

Pond Characteristics and Occupancy by Red-Necked Phalaropes in the Mackenzie Delta, Northwest Territories, Canada

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ABSTRACT. Red-necked phalaropes (*Phalaropus lobatus*) breed in Arctic and Subarctic lowlands throughout the circumpolar region. They are highly reliant on shallow freshwater ponds for social interaction, copulation, and foraging for small aquatic invertebrates. Threats related to warmer continental temperatures could lead to encroachment of shrub vegetation and premature drying of wetlands that serve as breeding habitat. We documented patterns of pond use over the breeding season and investigated pond characteristics associated with high occupancy by red-necked phalaropes. Research was conducted during two breeding seasons in a large wetland on Niglintgak Island, located in the mouth of the Mackenzie Delta, Northwest Territories. The frequency of pond occupancy declined between the onset of incubation and average hatch dates. Neither invertebrate assemblages (potential prey) nor physical characteristics (water chemistry and vegetation characteristics) varied significantly between ponds categorized as high-use, low-use, and no-use, in either year. Dry weight of potential prey (g/m^3) was higher during the incubation period than during the nest initiation period. Pond occupancy both prior to and during incubation showed a clumped distribution, suggesting that choice of ponds was related in part to social stimulation. Future studies should examine the proximity of ponds to nest sites, the effects of premature drying of ponds on food availability, the distribution of resources surrounding ponds, and the occupancy of ponds by broods during the period preceding fall migration.

Key words: shorebird, red-necked phalarope, *Phalaropus lobatus*, Arctic, Subarctic, Mackenzie Delta, habitat use, ponds, invertebrate assemblage

RÉSUMÉ. Les phalaropes à bec étroit (*Phalaropus lobatus*) se reproduisent dans les basses terres arctiques et subarctiques à l'échelle de la région circumpolaire. Ils dépendent beaucoup des étangs d'eau douce peu profonds car c'est là que se passent leur interaction sociale, la copulation et la consommation de petits invertébrés aquatiques. Les menaces liées au réchauffement des températures continentales pourraient se traduire par un empiètement sur la végétation d'arbrisseaux et l'assèchement prématuré des terrains marécageux qui servent d'habitat de reproduction. Nous avons documenté les tendances d'utilisation des étangs pendant la saison de reproduction et avons analysé les caractéristiques des étangs fréquentés par de grands nombres de phalaropes à bec étroit. Notre recherche a été effectuée pendant deux saisons de reproduction sur une vaste zone marécageuse de l'île Niglintgak, située à l'embouchure du delta du Mackenzie, dans les Territoires du Nord-Ouest. La fréquence de l'achalandage aux étangs chutait entre le début de l'incubation et les dates d'éclosion moyennes. Ni les assemblages d'invertébrés (proies potentielles) ni les caractéristiques physiques (chimie de l'eau et caractéristiques de la végétation) variaient considérablement entre les étangs classés comme étangs achalandés, étangs moins achalandés ou étangs pas achalandés du tout, pendant l'une ou l'autre des années. Le poids sec des proies potentielles (g/m^3) était plus élevé pendant la période d'incubation que pendant la période d'initiation du nid. La répartition de l'achalandage des étangs avant et pendant l'incubation était contagieuse, ce qui laisse croire que le choix d'étang se faisait, en partie, en fonction de la stimulation sociale. Les études effectuées à l'avenir devraient examiner la proximité des étangs aux nids, les effets de l'assèchement prématuré des étangs sur la disponibilité de nourriture, la répartition des ressources entourant les étangs et l'achalandage des étangs par les couvées pendant la période précédant la migration automnale.

Mots clés : oiseau de rivage, phalarope à bec étroit, *Phalaropus lobatus*, arctique, subarctique, delta du Mackenzie, utilisation de l'habitat, étangs, assemblage d'invertébrés

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INTRODUCTION

Warming in the North has accelerated over recent decades (Serreze et al., 2000; Johannessen et al., 2004). Arctic and

Subarctic freshwater lakes are shrinking, drying prematurely, or disappearing entirely (Smith et al., 2005; Riordan et al., 2006). Graminoid wetlands are also at risk as shrub vegetation invades Arctic ecosystems (Chapin et al., 1995;

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Sturm et al., 2001). Warmer climates may be advantageous for species with the space and ability to expand their northern range limit (Thomas et al., 2001) and adjust their phenology to a changing environment (Parmesan and Yohe, 2003; Root et al., 2003; Meltofte et al., 2007). However, increased temperatures may be detrimental to species that are dependent on the current structure of Arctic and Subarctic breeding grounds, such as the red-necked phalarope (*Phalaropus lobatus*). This small shorebird has been noted in both the Canadian and United States Shorebird Conservation Plans for its drastic population declines, particularly on staging areas (Donaldson et al., 2000; Brown et al., 2001). The red-necked phalarope breeds throughout the circumpolar region and is highly dependent on shallow, freshwater ponds and wetland habitat (Rodrigues, 1994; Rubega et al., 2000).

