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Space use of wintering waterbirds in India: Influence of trophic ecology on home-range size

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Abstract Relationship between species' home range and their other biological traits remains poorly understood, especially in migratory birds due to the difficulty associated with tracking them. Advances in satellite telemetry and remote sensing techniques have proved instrumental in overcoming such challenges. We studied the space use of migratory ducks through satellite telemetry with an objective of understanding the influence of body mass and feeding habits on their home-range sizes. We marked 26 individuals, representing five species of migratory ducks, with satellite transmitters during two consecutive winters in three Indian states. We used kernel methods to estimate home ranges and core use areas of these waterfowl, and assessed the influence of body mass and feeding habits on home-range size. Feeding habits influenced the home-range size of the migratory ducks. Carnivorous ducks had the largest home ranges, herbivorous ducks the smallest, while omnivorous species had intermediate home-ranges. Body mass did not explain variation in home-range size. To our knowledge, this is the first study of its kind on migratory ducks, and it has important implications for their conservation and management [*Current Zoology* 60 (5): 616–621, 2014].

Keywords Anatidae, Garganey, Gadwall, Northern Shoveler, Chilika, India

Home ranges of animals have long been related with their other biological traits. For instance, home-range size varies with body mass in several taxa including lizards, birds (Schoener, 1968) and mammals (McNab, 1963). The hypothetical mechanism is that the quantity of food required by animals varies allometrically with their energetics. Larger species have greater energy requirements, and thus tend to have larger home ranges. The relationship between home-range size and body mass however remains poorly understood, especially in migratory birds that are more difficult to track.Schoener (1968) also reported a strong relationship between birds' feeding habits and their home-range sizes. Carnivores tend to have larger home ranges compared to herbivores and omnivores, because they need larger areas to gather food, as their prey species are more scattered in the landscape (McNab, 1963; Schoener, 1968). Conversely, herbivores have smaller home ranges because of the greater concentration of their food within a given area. However, very few empirical studies have been carried out to validate these ecological hypotheses in migratory species. Limited studies on the issue are biased largely towards mammals. Furthermore, whether such relationships hold true in taxonomic sub-groups such as waterfowl has not been addressed explicitly, largely due to the difficulty associated with tracking them.

The development of transmitters have given a fresh impetus to the study of such ecological issues in migratory birds, which were historically difficult to study (Bowlin et al., 2010). With the advent of recent technology like satellite transmitters, bird locations can be determined with accuracy, often within tens of meters (Kie et al., 2010; Robinson et al., 2010). Therefore, tagging birds with satellite transmitters is an effective way of gathering information on their home range and movement patterns. Ducks are especially suitable for teleme-

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try study as they are robust, and can bear the weight of the transmitters without their daily activities affected (Yamaguchi et al., 2010). We used information from migratory ducks tagged with satellite transmitters to understand the relationship between their home-range size and various biological traits in India.

India hosts over 300 species of wetland birds, of which about 107 are winter migrants. A total of 44 Anatidae species are currently reported from India, of which six are threatened. Despite various threats associated with the rapid industrial growth in the country, there has been no apparent effort to understand their distribution and spatial use patterns that could guide conservation policies. Large scale utilization distributions and movement patterns of waterfowl in India have just started to be reported (Namgail et al., 2011).

We studied home ranges of migratory dabbling ducks during winter in three Indian states with an objective of understanding the influence of body mass and feeding habits on home-range sizes. We tested the following hypotheses: (a) body size influences home-range sizes of migratory ducks; bigger species should have larger home ranges, and (b) feeding habit is an important determinant of home-range size; carnivorous ducks should have the largest and herbivorous ducks the smallest home ranges.

1 Materials and Methods

1.1 Study sites

Ducks were marked in the Indian states of Tamil Nadu, Orissa and West Bengal In Tamil Nadu, we marked the ducks at Puthalam and Koonthankulam. The Puthalam saltpans (8°06′ N, 77°28′ E) are located in the Kanyakumari District, the southernmost tip of Peninsular India, and host both resident and migrant waterbirds in large numbers during the winter. Hitherto, a total of 110 species of birds were recorded here. Although unprotected, the saltpans are used heavily as feeding and roosting sites by waterbirds. On the other hand, Koonthankulam (8°28′ N, 77°43′ E) is a bird sanctuary, and is the largest reserve for breeding waterbirds in south India. It is located at about 30 km from Tirunelveli, a bustling town on the banks of the Thamirabarani River. It is rich in phytoplankton, and over 43 species of resident and migratory waterbirds use the reserve. It has been designated as an Important Bird Area (IBA) and a potential Ramsar site.

