Sex-specific food choices in Whiskered Terns *Chlidonias hybrida* during chick rearing

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We studied sex-specific differences in prey returned to nests and eaten by parents in Whiskered Terns *Chlidonias hybrida*. The species is size-dimorphic, with females being smaller than males. The sex of the birds was determined by molecular analysis. Prey consumed and carried to chicks was recorded at short (< 300 m) and long distances (> 300 m) from nests. Only females carried invertebrates to the chicks and they did so only from short distances. The proportion of vertebrates carried to the chicks by both sexes was greater when feeding at short distances from the nest. Males carried significantly larger vertebrates to chicks than those they consumed themselves. These results demonstrate that reproductive trade-offs differ between the sexes in the Whiskered Tern.

Key words: foraging behaviour, prey utilization, fish size, capture rates, carp ponds, *Sterninae*

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Prey availability for birds has a profound influence on individual decisions concerning the trade-off between somatic and reproductive investment (Dänhardt *et al.* 2011). Birds feeding chicks should deliver the most nutritious and optimally sized prey items to chicks in order to maximise chick growth (Baird 1991). However, whether a parent delivers prey to chicks or eats it itself, depends not only on prey value but also on the time and energy cost of transporting each prey item (Schoener 1979). For example, Caspian Gulls *Larus cachinnans* capture larger fish in ponds located further from the colony than in ponds near the colony (Skórka *et al.* 2009). Similarly, Snowy Owls *Nyctea sandiaca* prefer to deliver heavier rodents to the nest, whilst taking smaller rodents for themselves (Potapov & Sale 2012).

To maximise energetic investment in reproduction, colony-breeding single loaders, such as terns, mostly bring energy-rich prey items to their chicks (Dänhardt *et al.* 2011). Furthermore, parents should bring energy-rich prey to chicks when hunting at large distances from the nest (Schoener 1979). However, in species with sexual size dimorphism, males and females may differ in the selection of prey to feed chicks, depending on the distance from the nest. The larger sex is more predisposed to catch and transport large prey (González-Solis *et al.* 2000, Gwiazda & Ledwoń 2015). Sexual differences in foraging and provisioning behaviour have been observed in several size-dimorphic seabird species (Lewis *et al.* 2002).

The aim of this study was to determine whether there are differences between males and females in the proportion of different prey species and prey sizes that they consume themselves or carry to their chicks, in relation to the distance from the nest. Therefore, we studied Whiskered Terns *Chlidonias hybrida*, which are socially monogamous marsh terns (both partners incubate, brood and feed chicks), with no sexual plumage dimorphism (Cramp & Simmons 1985). In this species, males are significantly larger than females, with head

length differing by 7%, bill size by 10% and body mass by 6% (Ledwoń 2011). Males mainly forage on larger prey, such as vertebrates, which are captured by shallow plunge diving (Gwiazda & Ledwoń 2015). Females mainly capture smaller prey, such as invertebrates, by picking them from plants and from the water surface (Gwiazda & Ledwoń 2015). These differences are attributed to their sexual size dimorphism (González-Solis *et al.* 2000, Gwiazda & Ledwoń 2015).

Methods

The study was carried out in the Upper Vistula River Valley (southern Poland), at three carp pond complexes: Spytkowice (50°01'N, 19°29'E; 480 ha), Bugaj (49°59'N, 19°26'E; 180 ha) and Rudze (49°58'N, 19°26'E; 120 ha). For a detailed description of the study area see Ledwoń *et al.* (2013, 2014). The area of each carp pond varied from 0.5 to c. 20 ha. The mean water depth of all sites was 1.2–1.5 m. The emergent vegetation formed 3–6 m wide belts of reeds, and some ponds were covered with floating water-lilies *Nymphoides peltata*. In addition, there were islands of various sizes in some ponds, on which shrubs or trees grew. All sites were surrounded by agricultural land or settlements. The Common Carp *Cyprinus carpio* was the main fish species in the ponds. Similar production rates and fish densities were recorded at the studied sites (data of Fish Farm in Zator).

Whiskered Terns were studied during the breeding seasons (May–Aug) of 2007 and 2008. Adult birds were caught at the nest with a roof trap during the incubation period or when brooding downy chicks (Ledwoń *et al.* 2015). All individuals were ringed and marked individually by painting some parts of their feathers with hair dye. Blood samples of approximately 0.2 ml were taken from the tarsus vein for molecular sexing. The sex was determined from the CHD-gene on sex specific chromosomes (for molecular method see Ledwoń 2011, Ledwoń *et al.* 2015).