Freshwater ponds provide a stage where male and female red-necked phalaropes engage in social interactions such as attracting mates, forming pair bonds, and copulating early in the breeding season (Rubega et al., 2000). Ponds also provide feeding areas, particularly for females that must build energy for egg production (Monaghan and Nager, 1997). Additionally, ponds are important food sources for the phalarope's precocial young, who must undergo rapid weight gain to prepare for their long-distance migration to overwintering areas along the west coast of South America and the east coast of Africa (Rubega et al., 2000). Red-necked phalaropes feed on a variety of invertebrate prey and small fish, both during their breeding season and at other times throughout the year (Baker, 1977; Mercier and Gaskin, 1985; Brown and Gaskin, 1988). Phalaropes (*Phalaropus* spp.) are characterized by their unique feeding behavior termed "spinning," which allows them to create an upwelling that forces small prey from depths of up to 0.5 m to the water's surface (Obst et al., 1996).

Associations between the characteristics of ponds and their use by red-necked phalaropes have not been studied. The proportion of emergent aquatic vegetation in a pond may influence occupancy because feeding and resting individuals would be less conspicuous to visual predators such as jaegers (*Stercorarius* spp.) and hawks (*Buteo* spp.) in ponds with greater cover. Vegetated shorelines could also provide shelter from harsh weather. Prey assemblages may vary between ponds, especially if red-necked phalaropes preferentially eat particular prey (Dodson and Egger, 1980). Ponds with preferred prey assemblages are hypothesized to exhibit different physical and chemical pond characteristics (Nicolet et al., 2004) than those with fewer or less preferred prey.

The goal of this study was to assess whether potential prey availability, vegetation, and water chemistry characteristics are good predictors of pond occupancy by red-necked phalaropes. We predicted that ponds occupied regularly would contain a greater abundance of potential prey than those occupied only rarely. We documented changes in pond occupancy from just before egg-laying to

hatching, predicting that pond occupancy would be greatest early in the breeding season, when adults are active in social activities, and least during incubation, when females are emancipated from the nest area and males spend about 78% of their time incubating eggs (Rubega et al., 2000).

METHODS

Study Area and Field Methods

We studied pond use by red-necked phalaropes in a 6 km² study area on Niglintgak Island (69°19'42" N, 135°15'53" W), in the Kendall Island Bird Sanctuary, Mackenzie Delta, Northwest Territories, from 10 June to 17 July in 2005 and 2006. Ponds separated by 25–200 m were selected for their accessibility by foot. Differences in camp placement precluded monitoring any single pond in consecutive years, but all ponds were located within a single wetland. Over the two seasons, we sampled about 75% of the ponds in the wetland. The study site was 1–2 m above sea level and consisted of lowland Arctic wetland with a soft ground surface composed primarily of graminoids (grasses and sedges), shrubs, and open water. Ice breakup occurs in late May to early June (Gratto-Trevor, 1994, 1996). Flooding occurs regularly following ice breakup and in summer during periods of heavy rainfall with strong northerly winds that force ocean water into the mouth of the delta (Gratto-Trevor, 1996; pers. observ.). Weather data for Inuvik, Northwest Territories, 121 km SE of the study area, were obtained from Environment Canada.

We marked ponds with flagging tape attached to a graduated stake placed within 1 m of the pond perimeter, and recorded each location with a handheld Global Positioning System (GPS) unit. We attached IBCod miniature temperature data loggers (Alpha Mach Inc., Mont Saint-Hilaire, Quebec) to these stakes 1–2 cm above the bottom substrate to measure water temperature every hour throughout the season. We measured water depth at 4–10 random locations (with a greater number in larger ponds) and calculated average depths from these measurements. Percentages of mud, shrub (woody plants 30–100 cm high), and emergent aquatic vegetation were visually estimated to 1 m beyond the pond periphery, and percentage of open water was estimated for all ponds. Two observers conducted estimations once in early June, during the beginning of the study period.

