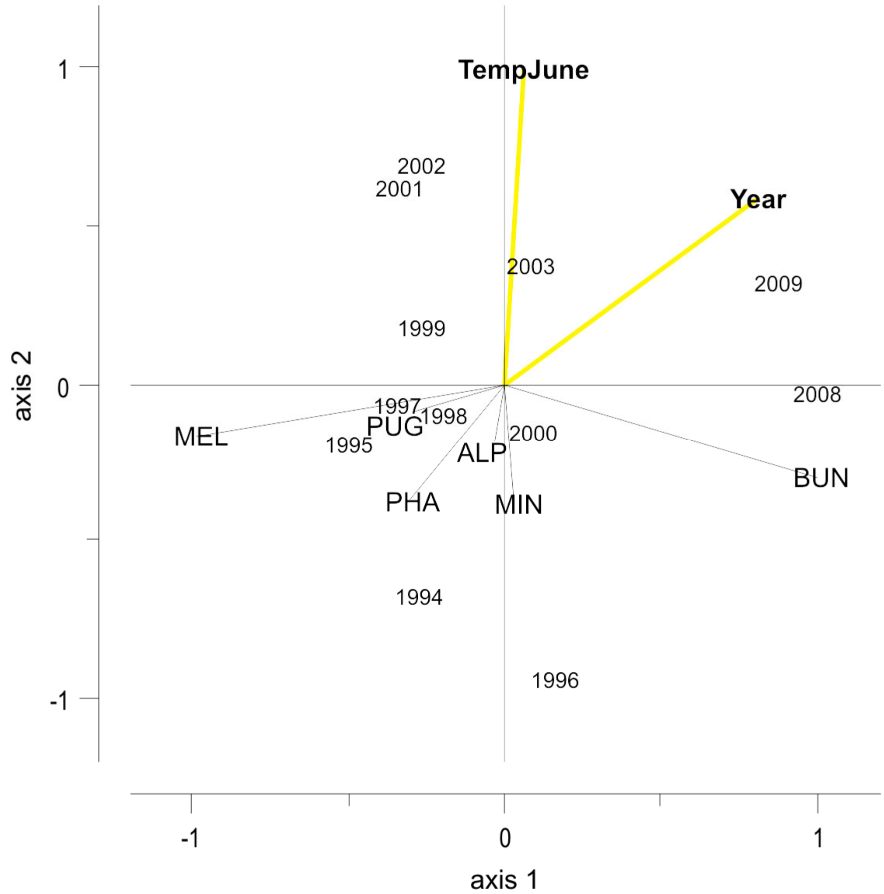



Figure 21. Triplot of the redundancy analysis, applied to densities of common birds on plot #1 in 1994–2003 and 2008–2009. Explanatory variables are denoted by yellow lines. Species: ALP – Dunlin, Bun – Lapland Bunting, MEL – Pectoral Sandpiper, MIN – Little Stint, PHA – Red Phalarope, PUG – Ruff.

We made RDA for 3 plots (#1 (terrace), #2 (watershed), #3 (floodplain)) sampled in 1998–2003 and 2008–2009 (Fig. 22) with view of exploring variation in structures of birds communities in different habitats. Plot # 4 was not included in this analysis because it had not been sampled in most years, and plots # 5 & 6 because they had no dominant species in common with the first three plots, which would have forced the first axis to explain the obvious difference between plots # 5 & 6 and plots #1–3. Two species, significantly contributing to bird diversity on watersheds (Pacific Golden Plover *Pluvialis fulva* and Curlew Sandpiper *Calidris ferruginea*), were added to response variables.