In Orissa, we marked the ducks at Chilika Lake (19°28′–19°54′ N, 85°05′–85°38′ E), which is the second largest coastal lagoon in the world. The water extent varies from 906 to 1,165 km^2 depending on the season. It comprises a wide variety of habitats including marshes, mudflats and open water with varying depths and salinity. Vegetation largely includes aquatic plants, reeds and grasses. It attracts 700,000–950,000 waterbirds annually. A total of 226 bird species, including nine globally threatened and 12 Near Threatened species have been recorded at Chilika. The lake is the largest wintering ground for migratory birds on the Indian sub-continent, and hosts over 130 species of migratory waterbirds including 101 long-distance migrants from Russia and Central Asia during the winter. It was designated as the first Indian wetland of international importance under the Ramsar Convention.

In West Bengal, ducks were marked at Purbasthali (23°27′ N, 88°21′ E), which is an oxbow lake on the Ganga River, and is designated as a wildlife sanctuary to protect migratory waterbirds. It is located about 120 km north from Kolkata, the capital of West Bengal. It is one of the most important waterbird sites in West Bengal. Thousands of waterbirds including ducks and waders visit these wetlands during the winter.

1.2 Study species

Garganey *Anasquerquedula* is a relatively small duck, and has a wide distributional range as it is strictly migratory. It largely eats plant materials including leaves, shoots and seeds (Ali, 1996; Kear, 2005). Gadwall *Anasstrepera* is a relatively large duck with a wide distribution (Ali and Ripley, 1978). It breeds in northern Europe, Asia and North America. The species inhabits highly productive and eutrophic freshwater marshes or lacustrine habitats, and feeds mainly on plants during the winter. Northern pintail *Anasacuta*is a large duck and breeds in northern parts of Europe, Asia and North America, and winters mostly in the tropics. The northern populations are migratory, but there are some sedentary populations in the Southern Hemisphere. The species feeds on both plant and animal matters during winter. The species also includes a considerable amount of seeds in its diet (Kear, 2005).

Similarly, the Eurasian wigeon *Anaspenelope* has a large range, breeding in northern Europe and Asia, and wintering in south Asia and Africa. It feeds mainly on plants during the winter. Finally, the northern shoveler *Anasclypeata* is a widespread species, which is highly migratory, although there are some non-migratory populations in parts of Europe. The species largely has an animal-based diet in Asia and North America.

For this study, we categorised the ducks into different trophic groups: carnivore, herbivore and omnivore. Car-

nivorous ducks were defined as ducks with more than 80% animal matter, largely zooplanktons, in their diets, while herbivorous ducks were defined as species with less than 20% animal matter in their diets. All other ducks with 20 to 80% of animal matter in the diet were categorised as omnivorous. Dietary information on the ducks was gathered from the literature (Bellrose, 1976; Ali, 1996; Paulus, 1982; Ballard et al., 2004).

1.3 Field methods

Ducks were captured with monofilament leg-nooses and mesh-nets. Upon capture, they were immediately removed from the nooses and nets, placed in bamboo cages and processed for measurements. Morphometric data including mass, flat wing-chord and short tarsus (diagonal length of the tarsometatarsus measured along its outer edge) were collected (Dzubin and Cooch, 1992). Capture, handling and marking procedures led by an international team wered approved by the U.S. Geological Survey (USGS) Western Ecological Research Centre's Animal Care and Use Committee (ACUC) following protocols identical to those used by the University of Maryland Baltimore County Institutional ACUC (Protocol EE070200710). Individuals were weighed, and their sex and age were determined by cloacal inspection and plumage. Selected individuals were then marked with solar-powered Platform Terminal Transmitters (PTTs; Microwave Telemetry Inc., Columbia, MD, USA). The PTTs were attached dorsally with 1.4 cm wide, woven tubular teflon ribbon (Bally Ribbon Mills, Bally, PA, USA). The transmitters were programmed to transmit location information every 2–3 days. The weight of a transmitter was kept below the recommended 3% of the body mass of the bird. Different sized (9.5–22 g) PTTs were thus attached to the ducks, depending on the average body mass of the species.

1.4 Analytical methods

Home ranges were derived with Animal Space Use 1.3 and Home Range Tools in ArcGIS version 9.3 (Environmental Systems Research Institute, Inc., Redlands, CA, USA). We used only those duck locations that had error estimates: L3 with a stated error of less than 150 m, L2 with error of 150–350 m, and L1 with error of 350–1000 m (Collecte Localisation Satellites [CLS] 2007). We used the kernel density estimator, a robust probabilistic technique (Powell, 2000), to estimate home-range sizes of the ducks. This method is preferred over other methods such as minimum convex polygon and harmonic mean because it is non-parametric, and it allows for multiple centres of activities, which is typical of highly mobile animals like migratory birds. The influence of feeding habit on a species' home-range size was tested with Kruskal-Wallis analysis of variance by ranks, and the relationship between body mass and home-range size was tested with general linear model. The statistical analyses were carried out in R 2.13.2 (R Development Core Team, 2008).

