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Abstract.—Nestling diets of the vulnerable Chinese Egret (*Egretta eulophotes*) were analyzed at two breeding colonies on islands off Fujian, Southern China, in 2007 and 2008. Fish and shrimps were the main prey, comprising 87.5% and 35.4% by frequency of occurrence in regurgitations, respectively. Prey in the 4-6 mm size class occurred most commonly (80.4% of regurgitations). Compared with nestling diets of the Little Egret (*Egretta garzetta*) from other island heronries, nestlings of the Chinese Egret depended on prey that only occurred in coastal wetlands, whereas nestlings of the Little Egret consumed prey found in all aquatic habitats, including freshwater marshes; however, both species preyed on fish and shrimps and took prey of a similar size. The results suggest that coastal wetlands near the heronries need to be considered in habitat conservation for Chinese Egret. *Received 19 July 2010, accepted 14 October 2010.*

Key words.—ardeidae, Chinese Egret, *Egretta eulophotes*, food habit, threatened species.

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The Chinese Egret (*Egretta eulophotes*) is classified as 'vulnerable' with an estimated global population of 2,600-3,400 (IUCN 2010). Currently, the species has a patchy distribution and breeds colonially on offshore islands in Russia, North Korea, South Korea and China (BirdLife International 2010). Although some studies have focused on the breeding behavior and genetics of the Chinese Egret (Wei *et al.* 2005; Zhou *et al.* 2010) the diet of the species has, hitherto, not been studied in depth.

The natural diet of a species provides a foundation for understanding its ecology and physiology. For threatened species, such understanding is essential for habitat management and wildlife conservation, as food supply and quality affect breeding success and the size of bird colonies (Gwiazda and Amirowicz 2006; Enriquez *et al.* 2010). While the diets of many ardeid birds are well documented (e.g. Papakostas *et al.* 2005; Hall and Kress 2008), further studies are required on the feeding ecology of other species, especially those that are either threatened or depend on particular areas where marked fluctuations in food supplies are likely (Herrera *et al.* 2005; Taylor and Schultz 2008). In this study, we aim to: 1) provide a quantitative assessment of the nestling diet for Chinese Egret; 2) identify the range of sizes of prey taken by the nestlings, and 3) describe nestling dietary differences between the Chinese Egret and the more widespread Little Egret (*Egretta garzetta*) on offshore islands.

METHODS

Nestling regurgitations from Chinese and Little Egrets were collected from heron colonies on uninhabited offshore islands along the coast of Fujian Province, southern China. Regurgitations of the Chinese Egret were from Riyu Island (27°01'N, 120°25'E) and the Caiyu Archipelago (23°46' N, 117°39'E) and regurgitations of the Little Egret were from Jiyu Island (24°25'N, 118°00'E) (Fig. 1). Riyu, Caiyu and Jiyu are 7,000, 8,000 and 1,200 m from the mainland, respectively. The adjacent mainland areas contain artificial wetland habitats, including seawater ponds for shrimp and fish culture, paddy fields, sloughs and ditches. Food Samples

The diets of both egret species were assessed by analyzing regurgitations as they reflect dietary composition and

Figure 1. Location of Caiyu, Jiyu and Riyu islands.

provide large-sized samples with a minimum of disturbance to the breeding birds (Herrera *et al.* 2005; Gwiazda and Amirowicz 2006; Hall and Kress 2008). During the 2007-2008 breeding seasons (May to July), visits to the colony were restricted to a maximum of two hours per day and nest checks were conducted during the morning. Nests were marked by hanging a piece of plastic record cardboard (3 × 2cm^2) on the nesting tree when the nests were found and subsequent visits to marked nests were made on a weekly basis (five-seven day intervals). Nestling age was divided into four classes: first week of age: one to seven days old; second week: eight-14 days old; third week: 15-21 days old; and fourth week: 22-28 days old. Newly-hatched nestlings found in marked nests were recorded as first week of age and banded for subsequent monitoring of nestling age. Spontaneously regurgitated prey were collected from hand-captured nestlings when the banded nestlings were less than 28 days old. Also, regurgitated prey were collected opportunistically from the ground under the egret nests during each visit to extend the samples and better understand the whole diet of the species; although these regurgitations were not used in subsequent quantitative analyses.