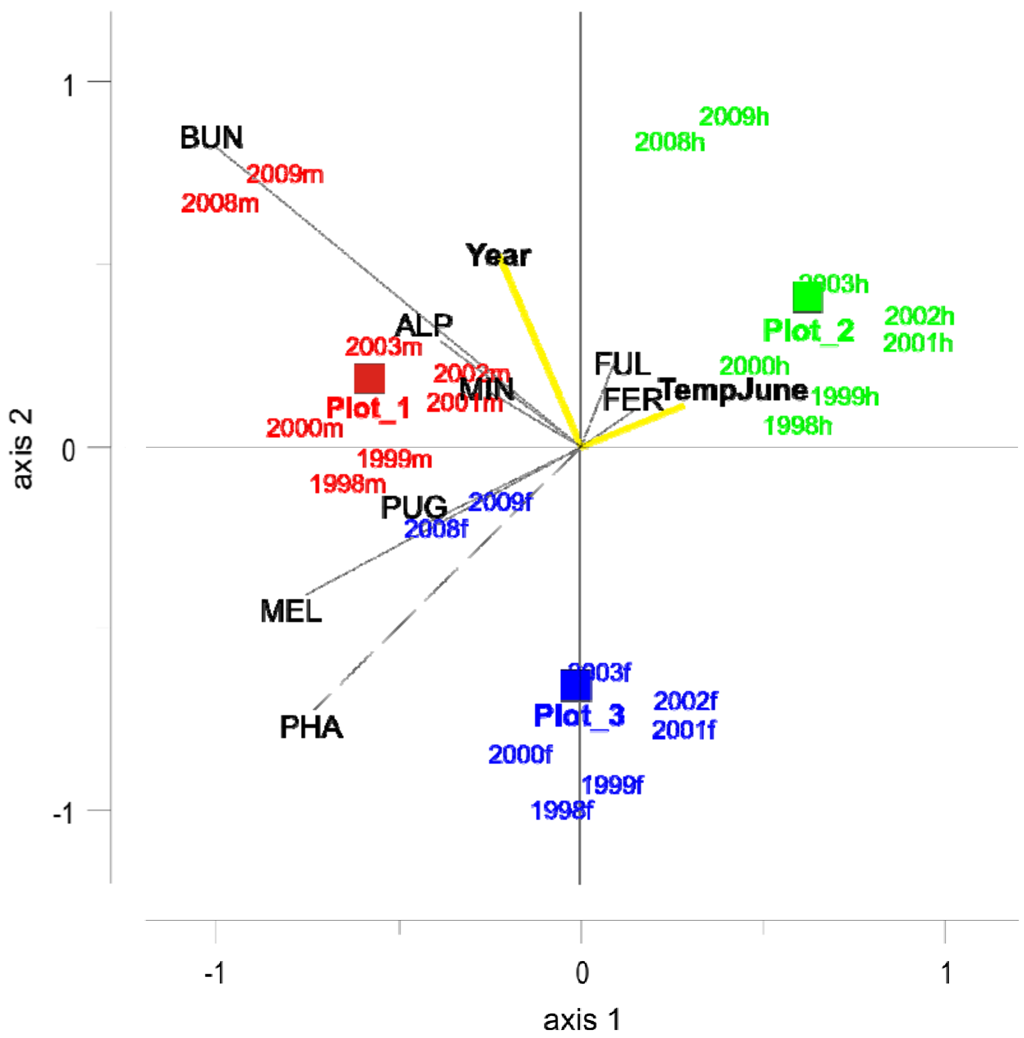



Figure 22. Triplot of the redundancy analysis applied to densities of common birds on plots #1-3 in 1998–2003 and 2008–2009. Species: ALP – Dunlin, BUN – Lapland Bunting, FER – Curlew Sandpiper, FUL – Pacific Golden Plover, MEL – Pectoral Sandpiper, MIN – Little Stint, PHA – Red Phalarope, PUG – Ruff. Quantitative explanatory variables are denoted by yellow lines, nominal explanatory variables (plots) by squares. Index near years and colour indicates samples from different plots: “m” – plot #1 (red), “h” – plot #2 (green), “f” – plot #3 (blue).