Water pH, conductivity (mS/m²), depth (cm) and prey availability (dry weight in g/m³) were measured once during the period of nest initiation (15–18 June, both years) and again during the incubation period (24–26 June, both years). Conductivity and pH were both measured (pH/ATC combination electrode, Corning Incorporated Scientific Products Division, Corning, New York, USA) at three random locations within each pond during each sampling period. Potential prey samples were collected by

sweeping through the water at three randomly selected locations, three times (1 m sweep length, 500 μm D-shaped dip net). We calculated the volume (m^3) of water sampled during each sweep to use in correcting our measures of potential prey dry weight. This was particularly important because ponds varied in depth and began to dry throughout the breeding season. Vegetation and debris were gleaned of insects and then removed from the net. All invertebrates and vertebrates were stored in 95% ethanol and later identified to Order (Clifford, 1991) and measured. Dry weights (mg) were determined for representative samples from each stage of development (larval or adult), Order, and length category.

Rate of drying, defined as the change in water level between sampling periods, was removed from analyses because of the extreme variation in weather (rainfall and wind), the degree of isolation from the river channel, and the distance to large, ice-covered lakes that contributed to ponds through ice melt. The time between sampling periods was too great to capture this variability in water levels because the depth of some ponds varied daily. One unoccupied pond that completely dried before the second sampling period was excluded from analyses because we could not collect potential prey samples or measure water chemistry.

We recorded the numbers of individuals feeding, resting, swimming, or interacting on ponds every one to four days between 8:00 and 20:00 throughout the breeding season. Each observation period lasted 10 minutes. Ponds were observed individually, and the number of ponds observed on a single day ranged from 2 to 24. Red-necked phalaropes are extremely tame (Hildén and Vuolanto, 1972) and we could observe them easily from a distance of 3 to 5 m. Nests were located through observations of pair behavior and by flushing males from nests. We monitored nests every one to three days to determine average date of onset of incubation and hatch for each year.

Statistical Methods

Analyses for 2005 and 2006 were computed separately because the two study areas, although adjacent, were not identical. Ponds were considered occupied if at least one red-necked phalarope was present during the observation period. We divided the number of ponds occupied by the total number of ponds observed for every two-day period. The resulting proportion of ponds occupied was plotted against date to determine trends in proportion of ponds occupied throughout the breeding season.

The frequency at which numbers of red-necked phalaropes were observed on sample ponds was compared to expected values based on a Poisson distribution (Zar, 1999). This analysis was completed by year and breeding stage (pre-incubation and incubation) to examine sociality as a factor influencing pond use. Pond occupancy was calculated for every pond by dividing the number of times at least one red-necked phalarope was present on each pond by the total number of observations for each pond.

Ponds were subsequently grouped into use categories (high-use, low-use, or no-use) on the basis of relative occupancy. Ponds never occupied were referred to as no-use ponds. Ponds used by phalaropes at least once, but with relative occupancies less than 50%, were arbitrarily considered low-use ponds, while those with relative occupancies greater than 50% were considered high-use ponds.

Average air temperatures from 1 June to the average date of clutch initiation were lower in 2005 ($9.8^\circ\text{C} \pm 1.5$ SE, $n = 13$ d) than in 2006 ($12.3^\circ\text{C} \pm 1.2$ SE, $n = 17$ d), but the difference was not significant. On 3 July 2006 a storm with winds from the north up to 60 km/hr caused a backup of freshwater throughout the mouth of the Mackenzie Delta, which flooded the entire study site. All areas within the wetland were immersed in approximately 20–100 cm of water, and ponds were no longer isolated. When winds receded, the water level within the Mackenzie Delta receded as well. There was no visible evidence of the flood within the wetland once excess water had drained. We retained occupancy observations from the period following the flood (3–7 July) since they did not result in a change in the designated grouping (high-use, low-use, or no-use) for any sample ponds compared to their designation before the storm. These observations were also included in the plot of proportion of ponds occupied over time (Fig. 1).