Analysis of Food Samples

In the field, prey items in regurgitations were identified by their external morphological characteristics with the aid of published guides (Liu 1988; Men *et al.* 1995) and, when possible, counted and their length measured to the nearest millimeter. Regurgitated prey were immediately placed back in the nest bottom after examination so that they could be re-consumed by either the nestlings or parents. Some prey items that proved difficult to identify or measure were preserved individually in plastic bottles with 70% ethanol for analysis in the laboratory using museum reference specimens (Hampl *et al.* 2005; Gwiazda and Amirowicz 2006; Hall *et al.* 2008). In the laboratory, prey were identified to the lowest possible taxonomic level using morphological characteristics, such as crustacean shell fragments and fish otoliths and bones. Most prey were identified to family but some were classified to species. The importance of each prey type in the diet was estimated by its frequency of occurrence (%O) and percentage contribution (%N) (Antczak *et al.* 2002; Herrera *et al.* 2005). The frequency of occurrence of a given prey item was calculated as the number of regurgitations containing that prey as a percentage of the total number of regurgitations in the sample. Percentage contribution of a given prey item was calculated by expressing the number of a given prey category as a percentage of the total number of all prey. The sizes of prey were estimated by comparison of undigested or partly-digested prey with whole reference specimens, and placed into four size classes on the basis of length: class 1: 1-3 mm; class 2: 4-6 mm; class 3: 7-9 mm; class 4: >10 mm.

The method of Hurtubia (1973) was used to determine whether there were sufficient regurgitation samples to reliably describe dietary diversity (Fisher and Dickman 1993). Statistical tests were performed using SIGMASTAT for Windows, version 3.11 (Jandel Scientific). Means are presented ±1 SE. The Pearson chi-square test was used to compare the overall percentage frequencies. One-way ANOVA was used to detect any differences in the mean numbers. Following ANOVAs, the Student-Newman-Keuls (SNK) test was used for pairwise multiple comparisons. Significance was accepted at the 0.05 probability level.

RESULTS AND DISCUSSION

Prey Types

A total of 19 and 29 nestling regurgitation samples of the Chinese Egret were collected from the Riyu and Caiyu heron colonies, respectively. The cumulative number of prey taxa (Families) reached an asymptote after seven regurgitations selected in a random order (Fig. 2), suggesting that total sample sizes were sufficient for dietary diversity analyses (Hurtubia 1973; Fisher and Dickman 1993). The overall occurrence frequencies of prey types in Chinese Egret regurgitations at the Riyu and Jiyu colonies were not significantly different (χ^2 = 1.933, df = 1, P = 0.164) (Table 1). Also, the mean number of prey individuals per regurgitation at Riyu (mean = 4.22 ± 0.10, n = 304) and Caiyu (mean = 4.61 ± 0.11, n = 269) were not significantly different ($F_{(0.05, 1)}$ = 3.59, P = 0.058); so data from the two colonies were combined for further analyses. Individual Chinese Egret regurgitations contained from one to 45 prey items (mean = 11.9 ± 2.43; n = 573), and between one and four different types of prey (mean = 1.4 ± 0.08; n = 48).

Fish were the dominant prey type in the diet of the Chinese Egret, followed by crustaceans. Fish and shrimps occurred in 87.5% and 35.4% of regurgitations, respectively (Table 1). Penaeid shrimps constituted

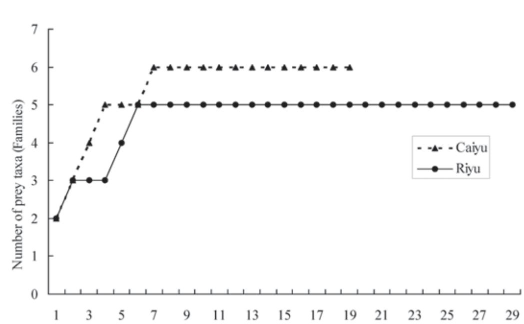

Figure 2. Cumulative number of prey taxa in regurgitations of Chinese Egret plotted against number of regurgitations analyzed (the total number of regurgitation sample *NR* = 9, *NC* = 39 and the total number of prey items *nr* = 269, *nc* = 304 collected from Caiyu and Riyu colonies, respectively).