Adult birds, identified as parents of known nests, were observed during the chick-rearing period. The observer moved through the pond complexes and looked for marked individuals every 3–7 days. Birds were observed, from the pond shore, using a spotting telescope or binoculars. Fifty-six individually marked terns were observed, for over 38 h in 2007 (15 females and 14 males) and in 2008 (13 females, 14 males). For each prey capture attempt, prey type and whether prey was immediately consumed or transported away, was recorded. Prey transported in the direction of the colony was considered prey carried to chicks. Distances of foraging sites from nests were measured using a map and categorised as either short (up to 300 m) or long (300–1200 m). Additionally, prey consumption of invertebrates was analysed at the following distances: 0–150 m and 150–300 m. Vertebrate size (total length, cm) was estimated, if possible, relative to bill length (culmen length c. 30 mm) and divided into two classes: 0.5–2 ×, and >2 × bill length (Figure 1). We assumed that prey length of the first class was smaller than 6 cm, and that of the second class was greater than 6 cm.

Figure 1. Whiskered Tern returning a small fish of c. 4 cm length to its nestlings (photo M. Baran).

A General Linear Mixed Model with a Bernoulli distribution was used to test differences in (1) the proportion of invertebrates carried to chicks by females as a function of distance, (2) the proportion of vertebrates carried to chicks by males and females as a function of distance, and (3) the proportion of smaller and greater vertebrates carried to chicks by males and females as a function of distance. Individual was entered as a random effect in the models. A Chi-squared test with Yates-correction was used to compare differences in the sizes of vertebrates caught and carried to chicks (Sokal & Rohlf 1987). Analyses were performed using STATISTICA v. 8.

Results

In general, Whiskered Terns delivered two types of food to the chicks: vertebrates (fish and frogs) and invertebrates. Females foraged on invertebrates at both short and long distances from the nest, but they only carried invertebrates to the nest from short distances (n =

685). Moreover, a higher proportion of invertebrates were carried to chicks when feeding close to the nest, at distances up to 150 m ($W = 37.35$, $P < 0.001$, $n = 241$). Males often consumed invertebrates ($n = 35$), but rarely carried them to the chicks ($n = 10$). The proportion of vertebrates carried to chicks by the parents was higher at short distances from the nest (male: $W = 5.55$, $P = 0.02$, $n = 378$; female: $W = 17.57$, $P < 0.001$, $n = 114$; Figure 2).

Vertebrates larger than 6 cm were mostly fed to the chicks, by both sexes (Figure 3). In males, a higher proportion of vertebrates longer than 6 cm was carried to chicks when feeding at a short distance from the nest ($W = 4.88$, $P = 0.03$, $n = 68$), while a higher proportion of vertebrates smaller than 6 cm was consumed at a long distance from the nest ($W = 12.00$, $P = 0.001$, $n = 219$). Males carried more of the larger vertebrates to the chicks ($X^2_1 = 33.47$, $P < 0.001$): prey longer than 6 cm constituted 39% of the consumed vertebrates ($n = 219$), but 79% of the prey carried to chicks ($n = 68$; Figure 3). No such differences were found in females ($X^2_1 = 0.78$, $P = 0.384$). Females consumed 67% of the vertebrates ($n = 54$) and carried 76% of the vertebrates ($n = 29$) longer than 6 cm to chicks.

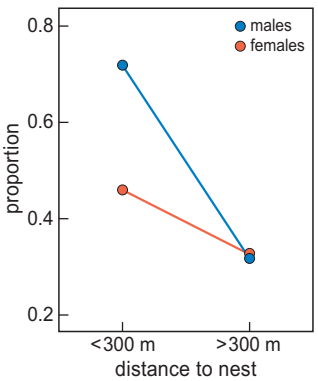

Figure 2. Proportion of vertebrates carried to chicks by females ($n = 114$) and males ($n = 378$) of the Whiskered Tern at lesser (<300 m) and greater (>300 m) distances from the nest.