Ordination was apparently dominated by the difference in bird communities in different habitats. The 1st axis contrasted the plot on watershed (# 2) with the plot on terrace (#1), and the 2nd axis contrasted two latter plots with the plot in floodplain (#3). Quantitative explanatory variables showed some correlation with axis 1 (TempJune) and axis 2 (Year), but their contribution was smaller compared with nominal variables (plots). Explanatory variables were responsible for 58% of the total variance, which is a relatively high value, and the first two axes were responsible for 92.1% of these 58%, which is also very high fraction. Contribution of all explanatory variables was significant, the largest for plots ($P<0.001$ for conditional effects), followed by year ($P=0.003$) and mean June temperature ($P=0.048$).

Positions of species lines in the ordination space tallies well with their average abundances on different plots. The abundance of Pectoral Sandpipers, Ruffs and Red Phalaropes is negatively correlated with June temperatures; the abundance of Red Phalaropes is negatively correlated with year and the abundance of Lapland Buntings is positively correlated with year.

Scores of samples corresponding to different plots formed generally dense clusters around plot centroids, which indicated that within-plot variation in the structure of bird communities is much smaller than between-plot variation. An interesting exception was a shift of all 2008–2009 scores in the upper-left direction, which even moved floodplain scores for these years closer to the terrace plot centroid than to the floodplain plot centroid. This shift was certainly caused by a high abundance of Lapland Buntings on all three plots in 2008–2009.

Thus, the results of the ordination showed the prevailing influence of habitat on the structure of bird communities in the study area. However, temperature conditions during early summer period and a general temporal trend made their own, independent of each other contribution to the variation. In the case of Lapland Buntings contribution of the temporal trend in 2008-2009 resulted in a larger variation than variation between habitats.

Interesting observations of birds in 2009 included breeding record of Bewick's Swans, which nest with a clutch of 4 eggs was found on 15 June on the plot # 4 (Fig. 23). Later the fifth egg appeared, chicks hatched successfully on 14-15 July, and the brood moved to a nearby large lake to the south of the nest. Previously, swans bred in the study area in 1995 on a lake system 1.5 km to the north-west of the nest in 2009. Rarity of swan breeding records in the area is probably due to a high level of disturbance by humans early in the season, when a lot of hunting and fishing activities have been undertaken by the Dolgan people. These activities are apparently the main reason for complete absence of breeding records of geese in the study area and low density of ducks.

Figure 23. Nesting habitat of Bewick’s Swans in a wet sedge bog on plot # 4; 15 June 2009. The nest with eggs is in the centre of the photo.

## *4.3. Nest success of birds*

Nest success of waders was low in 2009 (Fig. 24), although slightly higher than in typical seasons with heavy egg predation (1994, 1995, 1997, 1998). Hatching success of passerines was below average, and other than waders non-passerines was close to average, although the last assessment was based on small sample (n=23) and subject to suspect. Given low abundance of lemmings and high abundance of Arctic Foxes low nest success of birds in 2009 tallied well with the predictions of the prey-switching hypothesis, which were violated since 2001 at least for the stage of low lemming abundance.