Table 1. Prey taxa in the regurgitation of the Chinese Egret (the total number of regurgitation sample NR = 9, NC = 39 and the total number of prey items nr = 269, nc = 304 collected from Caiyu and Riyu colonies respectively).

Prey taxa	Occurrence frequency (%O)			Percentage contribution (%N)		
	Caiyu	Riyu	Mean	Caiyu	Riyu	Mean
Crustacea	21.1	44.8	35.4	14.1	8.5	11.2
Pisces	94.7	82.8	87.5	85.9	91.5	88.8

11.2% by percentage contribution and the fish (88.8% percentage contribution) included Clupeidae, Gobiidae, Trichiuridae, Leiognathidae and Mugilidae. Prey collected from under the nests of the Chinese Egret included palaemonid shrimps, ocypodid crabs and engraulid fish, which further extended the dietary repertoire.

Size of Prey

The Chinese Egret ate significantly more individuals of prey in the 4-6 mm size class than the 1-3 mm, 7-9 mm and >10 mm size classes ($F_{(0.05,\ 3)}$ = 69.14, P = < 0.001) (Table 2). Gobiidae and Clupeidae fish were the two major prey types in the 4-6 mm prey size class, accounting for 25% and 23% of the total, respectively. The percentage occurrence frequency of different-sized prey in the sampled regurgitations was 34.8% for the smallest class, 80.4% in the 4-6 mm size class, 37.0% in the 7-9 mm size class, and 2.2% in the >10 mm size class (Fig. 3), indicating that prey in the 4-6 mm size class were taken more consistently by the Chinese Egret than prey in any other size classes (χ^2 = 142.34, df = 9, P < 0.001). The mean number of different-sized prey items in each regurgitation among the different age groups of Chinese Egrets was not significantly different ($F_{(0.05,\ 3)}$ = 7.14, P = 0.07) (Table 2).

Interspecific Comparison of Diet

Although fish and shrimps were the main food for both Chinese and Little Egret nestlings, the percentage occurrence frequency of prey types between the Chinese Egret and the Little Egret was significantly different (χ^2 = 87.00, df = 11, P < 0.001) (Table 3). The only shared important prey for the nestlings of both egret species were mugilid fish. Freshwater prey were not found in the regurgitations of Chinese Egret, while freshwater fish of the Families Cichlidae and Cyprinidae occurred in 21.7% and 6.5%, respectively, in regurgitations of Little Egret. Chinese Egret took clupeid, trichiurid and leiognathid marine fish which Little Egret did not consume, whereas Little Egret consumed hippolytid marine shrimps which Chinese Egret did not take.

The most numerous prey of both the Chinese Egret and the Little Egret were in the 4-6 mm size class (Fig. 4); with up to 80.0% and 55.9%, respectively. Prey in the >10 mm size class were taken less frequently than any other size classes by these two ardeid species. The Little Egret took more individual prey

Table 2. Mean number of different-sized prey items in each regurgitation of the Chinese Egret (the total number of regurgitations N = 48 and the total number of prey items n = 573)*.

Age (week)	1-3 cm	4-6 cm	7-9 cm	>10 cm	Total
1st	0.5 ± 0.5	12 ± 10.3	0	0	12.5 ± 10.8 a
2nd	1.8 ± 0.9	6.9 ± 2.2	0.4 ± 0.2	0	9.1 ± 2.7 a
3rd	0.4 ± 0.1	6.9 ± 2.0	1.1 ± 0.8	0	8.4 ± 1.9 a
4th	12.3 ± 7.4	5.8 ± 2.8	2.3 ± 1.1	0.08 ± 0.1	20.6 ± 7. 8 a
Mean	3.9 ± 2.0 A	7.1 ± 1.4 B	1.1 ± 0.4 A	0.0 ± 0.0 C	11.9 ± 2.4

*Values with different letters (a, b) in rows among different ages, and values with different letters (A, B) in columns for means, represent significant differences (P < 0.05).

Table 3. Comparison of percentage occurrence frequency of prey types between the Chinese Egret (the total number of regurgitations $N = 48$) and the Little Egret ($N = 46$).

