Commentary

From spoonbill to Spoon-billed Sandpiper: the perceptual dimensions to the niche
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According to Begon et al. (2006), a niche is not a place but an idea. A niche is a summary of an animal’s tolerances and requirements. This determines where an animal would do best and where it likes to be; in other words, how an animal would select its habitat. Habitat selection is usually represented graphically in terms of prey selection, food intake rates and predator avoidance (Piersma 2011), but when this is done for particular animal species, their morphological, physiological, behavioural and sensory design features are mostly taken for granted (e.g. Wiens 1989, Morrison et al. 1990, Goss-Custard et al. 2006).

How helpful even a limited understanding of, in this case, prey detection mechanisms could be for predictive models of habitat selection and foraging distributions became clear early on in our work on Red Knots Calidris canutus. The precise arrangement of pressure sensors in the bill tip and their wiring to and in the brain explained the considerable capacity of Red Knots to detect hard objects such as bivalves and snails in wet soft sediments (Piersma et al. 1998). However, these sensory insights then also helped us to understand the rather low giving-up densities of available prey at some sites (Piersma et al. 1993), the near-absence of soft-bodied prey such as polychaete worms in their diets (Piersma 1991), and the foraging distributions of Red Knots over intertidal mudflats at a variety of spatial and temporal scales (Piersma et al. 1995, van Gils et al. 2006b, Quaintenne et al. 2011). Thus, if a little understanding of even a single ‘design’ feature helped so much to make sense of this species’ ecology, imagine what an understanding of multiple design features would do (van Gils et al. 2006a).

This takes me back to a symposium that I once attended at Leiden University. I was there to tell the story of the specialized bill-tip organ of Red Knots and how this helped us understand their food and habitat choices. The audience consisted of functional morphologists in the tradition of Leiden’s van der Klaauw (1948) and see, for example, Gerritsen & Sevenster 1985, Zweers et al. 1995, van der Leeuw et al. 2003). Apart from the widespread whisperings during the conference dinner about functional morphology rapidly becoming a dying trade, the composition of the nationalities around the table struck me as odd. Whereas the behavioural, ecological and ornithological meetings that I was used to were usually dominated by scientists from English-speaking countries, none of those were there; the audience was German, Dutch, Austrian and French only. Here were the scientists who could tell one bone, one set of muscles or one sensory organ from another and know how to study their morphology and functionality, and there we were, apparently losing these remarkable, if somewhat inward-looking, specialists.

Still, as witnessed by a steady trickle of new bird-related publications (e.g. Guillemaïn et al. 2002, Cunningham et al. 2010a, 2010b, Demery et al. 2011), the trade that merges insights from morphology, sensory physiology and ecology is alive and well. In this issue of Ibis, Martin and Portugal (2011) describe the visual fields of four ecologically distinct but phylogenetically related wading birds from one family, two ibises and two spoonbills, and interpret their findings in the context of the foraging ecology of these threskiornithids. They were in for a surprise when finding that even such tactile foragers with long bills have fields of vision that enables them to look binocularly at freshly captured prey. Clearly, careful scrutiny of captured prey, during handling between the tips of their mandibles before ingestion, is important enough for these spoonbills and ibises to give up the possibility of complete celestial coverage by having highly placed eyes. The ingestion of Three-spined Sticklebacks Gasterosteus aculeatus in full self-defence must be something like eating barbed wire. It involves the disarmament of the spines by careful head-up positioning of the fish before swallowing, and I can see why spoonbills need to use binocular visual input to do this efficiently. That spoonbills and ibises are large bodied, and thus have less to fear from avian predators than have smaller tactile-feeders such as ducks, may explain why the large wading birds have given up complete celestial vision, whereas the ducks have not (Martin 1986b, 2007, Guillemaïn et al. 2002, Martin et al. 2007a).

Such trade-offs are paramount in the designs of all animals, and it is tribute to Graham Martin that he has built up such an extraordinary portfolio of comparative studies at the interface between morphology, sensory physiology and ecology (e.g. Martin 1994, 2009, 2011, Martin & Katzir 1995, Martin & Coetzee 2004, Martin...
Starting off with studies explaining aspects of the ecology of owls with reference to their capacity to see in the dark (Martin 1984, 1986a, 1990), he went on to examine a wide variety of birds using his self-constructed avian ophthalmoscope (Martin 2007). Time and again Martin and his associates have found that, beyond the grand design features of clades of birds, the details of the perceptual systems reflect the finer details of birds’ ecologies rather than shared ancestry. More often than not, studies of fields of vision hint at key ecological features that ecologists had failed to notice. For example, Eurasian Golden Plovers Pluvialis apricaria are known as night foragers (Gillings et al. 2005, Gillings & Sutherland 2007), and indeed they have very large eyes (and probably sharp ears as well, Lange 1968) to help them locate earthworms (Lumbricidae) close to and on the surface of arable fields and meadows. In fact, the eyes are so big that this has necessitated special supraorbital bones to better anchor the eyes in the eye-sockets (Martin & Piersma 2009). However, the presence of this extra bone, the eye-brow of plovers, then leads to a wide blind area above the head: the plovers cannot detect dangers coming from above and behind. This realization suddenly explained why European Golden Plovers are often so immensely cryptic in their behaviour. They are true masters of appearance even in daytime and even in open landscapes. They do this by sitting tight on the ground (this would make them hard to locate and unavailable for Peregrines Falco peregrinus which do not capture prey on the ground), or by circling in flocks high in the air on warm days with thermals (this tallies with behavioural observations on captive Great Knots (T. Piersma unpubl. data). I am quite convinced that neither Great Knots nor Surfbirds possess the remote prey detection system of Red Knots. However, they may not be as ‘blind’ to vibrations made by burrowing worms and shrimp as Red Knots are, a sensory modality that appears to be the specialization of Sanderling Calidris alba (Gerritsen & Meijboom 1986). Then there exists the fantastic morphological spoon-bill-like bill specialization of the critically endangered Spoon-billed Sandpiper Calidris/Eurynorhynchus pygmeus (Piersma 1986, Taldenkov & Gerasimov 2006), but by and large sandpiper bills are rather uniform in shape and size. I suggest that the evolutionary radiation of sandpipers to large extent is a radiation of the bill-tip organ. Comparative studies of that organ, in combination with other sensory modalities such as taste (Gerritsen et al. 1983) and vision, as explored by Martin and Portugal in this issue of Ibis, could generate considerable and unexpected insights into the ecology and distribution of this group of birds. In fact, I believe that future studies in avian biology that deal with daily activity rhythms, foraging distributions, habitat selection and indeed the niche will always profit from taking the perceptual characteristics of the focal species seriously into account.

REFERENCES