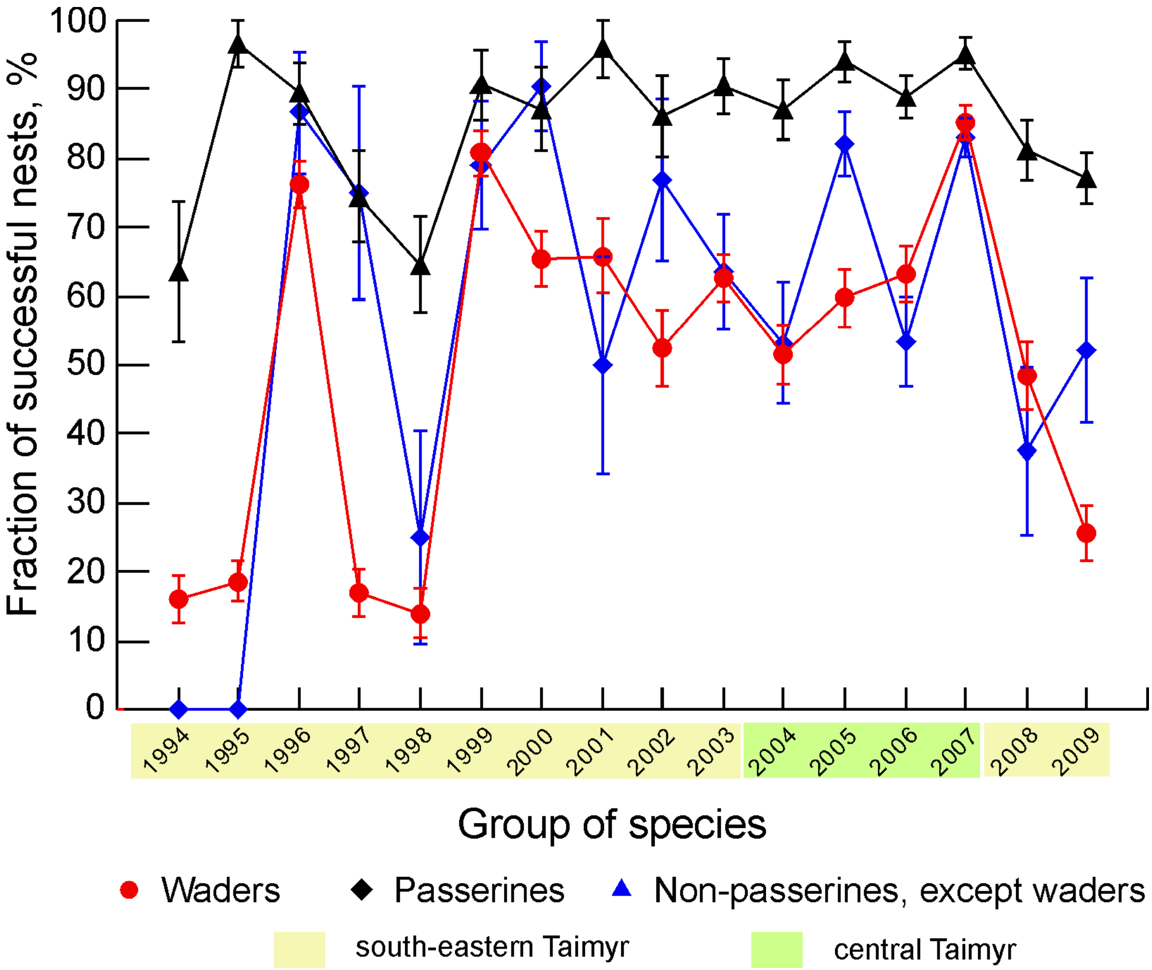



Figure 24. Nest success of principal bird groups in 1994–2009. Lines extend one standard error from the value in each direction.

In respect to nest success of individual species of birds, nest success of Red Phalaropes was clearly higher than that of other waders (Fig. 25). Nest success of other common waders was below 20%, and similar in this respect to other years of heavy egg predation. We made pairwise comparisons of apparent nest success of 5 species of waders during 16 years using Wilcoxon signed ranks test, and found that nest success of Pectoral Sandpipers and Ruffs was significantly lower than nest success of Dunlins (P<0.005) and Red Phalaropes (P<0.05). Noteworthy is very high nest success of Temminck's Stints and Common Redpolls (Table 3), which apparently was explained by their nesting predominantly on river islands. The islands were accessible to Arctic Foxes, and we observed fox tracks and found predated nests of Temminck's Stints and redpolls on the plot # 6 (Lower Island). However, this appeared to be an occasional visit, and the survival of nests on islands was still much higher than elsewhere. Among other than waders non-passerines Arctic Terns *Sterna paradisea* were doing relatively well (Table 3), apparently due to their aggressive nest defence. A detailed analysis of the influence of different factors on nest success of birds and interspecific differences will be presented elsewhere.