Discussion

The foraging behaviour of male and female terns has been studied in a number of species (Wiggins & Morris 1987, Wagner & Safina 1989, Uttley 1992, Fasola & Saino 1995, Sorokaitė 2005). Different foraging techniques are used by both sexes in the sexually dimorphic Whiskered Tern (Gwiazda & Ledwoń 2015). We found that females of the Whiskered Tern carried invertebrates to chicks from short distances only. Males rarely

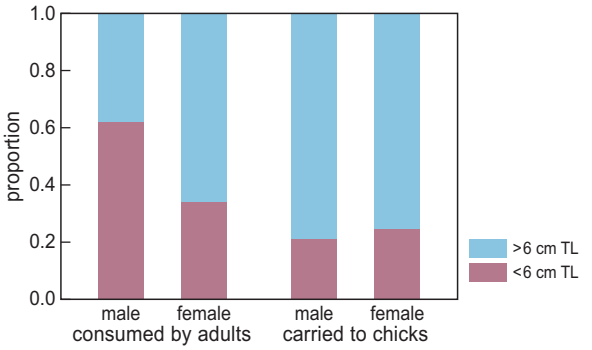

Figure 3. Proportion of vertebrates smaller and larger than 6 cm in total length, consumed by adults and carried to chicks by males ($n = 219$ and $n = 68$, respectively) and females ($n = 54$ and $n = 29$, respectively) of the Whiskered Tern.

carried invertebrates to the chicks. An explanation for the females' behaviour is probably the low energy yield per invertebrate prey item. For single loaders it is profitable to carry low quality prey from a short distance only, especially in situations when high quality prey is available. Earlier we showed that high quality vertebrate prey is common in the study area (Gwiazda & Ledwoń 2015). The proportion of vertebrates carried to chicks by males and females was higher at short distances from the nest. Furthermore, in males but not in females, a higher proportion of vertebrates longer than 6 cm was carried to chicks from a short distance. In general, these results indicate that in Whiskered Terns, parents selected food with the highest possible nutritional value and lowest costs for provisioning their young, as predicted by size-distance models of optimal feeding (Schoener 1979).

The vertebrates that male Whiskered Terns brought to their chicks were larger than the ones they consumed themselves. In females, fish carried to the chicks and consumed themselves were not different in size. Fasola & Saino (1995) showed that fish species fed by males and females of Common *Sterna hirundo*, Little *Sterna albifrons* and Sandwich Terns *Sterna sandvicensis* were similar in each species, but males tended to bring larger prey. Similarly, in Common Terns high quality prey was carried to the chicks disproportionately often, while almost all low quality prey items were ingested by the foraging adult (Dänhardt 2011). Apparently, prey biomass or energetic value is an important factor in the decision of whether prey is consumed or delivered to the chicks (Hubbard *et al.* 1982, Baird 1991, Davoren & Burger 1999). This pattern has also been reported for other tern species (Shealer 1998a, 1998b, McLeay *et al.* 2009, Dänhardt *et al.* 2011).

It is difficult to explain why we did not find differences in females between the sizes of consumed and fed vertebrates, as was found in males. One of the explanations could be due to the fact that, overall, females deliver significantly less food to the chicks than males (Ledwoń unpubl. data), because the smaller females catch smaller prey than the males (Gwiazda & Ledwoń 2015), and that females, therefore, are under less pressure to select the appropriate food types for their chicks.

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Samenvatting

In dit onderzoek is gekeken of er verschillen in prooikeuze bestaan tussen mannetjes en vrouwtjes Witwangsterns *Chlidonias hybrida* tijdens de jongenfase. De oudervogels hebben de keuze tussen verschillende prooitypen (vertebraten – meestal vis, of evertebraten) en prooigroottes. Vervolgens maken ze de keuze of ze de prooi zelf opeten of naar hun kuikens brengen. Er werd ook onderscheid gemaakt tussen prooien die dichtbij (< 300 m) of veraf (> 300 m) van het nest werden gevangen. Vrouwtjes van de Witwangstern zijn kleiner dan de mannetjes, wat ook invloed heeft op hun foerageergedrag. Alleen vrouwtjes brachten evertebraten naar het nest en deden dit altijd vanaf een korte afstand van het nest. Het aandeel vertebraten dat door beide seksen naar het nest werd gebracht was groter wanneer de vogels dicht bij het nest foerageerden. Mannetjes brachten meer grote vertebraten naar hun kuikens dan ze zelf opaten. Dit laat zien dat de afwegingen die beide ouders tijdens het foerageren maken in de jongenfase verschillen.

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