Simple linear and polynomial regression analyses were conducted on dry weights of potential prey to determine relationships between length and weight for each larval stage of each taxonomic Order. The models resulting in the best fit for each larval stage and Order were used to calculate the dry weight of prey in all samples. The environmental and potential prey assemblage data were highly skewed. Thus, we analyzed these data with MANOVA based on sum of squared distances with DISTLMv5 (Anderson, 2001; McArdle and Anderson, 2001). We compared the structure of potential prey assemblages and environmental characteristics separately between high-use, low-use, and no-use ponds with unbalanced, semiparametric, permutational MANOVA. All factors were fixed, and the Bray-Curtis dissimilarity measure of ecological distance was used to create a distance matrix. The resulting test statistic, a multivariate analogue to Fisher's F-ratio, determined whether the multivariate distance was greatest between groups when compared to distances within groups. Corresponding probability measures (p -values) were calculated with permutations (Anderson, 2001; McArdle and Anderson, 2001). Before analysis, environmental characteristics were standardized. Potential prey abundances were square-root transformed to increase the relative contribution of rare species compared to abundant species (Clarke and Green, 1988). We log-transformed dry weights of samples of prey aggregated across species and used a paired t-test to compare dry weights at ponds during nest initiation and during the incubation period, analyzing data from 2005 and 2006 separately. We present dry weights for common potential prey (present in at least 50%