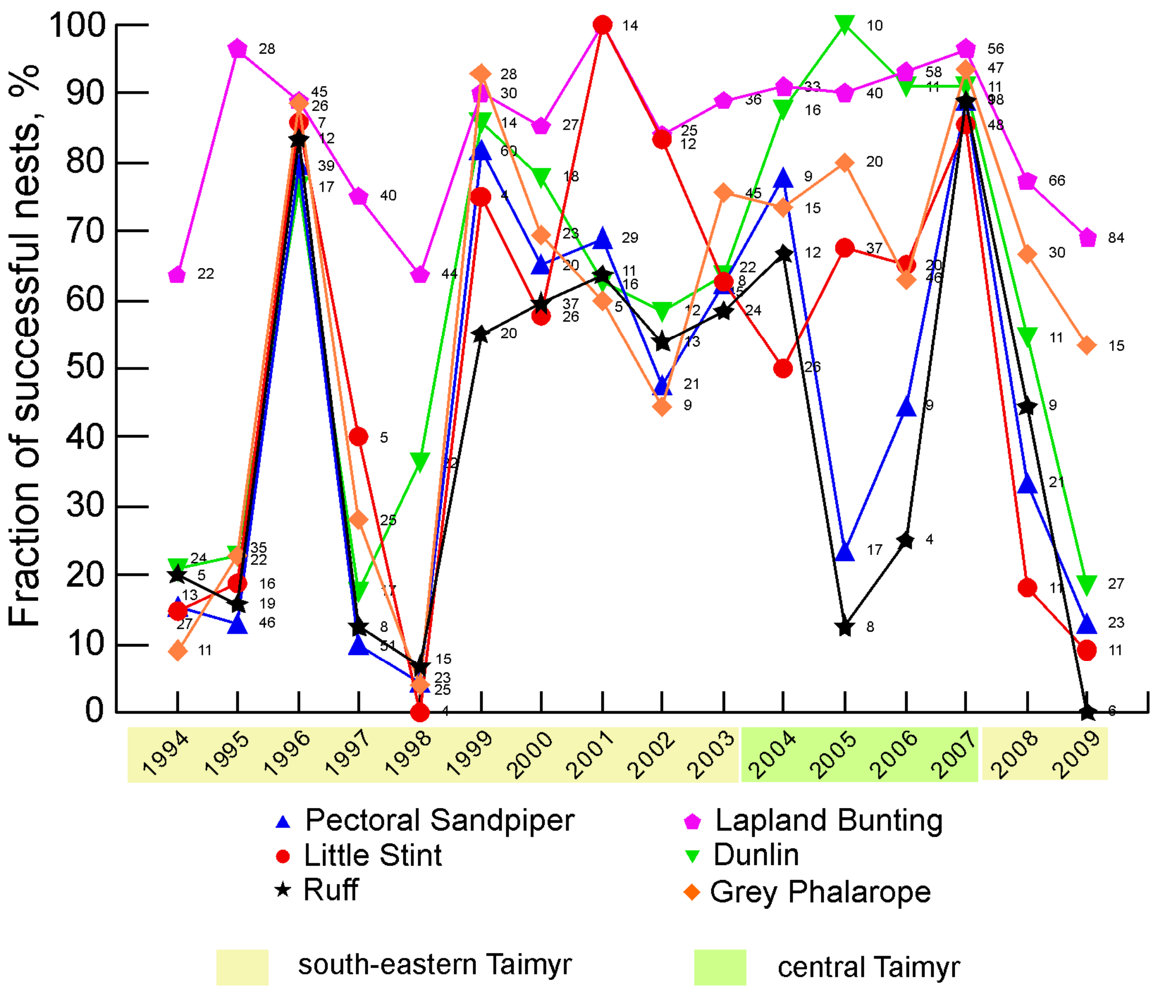



Figure 25. Nest success of common birds in 1994–2009. Numbers near symbols indicates sample sizes.