2 Results

Among 65 individuals of five species fitted with satellite transmitters, only 26 transmitted adequate number and quality of locations that are required by the kernel method for estimating home range, and were thus selected for the analysis (Table 1). Of these five were Eurasian wigeon, three were Gadwall, nine were garganey, four were northern pintail and five were northern shoveler. Overall, number of locations per individual ranged from 25 to 211 (Table 2).

Gadwall, a herbivore, had the smallest fixed kernel home range (mean $\pm SE$ = 45.4 ± 7.5 km^2; Fig. 1), while the northern shoveler, a carnivore (consuming zooplanktons), had the largest home range (207.4 ± 30.8 km^2). Both omnivorous ducks: northern pintail (129.1 ± 56.6 km^2) and garganey (122.5 ± 7.5 km^2) had intermediate home ranges. We found that feeding habit is related to the home-range size (95%) of migratory

Table 1 Number of PTT-marked dabbling ducks and their average body mass and feeding habit in three Indian states during three consecutive winters (2008–2010)

Common name	Scientific name	Average body mass (g)	Feeding habit	Number of individuals marked			
				West Bengal	Orissa	Tamil Nadu	Total
Garganey	*Anasquerquedula*	332	Omnivore	3	2	4	9
Northern shoveler	*Anasclypeata*	541	Carnivore	0	5	0	5
Eurasian wigeon	*Anaspenelope*	689	Herbivore	3	2	0	5
Gadwall	*Anasstrepera*	719	Herbivore	2	1	0	3
Northern pintail	*Anasacuta*	751	Omnivore	0	2	2	4
Total				8	12	6	26

Table 2 Home range (95% kernel; km^2) and core-use area (50% kernel; km^2) of 26 individuals of six dabbling ducks wintering in India during three consecutive winters (2008–2010)

Species	State	PTT Id.	Body mass	Start date	End date	Locations	50%	95%
Eurasian wigeon	West Bengal	91223	594	26-12-2009	02-04-2010	56	45.47	407.08
		91225	668	26-12-2009	12-02-2010	63	4.28	18.96
		91662	680	26-12-2009	13-04-2010	25	27.38	119.58
	Orissa	82157	624	16-12-2008	16-03-2009	118	2.48	17.98
		85668	590	16-12-2008	30-04-2009	79	28.91	186.16
Gadwall	West Bengal	91661	835	24-12-2009	15-04-2010	53	7.61	53.86
		97679	670	06-02-2010	29-04-2010	112	9.43	56.37
	Orissa	82158	596	16-12-2008	30-04-2009	211	3.00	26.09
Garganey	West Bengal	89115	360	27-12-2009	30-04-2010	95	22.52	154.73
		97676	324	26-12-2009	28-03-2010	114	15.71	79.09
		97677	340	27-12-2009	13-04-2010	82	78.85	400.48
	Orissa	89119	324	16-12-2008	30-04-2009	123	6.66	42.18
		89126	374	16-12-2008	26-04-2009	125	25.20	193.47
	Tamil Nadu	89116	270	24-12-2008	21-04-2009	156	8.56	65.56
		89123	320	28-12-2008	16-04-2009	155	13.14	72.31
		89124	305	28-12-2008	27-03-2009	107	5.75	29.71
		89128	270	28-12-2008	25-04-2009	165	10.78	65.15
Northern pintail	Orissa	82156	668	17-12-2008	01-04-2009	120	17.51	91.51
		85669	772	17-12-2008	30-04-2009	55	36.23	315.71
	Tamil Nadu	44679	845	17-12-2008	16-03-2009	122	7.85	36.43
		82131	840	24-12-2008	10-02-2009	61	13.60	72.59
Northern shoveler	Orissa	44674	470	18-12-2008	28-03-2009	97	24.00	120.87
		82132	444	16-12-2008	16-04-2009	83	49.05	190.66
		82138	456	17-12-2008	06-04-2009	87	46.99	236.71
		82139	456	17-12-2008	30-04-2009	41	65.31	306.08
		85667	530	16-12-2008	30-04-2009	136	20.02	182.48

ducks (Kruskal-Wallis χ^2 = 4.977, *df*=2, *P* = 0.06) and core use area (50%: Kruskal-Wallis χ^2 = 6.144, *df*=2, *P* = 0.04); herbivorous ducks had the smallest home ranges, while the carnivorous ducks had the largest home range, and the omnivorous species had intermediate home ranges (Fig. 1).