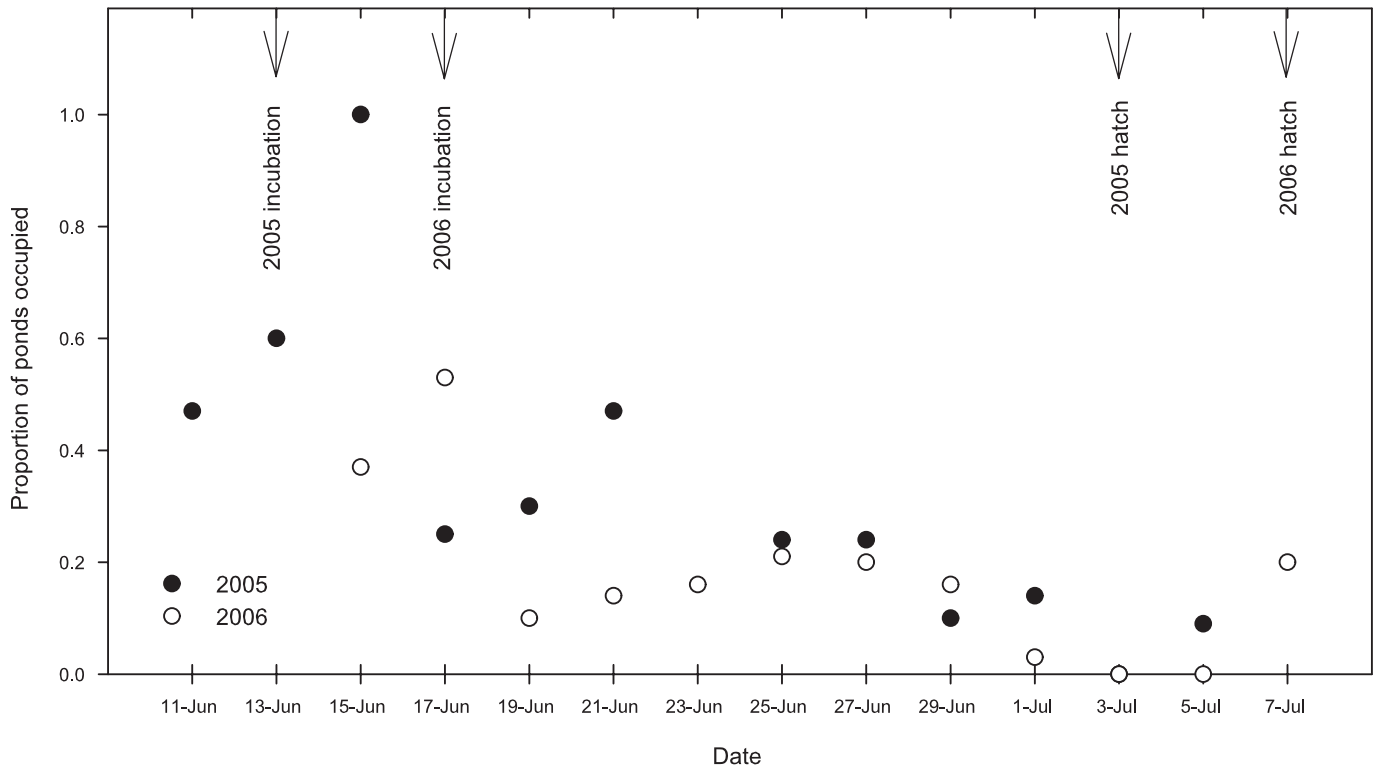


FIG. 1. Proportion of ponds occupied by red-necked phalaropes throughout their breeding season on Niglintgak Island in the Mackenzie Delta, Northwest Territories in 2005 ($n = 23$) and 2006 ($n = 24$). Average date for onset of incubation was 13 June in 2005 and 17 June in 2006, while average hatch dates were 3 July 2005 and 7 July 2006. Observations were recorded from 11 June to 5 July 2005 and 15 June to 7 July 2006.

of ponds) and compare environmental characteristics between years and use categories.

RESULTS

Individual ponds used most frequently by red-necked phalaropes in 2005 ($n = 23$) and 2006 ($n = 24$) had occupancy rates of 80% and 50%, respectively, with 1–9 birds observed per pond (2005 mean = 1.93 and 2006 mean = 2.14). In 2005, 52% (12/23) of ponds monitored were low-use (mean relative occupancy = 25%), 22% (5/23) were high-use (mean relative occupancy = 72%), and the remaining six were not used. In 2006, about 25% (6/24) were low-use (mean relative occupancy = 24%), 38% (9/24) were high-use (mean relative occupancy = 70%), and the remaining nine were not used (Table 1). Although the majority of time on ponds was spent feeding, individuals were also observed socializing, copulating, preening, and resting. The proportion of ponds occupied was highest in mid-June, which coincided approximately with the average onset of incubation in both years: 13 June 2005 ($n = 16$ nests) and 17 June 2006 ($n = 26$ nests, Fig. 1). Following this peak, there was a gradual and steady decline in the proportion of ponds occupied. Red-necked phalaropes occupying ponds prior to the onset of incubation ($n = 68$, $\chi^2 = 69.1$, $p < 0.01$) and during incubation ($n = 341$, $\chi^2 = 48.6$, $p < 0.01$) were significantly aggregated.

No differences were detected in water quality, vegetation characteristics, or potential prey assemblages between high-use, low-use, and no-use ponds in either year (Tables 1 and 2). We found some variability in potential prey assemblages (Acarina, Ephemeroptera, Gastropodiformes and Trichoptera) between sites and years although water quality and vegetation characteristics were consistent. Dry weight of potential prey aggregated across species was higher during incubation than during pre-incubation in both 2005 ($t_{1,22} = -3.83$, $p < 0.01$) and 2006 ($t_{1,23} = -2.89$, $p < 0.01$; Fig. 2).

DISCUSSION

We did not identify any differences in prey assemblages, water quality, or vegetative characteristics of ponds corresponding to varying rates of occupancy by adult red-necked phalaropes. Our prediction that high-use ponds would have the highest dry weights of potential prey, followed by low-use and no-use ponds, was not supported. Within the large wetland complex that we studied, ponds had relatively homogeneous characteristics and pond occupancy appeared to be related, at least in part, to the presence of other phalaropes. Given the highly social and non-territorial nature of this species (Höhn, 1968; Reynolds, 1987), this result is not surprising. It also agrees with previous findings, which suggest that pond-use by breeding

TABLE 1. Median (lower and upper quartiles) dry weights (mg/m³) of common potential prey sampled from ponds in 2005 and 2006. Ponds were characterized, according to the percentage of total observations with a phalarope present, as no-use (0), low-use (< 50%), and high-use (≥ 50%). Unbalanced semi-parametric MANOVA (Anderson, 2001; McArdle and Anderson, 2001) showed no significant differences between use categories (2005: pseudo-F₂ = 0.54, *p* = 0.75; 2006: pseudo-F₂ = 0.08, *p* = 0.76). Years were not compared because different ponds were sampled each year.