Prey taxa	Chinese Egret (%)	Little Egret (%)
Crustacea		
Hippolytidae		2.2
Lysmata sp.		
Palaemonidae		6.5
Exopalaemon carincauda		
Palaemon sp.		2.2
Penaeidae	16.7	23.9
Fenneropenaeus chinensis	10.4	13.0
Fenneropenaeus penicillatus		10.9
Metapenaeopsis afinis		4.4
Metapenaeus barbata	6.3	4.4
Parapenaeus tenella	4.2	2.2
Penaeus spp.		8.7
Penaeus vannamei		15.2
Trachypenaeus curvirostris	2.1	10.9
Pisces		
Periophthalmidae		2.2
Periophthalmus cantonensis		
Clupeidae	20.8	
Illisha elongate	18.8	
Konosirus punctatus	10.4	
Sardinella zunasil	2.1	
Sardinella spp.	8.3	
Dussumieria hasselti	2.1	
Gobiidae	10.4	10.9
Acentrogobius caninus	8.3	6.5
Ctenogobius brevirostris	8.3	8.7
Parachaeturichthys polynema		2.2
Trypauchen vagina	4.2	4.4
Trichiuridae	14.6	
Trichiurus haumela		
Leiognathidae	6.3	
Leiognathus brevirostris	6.3	
Leiognathus ruconius	4.2	
Mugilidae	47.9	30.4
Liza carinatus	25.0	17.4
Liza haematocheila	14.6	13.0
Liza macrolepis	4.2	4.4
Mugil cephalus	12.5	21.7
Osteomugil ophuyseni	2.1	2.2
Osteomugil strongylocephalus		2.2
Cichlidae		21.7
Tilapia spp.		
Cyprinidae		6.5
Carassius auratus		6.5
Pseudorasbora parva		4.4
Unidentified	10.4	8.7

in the 1-3 mm size class than the Chinese Egret ($\chi^2 = 20.84$, df = 3, $P < 0.001$).

Nestlings of the Chinese Egret consumed fish and shrimps from coastal and estuarine

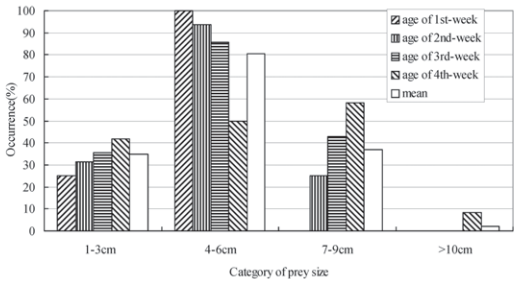

Figure 3. Percentage occurrence frequency of different-sized prey in the regurgitation of the Chinese Egret (the total number of regurgitations $N = 48$).

wetlands, whereas the Little Egret took prey from all aquatic habitats including freshwater marshes (Liu 1988; Men *et al.* 1995). These dietary differences may have been caused by, variously, variations in food availability (Enriquez *et al.* 2010), independent selection of resources or interspecific competition (Fasola 1994). As wetlands are the important foraging habitat for egrets, preservation of wetlands suitable for egrets is essential for egret conservation. Nowadays, loss and degradation of natural wetlands have reduced the food supply and pose a threat to the Chinese Egret (BirdLife International 2010). Nestlings of the Chinese Egret on the offshore islands depend on food from coastal and estuarine wetlands, indicating that coastal wetlands around the island heronries are the most important foraging habitat for the egret and conservation efforts should focus on the preservation of these coastal wetlands.

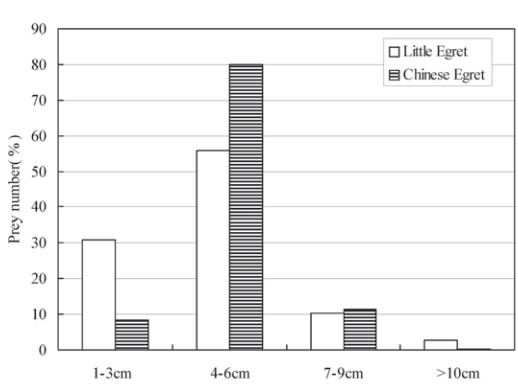

Figure 4. Comparison of percentage contribution of different-sized prey in regurgitations between the Chinese Egret (the total number of prey items $n = 573$) and the Little Egret ($n = 406$)