Apparent nest success of all species of birds in 2009 is presented in Table 3.

**Table 3**
Apparent nest success of birds in 2009, %±SE, sample size in brackets. Hatching success is given for passerines

| Species | Nest success |
|---|---:|
| *Gavia arctica* | 100±0 (1) |
| *Cygnus bewickii* | 100±0 (1) |
| *Clangula hyemalis* | 0±0 (2) |
| *Somateria spectabilis* | 100±0 (1) |
| *Melanitta fusca* | 0±0 (1) |
| *Pluvialis fulva* | 0±0 (8) |
| *Pluvialis squatarola* | 40±21.9 (5) |
| *Limosa lapponica* | 0±0 (2) |
| *Phalaropus fulicarius* | 53.3±12.9 (15) |
| *Phalaropus lobatus* | 0±0 (1) |
| *Calidris ferruginea* | 0±0 (2) |
| *Calidris melanotos* | 13±7 (23) |
| *Calidris minuta* | 9.1±8.7 (11) |
| *Calidris ruficollis* | 100±0 (1) |
| *Calidris temminckii* | 75±12.5 (12) |
| *Calidris alpina* | 18.5±7.5 (27) |
| *Philomachus pugnax* | 0±0 (6) |
| *Larus heuglini* | 100±0 (1) |
| *Larus hyperboreus* | 100±0 (1) |
| *Stercorarius longicaudus* | 0±0 (2) |
| *Stercorarius parasiticus* | 100±0 (2) |
| *Rhodostethia rosea* | 0±0 (2) |
| *Sterna paradisaea* | 55.6±16.6 (9) |
| *Eremophila alpestris* | 100±0 (5) |
| *Luscinia svecica* | 100±0 (8) |
| *Phylloscopus trochilus* | 33.3±27.2 (3) |
| *Anthus cervinus* | 100±0 (2) |
| *Acanthis flammea* | 88.2±7.8 (17) |
| *Ocyris pusillus* | 100±0 (4) |
| *Schoeniclus pallasi* | 100±0 (5) |
| *Motacilla alba* | 100±0 (1) |
| *Oenanthe oenanthe* | 100±0 (2) |
| *Calcarius lapponicus* | 69±5 (84) |

# 5. Ringing activities in 2009 and related observations

We ringed 238 birds of 21 species in 2009 (Table 4), which was an apparent improvement over 145 birds of 15 species in 2008. However, ringing still was not a highest priority for a relatively small team of 3 researchers, and most of ringed birds were represented by chicks of passerines. Low nest success of waders was one of the reasons for a low number of ringed wader chicks.

**Table 4**
Ringing results in 2009

| Species | Adult birds | Chicks |
|---|---|---|
| *Melanitta fusca* | 1 | 0 |
| *Charadrius hiaticula* | 0 | 1 |
| *Phalaropus fulicarius* | 0 | 8 |
| *Phalaropus lobatus* | 0 | 1 |
| *Calidris melanotos* | 4 | 9 |
| *Calidris minuta* | 7 | 10 |
| *Calidris ruficollis* | 0 | 2 |
| *Calidris temminckii* | 0 | 4 |
| *Calidris alpina* | 14 | 5 |
| *Limicola falcinellus* | 0 | 1 |
| *Philomachus pugnax* | 0 | 2 |
| *Acanthis flammea* | 0 | 5 |
| *Anthus cervinus* | 0 | 11 |
| *Schoeniclus pallasi* | 0 | 20 |
| *Ocyris pusillus* | 0 | 19 |
| *Eremophila alpestris* | 0 | 8 |
| *Luscinia svecica* | 0 | 31 |
| *Motacilla alba* | 0 | 5 |
| *Oenanthe oenanthe* | 0 | 11 |
| *Phylloscopus trochilus* | 0 | 10 |
| *Calcarius lapponicus* | 0 | 49 |
| **Total:** | **26** | **212** |