Taxon	2005 – Plot A			2006 – Plot B		
	No-use (n = 6)	Low-use (n = 12)	High-use (n = 5)	No-use (n = 9)	Low-use (n = 6)	High-use (n = 9)
Acarina	0.3 (0–0.5)	0.3 (0.1–0.7)	0.1 (0–0.2)	0 (0–0.3)	0 (0–0)	0 (0–1.5)
Coleoptera	6.5 (1.6–38.3)	4.6 (1.4–7.1)	0 (0–2.6)	5.0 (3.7–13.6)	9.6 (5.8–18.8)	3.7 (0–9.5)
Diptera	6.6 (1.4–9.5)	9.9 (1.5–17.1)	11.1 (8.9–26.9)	5.2 (2.3–9.5)	3.7 (1.8–5.2)	3.4 (1.5–11.4)
Ephemeroptera	0 (0–0)	0 (0–0)	0 (0–0)	0.5 (0.1–0.7)	1.1 (0.2–2.6)	0.4 (0.2–1.0)
Gasterosteiformes	0 (0–0.1)	0 (0–0)	0 (0–0)	0.9 (0.2–3.2)	0.6 (0–2.8)	1.2 (0.5–2.4)
Gastropoda	0 (0–74.7)	11.1 (0–56.2)	11.9 (0–65.8)	8.2 (0–28.2)	23.8 (11.9–28.5)	3.8 (0–8.6)
Trichoptera	0 (0–0)	0 (0–0)	0 (0–0)	5.2 (4.3–19.1)	10.6 (5.4–41.1)	4.2 (0–20.2)

TABLE 2. Median (lower and upper quartiles) for environmental characteristics of ponds monitored in 2005 and 2006. Physical qualities of ponds were measured at the start of the breeding season, and chemical properties and dry weights of sample prey aggregated across species were measured twice through the breeding season. Unbalanced semi-parametric MANOVA (Anderson, 2001; McArdle and Anderson, 2001) showed no significant differences between use categories (2005: pseudo-F₂ = 0.18, *p* = 0.36, 2006: pseudo-F₂ = 1.50, *p* = 0.28).

	2005 – Plot A			2006 – Plot B		
	No-use (n = 6)	Low-use (n = 12)	High-use (n = 5)	No-use (n = 9)	Low-use (n = 6)	High-use (n = 9)
% emergent	68 (20–90)	73 (55–100)	85 (60–90)	100 (85–100)	100 (100–100)	100 (90–100)
% mud	15 (10–50)	0 (0–5)	0 (0–5)	0 (0–15)	0 (0–0)	0 (0–10)
% shrub	3 (0–30)	8 (0–45)	10 (5–40)	0 (0–0)	0 (0–0)	0 (0–0)
% open water	95 (85–100)	73 (65–90)	75 (70–85)	68 (40–85)	85 (75–90)	75 (65–90)
Depth (cm)	15.3 (11.1–37.7)	15.6 (11.9–29.1)	16.4 (15.5–21.8)	23.4 (12.2–30.8)	23.1 (21.4–27.3)	27.9 (18.0–34.0)
pH	8.2 (8.0–8.3)	8.2 (8.1–8.3)	8.2 (8.0–8.3)	8.0 (7.9–8.1)	8.0 (7.8–8.0)	8.1 (8.0–8.2)
Conductivity (mS/m ²)	1.5 (1.2–2.1)	1.3 (1.1–1.6)	1.8 (1.3–2.0)	1.7 (1.4–2.7)	1.6 (1.5–1.8)	1.4 (1.1–1.7)
Temperature (°C)	10.9 (9.6–11.3)	10.1 (9.9–10.7)	9.9 (9.8–10.2)	12.5 (11.9–12.5)	12.4 (12.2–12.9)	12.5 (12.3–12.5)
Weight 1 (g/m ³)	0.1 (0–0.2)	0.1 (0.1–0.3)	0 (0–0.1)	0.2 (0.1–0.4)	0.2 (0.1–0.3)	0.1 (0.1–0.2)
Weight 2 (g/m ³)	0.9 (0.4–2.8)	0.4 (0.1–1.0)	0.4 (0.2–1.0)	0.2 (0.2–0.7)	0.3 (0.2–0.4)	0.2 (0.1–0.5)

Wilson's phalaropes (*Phalaropus tricolor*) is not driven by density, dry mass, crude protein, or gross energy content of available prey (Gammonley and Laubhan, 2002). Although there is some evidence that waterfowl show preferences for ponds with certain prey characteristics (Guillemain et al., 2000; LaMontagne et al., 2003), we suggest that red-necked phalarope pond use is not related to potential prey if ample prey is available. The suggestion that food was not limiting within our study site is supported by the fact that the species' characteristic "spinning" behavior was never observed during the study period. Spinning is an energetically expensive behavior that is limited to environments where prey is not immediately available (Obst et al., 1996). We often observed phalaropes rapidly eating mayflies or chironomids off pond surfaces.

