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Differences in food assimilation between two coot species assessed with stable isotopes and particle size in faeces: Linking physiology and conservation

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Abstract

The red-knobbed coot *Fulica cristata* experienced a dramatic population decline in Spain, where the common coot *F. atra* does not face conservation problems. This is puzzling because both species have similar ecologies. It has been suggested that habitat alterations affected the quality of food plants, and this impacted differentially both coots. To verify this, we conducted experiments to determine the assimilation efficiency of both species in relation to food quality. Two types of diets differing in fibre content (commercial food and *Potamogeton pectinatus*) were offered to captive red-knobbed and common coots, during both spring and autumn. We examined variations in faecal particle size among coot species and diets, indicative of the facility with which food can be assimilated, and used the stable isotope technique to study differences between coot species in stable isotope fractionations from consumption to excretion. Faecal particle size was larger in red-knobbed than in common coots when fibre content was high, but was similar when it was low. Faecal particle sizes were larger in autumn, when fibre content was higher, than in spring. In general, $\delta^{15}N$ in faeces of red-knobbed coots was greater than in faeces of common coots. These results suggest that the digestive efficiency of the red-knobbed coot was lower than that of the common coot, and that the differences increased when the fibre content in food plants increased. Managers should try to make available to coots wetland habitat with high quality food, which may be facilitated by prolonging the hydroperiods.

Keywords: Faecal particle size; Food assimilation efficiency; Herbivorous birds; Mediterranean wetlands; Physiological constraints; Stable isotopes; Waterbirds

1. Introduction

Herbivorous diets may pose serious assimilation problems to consumers. Although plants have easily metabolizable components, such as proteins and non-structural carbohydrates (Karasov, 1990), they also have structural components that make difficult their digestion (Drobney, 1984; Buchsbaum et al., 1986; López-Calleja and Bozinovic, 1999; Cornelissen et al., 2004). One such component is fibre, which for herbivorous birds may represent a constraint on food assimilation efficiency (Durant, 2003). Fibre is mainly composed of cellulose, hemicellulose and lignin, and although birds may digest some cellulose and hemicellulose, they are not able to digest lignin (Durant, 2003). Because birds lack enzymes to digest fibre, they rely on symbiotic microbes. However, to facilitate digestion processes, birds have to break down their food items into smaller particles in the gizzard. This is because the smaller the particle sizes of the digesta, the easier its fermentation (Bjorndal et al., 1990), so that we should expect that bird species with a lower capacity in grinding their food into small particles should show lower assimilation efficiency.

It is important to know the efficiency with which food is assimilated because this determines the quantity of energy that animals obtain from their diets (Buchsbaum et al., 1986; Veloso and Bozinovic, 1993), as well as their fitness (Karasov, 1986). Therefore, a study on assimilation efficiencies may clarify in those cases in which closely related species relying on similar food types have different ecological performances. Such a case

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may be found in southern Spain with the red-knobbed *Fulica cristata* and common *F. atra* coots.

Red-knobbed and common coots are phylogenetically closely related (Livezey, 1998), ecologically similar rails, which are sympatric in a small portion of their ranges in the southwestern Palearctic (Cramp and Simmons, 1980). Given their similar ecologies, it is puzzling that in the sympatric range in Spain the red-knobbed coot, but not the common coot, faces serious conservation threats that led to the almost complete disappearance of the former species from this country in the 20th century, where it is critically endangered (Bernis, 1964; Amat and Raya, 2004). A recent comparative study on the breeding biology of both species in southern Spain showed a much lower breeding success for the red-knobbed than for the common coot, and also a negative relationship between the mean time that breeding adult red-knobbed coots spent foraging and the number of chicks raised per brood. This last relationship was not found for the common coot (Varo, 2007).