The Chinese Egret consistently took more prey in the 4-6 mm size class than those in any other size classes, and the frequency suggests that prey in that size class are preferred. Werner *et al.* (2001) found that adult Great Egrets (*Ardea alba*) consumed significantly smaller (7.5-10 cm) fingerlings than medium (15-18 cm) or large (23-25 cm) catfish. Moreover, the older nestling of the Chinese Egret consumed not only more individual prey items on average, but also more prey in the large size classes (7-9 mm and >10 mm). Similarly, Hampl *et al.* (2005) found that adult Black Storks (*Ciconia nigra*) provisioned their nestlings with smaller fish and the length of consumed prey increased significantly with nestling age. Many studies have shown a positive relationship between the body size of predators and the mean size of their prey (Bayer 1985; Fisher and Dickman 1993), as predators are morphologically constrained in the sizes of prey that they can handle and prey-size selection could maximize their rate of energy intake (Werner *et al.* 2001; Chen *et al.* 2004; Gwiazda and Amirowicz 2006).

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LITERATURE CITED

Antczak, M., S. Konwerski, S. Grobelny and P. Tryjanowski. 2002. The food composition of immature and non-breeding White Storks in Poland. Waterbirds 25: 424-428.

Bayer R. D. 1985. Bill length of herons and egrets as an estimator of prey size. Colonial Waterbirds 8: 104-109.

BirdLife International. 2010. Species factsheet: *Egretta eulophotes*. http://www.birdlife.org, accessed 2 June 2010.

Chen, X., C. R. Dickman and M. B. Thompson. 2004. Selective consumption by predators of different body regions of prey: Is rate of energy intake important? Journal of Zoology (London) 264: 189-196.

Enriquez, P. L., K. M. Cheng and J. E. Elliott. 2010. The 'near threatened' Bearded Screech-owl *Megascops barbarus*: Diet pattern and trophic assessment using δ13C and δ15N stable-isotopes. Bird Conservation International 20: 25-33.

Fasola, M. 1994. Opportunistic use of foraging resources by heron communities in southern Europe. Ecography 17: 113-123.

Fisher, D. O. and C. R. Dickman. 1993. Diets of insectivorous marsupials in arid Australia: Selection for prey type, size or hardness? Journal of Arid Environment 25: 397-410.

Gwiazda, R. and A. Amirowicz. 2006. Selective foraging of Grey Heron (*Ardea cinerea*) in relation to density and composition of the littoral fish community in a submontane dam reservoir. Waterbirds 29: 226-232.

Hall, C. S. and S. W. Kress. 2008. Diet of nestling Black-crowned Night-herons in a mixed species colony: Implications for tern conservation. Wilson Journal of Ornithology 120: 637-640.

Hampl, R., S. Bures, P. Balaz, M. Bobek and F. Pojer. 2005. Food provisioning and nestling diet of the Black Stork in the Czech Republic. Waterbirds 28: 35-40.

Herrera, G., G. Punta and P. Yorio. 2005. Diet specialization of Olrog's Gull *Larus atlanticus* during the breeding season at Golfo San Jorge, Argentina. Bird Conservation International 15: 89-97.

Hurtubia, J. 1973. Trophic diversity measurement in sympatric predatory species. Ecology 54: 885-890.

IUCN. 2010. 2010 IUCN Red List of Threatened Species. http://www.iucnredlist.org, accessed 2 June 2010.

Liu, R. 1988. Prawn in South China Sea. China Agriculture Press, Beijing, China.

Men, Q., J. Su and X. Miao. 1995. Fish Taxonomy. China Agriculture Press, Beijing, China.

Papakostas, G., S. Kazantzidis, V. Goutner and I. Charalambidou. 2005. Factors affecting the foraging behavior of the Squacco Heron. Waterbirds 28: 28-34.

Taylor, I. R. and M. C. Schultz. 2008. Breeding season diets of egrets in southeast Australia: implications for future population viability. Waterbirds 31: 593-601.

Wei, G. A., Z. H. Yin and F. M. Lei. 2005. Copulations and mate guarding of the Chinese Egret. Waterbirds 28: 527-530.

Werner, S. J., M. E. Tobin and P. B. Fioranelli. 2001. Great Egret preference for catfish size classes. Waterbirds 24: 381–385.

Zhou, X., W. Fang and X. Chen. 2010. Mitochondrial DNA diversity of the vulnerable Chinese Egret (*Egretta eulophotes*) from China. Journal of Ornithology 151: 409-414.