Although the macroinvertebrates that we sampled in the two years were superficially similar, we sampled ponds in a different part of the wetland complex in the second year so the variables "site" and "year" were confounded. In the second year, we sampled more Ephemeroptera, Gasterosteiformes, and Trichoptera from the adjacent section of the wetland, but noted the complete absence of Acarina. Although community assemblages of macroinvertebrates in our study were similar to those in ponds of the Yukon Delta, Alaska (Maciolek, 1989), much

more could be done to examine temporal and spatial variation in the factors influencing the composition and productivity of invertebrates in Arctic ponds.

Adult red-necked phalaropes may exhibit pond preferences based on features of ponds that we failed to identify. Pond occupancy may, for example, be defined by characteristics of the surrounding habitat and not necessarily those of the pond itself. For example, one pond in 2006 supported nesting long-tailed jaegers (*Stercorarius longicaudus*), tundra swans (*Cygnus columbianus*), and red-throated loons (*Gavia stellata*). The predatory long-tailed jaegers were aggressive towards all individuals using the pond, including red-necked phalaropes. Pond occupancy by aggressive birds would probably discourage red-necked phalaropes, as their feeding would be regularly interrupted. Pond use could also have been determined by proximity to potential nest sites (at least early in the season). Although we did find nests in the study area, we most certainly did not find all the nests. As we cannot be confident that nests were absent around those ponds that we characterized as no-use, this hypothesis cannot currently be evaluated.

Our results support the prediction that the proportion of ponds occupied would decrease throughout the breeding season as males increasingly bias their time budget towards

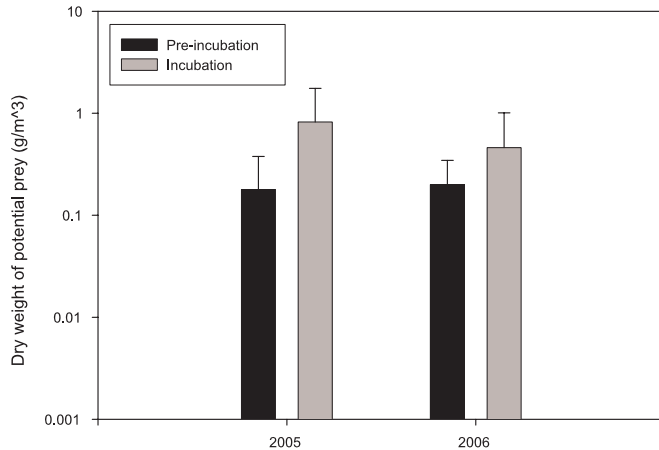


FIG. 2. Dry weight (median and quartiles) of potential macroinvertebrate prey sampled from ponds during nest initiation (15–18 June) and incubation (24–26 June) of red-necked phalaropes. All ponds sampled (23 in 2005 and 24 in 2006) were located within a wetland on Niglintgak Island, Mackenzie Delta, Northwest Territories.

incubation (Rubega et al., 2000). This strategy is supported by the increased availability of potential prey in ponds during the incubation period, which possibly allows males to build their energy reserves in a shorter time period relative to the nest initiation period. An abrupt decline following the onset of incubation was probably not evident in our data because females remained on ponds throughout the beginning of the incubation period until about the middle of June. We observed females congregating on lakes in preparation for fall migration from the middle to the end of June. The peak in occupancy in early July 2006 followed the flood of 3 July that resulted in almost complete nest failure in the study area.

Future studies that examine patterns of pond use immediately after arrival of red-necked phalaropes on the breeding grounds and continue until juveniles initiate their southward migration would provide additional insights. We were unable to collect observations of pond occupancy by red-necked phalarope chicks because we left the study area just after the date of average hatch in 2005 and because the flood destroyed virtually all active nests in 2006. Pond occupancy at the end of the breeding season is of particular interest, as preference by waterfowl broods has been documented in studies where this preference was absent during the nesting phase (Godin and Joyner, 1981). These insights would also be appealing because the increased temperatures predicted for the North will entail the premature drying of ponds (Smith et al., 2005; Riordan et al., 2006). One unused pond within our study site completely dried before average hatch in 2006. Premature drying would be particularly problematic for hatchlings, since they depend on ponds for building energy reserves in preparation for long-distance fall migrations. Large-scale drying would signal the end of suitable breeding habitat for this highly pond-dependent shorebird.

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