It has been suggested that, as a consequence of habitat alterations in wetlands, the quality of food available to red-knobbed coots would be nowadays lower than when the species was more widely distributed in Spain (Amat and Raya, 2004). Under this scenario, the aim of our study was to examine whether the nutritional quality of food plants could affect differentially the assimilation efficiency of red-knobbed coots in relation to that of common coots. For this, we conducted a study comparing the assimilation efficiencies of both coot species in relation to the nutritional quality of foods. The occurrence of stable isotopes of C and N in tissues of consumers and their food has been widely used to reconstruct diets of animals and to study their feeding ecology (e. g., Hobson and Clark, 1992; Ganes et al., 1998; Carmichael et al., 2004; Fry, 2006). Some studies have used stable isotopes in faeces to get information on diets (e. g., Sponheimer et al., 2003a; Codron et al., 2005, 2007; Hwang et al., 2007), and some of them found that stable isotopes in faeces may not represent adequately the composition of diets, mainly because undigested components may be over-represented (Sponheimer et al., 2003a,b; Codron et al., 2005). However, this over-representation of undigested components may be used to study the differences in food assimilation in closely related species fed with the same diets. Therefore, we compared stable isotopes composition in diets and faeces to assess food assimilation efficiencies in both coot species.

We predicted that the assimilation efficiency of the red-knobbed coot would be lower than that of the common coot mainly when the quality of food plants diminishes (i. e., due to a higher fibre content), a situation that in southern Spain usually takes place in late summer–early autumn when declining water levels in wetlands affect negatively the production of submerged aquatic macrophytes, which is typical in Mediterranean-type wetlands (Van Wijk, 1988; Santamaría and Hootsmans, 1998; Menéndez, 2002). The higher fibre content of food would limit the size into which particles may be broken down during digestive processes (Van Soest, 1996). Thus, the differences in assimilation efficiencies between species would be related to a lower ability of red-knobbed coots to grind their food into small particles in comparison with common coots. It is important to document whether this is actually occurring because knowing the precise mechanisms that affect population performance may be essential for the successful implementation of conservation measures.

2. Methods

2.1. Experimental protocol

We conducted experiments with common and red-knobbed coots in captivity to determine the assimilation efficiency of each species, both in spring and autumn. In a pilot experiment we placed ten individuals of each species in individual cages (1.0 × 0.5 × 0.5 m). All individuals were visually isolated from the others. In spite of both water and food being provided *ad libitum*, most individuals lost body mass during the first week of isolation because they seemed to be stressed (see also Fairall, 1981). We therefore decided to use four outdoor aviaries (2.5 × 2.5 × 2 m). We used 16 adult individuals of each species (eight per aviary), though the identity of these individuals was different in spring and autumn. We recorded body masses, and did not find differences between the start and the end of the experiment, neither in spring (for red-knobbed coots: 706.4 ± (SD) 65.7 g (n = 14) vs. 703.6 ± 63.0 g, respectively, Student's paired t-test, t = 1.07, P = 0.302; for common coots: 649.3 ± 57.4 (n = 15) g vs. 644.7 ± 51.4 g, respectively, paired t = 1.13, P = 0.278), nor in autumn (for red-knobbed coots: 690.0 ± 48.7 g (n = 12) vs. 682.3 ± 51.3 g, respectively, paired t = 1.87, P = 0.09; for common coots: 587.9 ± 47.1 g (n = 13) vs. 580.7 ± 49.2 g, respectively, paired t = 1.86, P = 0.09).

We used two diets: commercial bird food (Visán Industrias Zootécnicas, S. A., Madrid), and *Potamogeton pectinatus*. We used commercial food as a standard diet for seasonal comparisons, so that any seasonal difference in assimilation of natural foods could be attributed to variations in their quality, and not to seasonal variations in the physiology of coots. The submerged aquatic macrophyte was collected in wetlands of southwestern Spain, and is frequently consumed by both species (Cramp and Simmons, 1980; Fairall, 1981; Fernández-Palacios and Raya, 1991; Taylor and Van Perlo, 1998). The plants were collected in sites with monospecific stands. We collected all *P. pectinatus* samples in the Guadalquivir marshes. Nevertheless, due to a marked seasonality in the wetlands of SW Spain (Amat, 1984), it was not possible to collect the *P. pectinatus* samples in the same sites in spring and autumn, as the sites where the plants were collected in spring had dried out in autumn. The food plants were collected every season a day before we offered them to coots.

During six days prior to the start of the experiment, the coots were fed with commercial food to acclimate their digestive tracts (Ziswiler and Farner, 1972; Kehoe et al., 1988). After that, the birds were fed each type of diet during periods of two consecutive days, until the two diets were offered. Two days might not be long enough to know the real assimilation efficiency of the coots when they are being fed on a given food, but it may be long enough for comparative purposes (Caviedes-Vidal et al., 2000). The order with which each diet type was