As far as the body mass is concerned, garganey had the smallest mean body mass (332 g), while northern pintail had the largest mean body mass (751 g; Table 1), but as mentioned, these species had intermediate home ranges (Fig. 1). Our analysis was unable to relate body mass with the variation in home-range size of migratory ducks (herbivore, *R* = 0.22, *P* = 0.73; omnivore, *R* = 0.12, *P* = 0.78; carnivore, *R* = 0.29, *P* = 0.75).

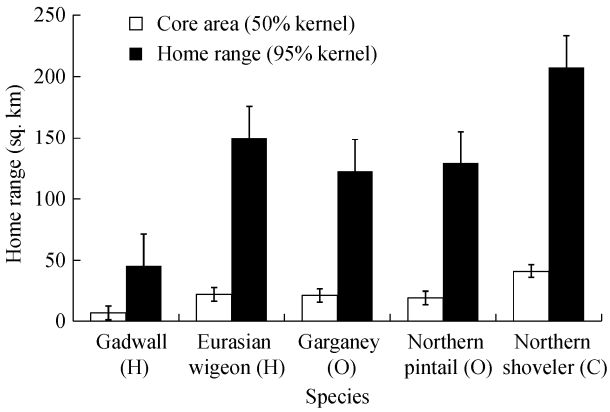

Fig. 1 Mean ±*SE* of home range (95% kernel) and core use area (50% kernel) of migratory ducks wintering in India during three consecutive winters (2008–2010)

Alphabets in parentheses represent feeding habit. H: herbivore; O: omnivore; C: carnivore.

3 Discussion

The results of our study support the hypothesis that feeding habits of migratory ducks influence their home-range size; carnivorous ducks had significantly larger home ranges than herbivorous ducks, and omnivorous ducks exhibited intermediate home ranges. This is con-

sistent with Schoener's (1968) contention that carnivorous birds have larger home ranges, as their prey species are generally more dispersed in the environment, and herbivores should have greater utilizable energy per unit area than carnivores. On the other hand, 'an omnivore does not need as large an area as a carnivore, as some of its required-energy is obtained from plant sources available within the area used to obtain animal food'.

However, our results did not support the 'food-exploitation hypothesis', as the bigger ducks did not have larger home ranges. This is in concordant with the results of Kelt and Van Vuren (1999), who also found a lack of clear relationship between body mass and home-range size. Therefore, we suggest that feeding habit is a more important determinant of home-range size than body mass in migratory ducks.

Winter-home ranges of the study species were larger than those of their counterparts in breeding areas. For instance, Derrickson (1978) reported a breeding home range of 8.96 km^2 for a paired-male and 4.8 km^2 for a paired-female Northern pintail in North America, which are smaller than home ranges of the respective sexes of the species in India. Such differences in home ranges between breeding and non-breeding areas have largely been attributed to the birds' territorial behaviour in the breeding areas, unlike in the non-breeding areas where they congregate in large numbers (Rahmani and Islam, 2008), necessitating them to use larger areas. The discrepancy could also related to the differences in dietary intake as the species consumes more invertebrates on its breeding ground (Kear, 2005).

The home ranges of the study species in India were also larger than those in wintering areas elsewhere. A space use study on northern pintail on the Atlantic Coast of France reported a home-range size of 0.6 km^2 (Legagneux et al., 2009), which is much smaller than our estimate for the species (129 km^2). Since the area used by an animal is a function of the time period considered, this difference could be attributed to the number of days the ducks are tracked in the two areas; we tracked these ducks for an average 94 days as opposed to 22 days in France. But the difference could also be due to a difference in movement pattern of the ducks determined by resource availability, which should be explored.

There was inter-specific overlap in home ranges among the study species. All studied ducks are sympatric over much of their distributional ranges; perhaps species in the same trophic status are relying on different food items in the same areas. In any case, most of the ducks had multiple centres of activities, and they moved frequently between different sites. Core-use areas were generally around the water bodies such as lakes, rivers and water reservoirs, while the overall home ranges covered a broader array of habitats such as forested areas, grasslands and agricultural fields.

In conclusion,Feeding habits influenced home-range size of migratory ducks. Carnivorous ducks had significantly larger home ranges than herbivorous ducks with omnivorous species having intermediate home-range sizes. Body size was not important in explaining the variability in home-range sizes of dabbling ducks. The results of this study may serve as baseline information for further work to relate biological traits with home-range size in migratory ducks.

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