New long-distant recovery of a bird, previously ringed in cause of the Wader monitoring project, was reported in 2009 by ornithologists, trapping waders with cannon nets in the north of Australia, Roebuck Bay near Broome. A female Curlew Sandpiper, banded on the nest on 28 June 2005 at the study site on central Taimyr, was recaptured on 17 October 2009 at 18°00'00" S, 122°22'00" E. The bird was originally banded with metal ring, plastic flag and two plastic bands, however, plastic bands were not discovered at recapture. This was an important recovery, because we had captured a female Curlew Sandpiper with a Polish ring in 2004 on central Taimyr; thus, Curlew Sandpipers from central Taimyr may migrate to both directions – east and west.

Female Curlew Sandpiper near nest

# 6. Principal results of studies in 2009

## *Breeding conditions*

1. At the study site on south-eastern Taimyr May was slightly warmer than average, June and July considerably warmer in 2009. Estimated date of 50% of snow cover on flat surface was 10 June, which was close to the median date for the study area (12 June). Precipitation occurred relatively often during the period of studies, but its amount was very low, which resulted in drying out of most habitats on terrace and watershed by early July. Extreme weather events were not recorded during the study period. Flood was very low in 2009 for the second year in a row, and most of the middle floodplain of the Bludnaya River was not covered by water.

2. Lemming abundance was very low in 2009, and only 4 lemmings (two Siberian Lemmings *Lemmus sibiricus* and two Collared Lemmings *Dicrostonyx torquatus*) were recorded by three observers during the study period.

3. Arctic Foxes *Alopex lagopus* did not breed in the study area in 2009, but their abundance was still high, for the second year in a row. Numbers of avian predators were low in 2009. Long-tailed Skuas *Stercorarius longicaudus*, Arctic Skuas *St. parasiticus* and gulls were rare breeders; Pomarine Skuas *St. pomarinus* were common migrants in June. Rough-legged Buzzards *Buteo lagopus* were rare non-breeders in the study area. Owls were represented by a single record of a Short-eared Owl *Asio flammeus*. One breeding pair of Peregrine Falcons *Falco peregrinus* and one pair of Ravens *Corvus corax* inhabited the study area.

## *Phenology, numbers and nest success of birds*

4. Distribution of breeding dates of waders in 2009 was typical for a season with average timing of snowmelt. Breeding phenology did not differ between habitats in the Lapland Bunting and Little Stint, while the Dunlin, Pectoral Sandpiper and Red Phalarope bred later in the floodplain compared with the river terrace. Birds bred very late on river islands.

5. Numbers of breeding waders continued to decline in 2009 on the main study plot on the river terrace, and their total density dropped to the lowest value on record for this habitat. The abundance of Lapland Buntings was record high in 2009 in all habitats where this species was the most common passerine. Structure of bird communities in

the study area was mostly determined by differences between habitats, however, temperature conditions during early summer period and a general temporal trend made their own, independent of each other contribution to the variation.

6. Nest success of wader species combined was low in 2009, although slightly higher than in typical seasons with heavy egg predation due to moderate nest success of Red Phalaropes. Hatching success of passerines was below average, and other than waders non-passerines was close to average. A typical prey-switching scenario was realised in 2009 due to the low abundance of lemmings and high abundance of Arctic Foxes. Nest success of Temminck's Stints and Common Redpolls was high on river islands, although the islands were accessible to predators.

*Other results*

7. A female Curlew Sandpiper, banded on the nest in June 2005 at the study site on central Taimyr, was recovered in December 2009 in the north of Australia. This recovery indicated that Curlew Sandpipers from central Taimyr may migrate to both directions – east and west, because a female Curlew Sandpiper with a Polish ring was captured in 2004 on central Taimyr.

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