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ORIGINAL ARTICLE

Nest-site selection by Purple Swamphen in Haifeng, China

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Abstract The Purple Swamphen (*Porphyrio porphyrio*) is a rare species with an extremely small range in China. From March to June in 2005 and 2006, we investigated the nest-site selection of the Purple Swamphen in the Guangdong Haifeng Avian Natural Reserve, China. Nests were bowl-shaped or shallow cups with most of them constructed in hydrophyte clusters of *Scirpus tabernaemontani*. Distance to road and distance to water edge were significantly different between nest sites and non-nest sites and were important for determining nesting sites based on stepwise discriminant analysis. Our results suggest restoring and protecting the extant nesting areas is essential for effective conservation of the Purple Swamphen in China.

Keywords Haifeng wetland, nest-site selection, *Porphyrio porphyrio*, conservation

Introduction

Nest-site selection, i.e., where to make a nest, is an important behavioral reproductive decision for birds (Cody, 1985; Traylor et al., 2004). Environmental factors, such as suitable territories (Hunter, 1987), appropriate habitat structure (Murkin et al., 1997), resources for breeding (Nudds and Ankney, 1982) and protection against predators (Craig, 1980; Martin, 1993), are involved in determining nest-site selection (Cody, 1985; Good, 2002). Of these factors, nest predation is considered the primary source of nest mortality (reproductive loss) and a strong selective pressure (Schieck and Hannon, 1993). The selection of suitable nest sites is critical for the success of a species since it affects the risk of nest-predation (Martin, 1993; Badyaev, 1995; Lee et al., 2006). The concealment of nest is subsequently considered to be important for nest success (Martin, 1995; Clark and Shutler, 1999).

The Purple Swamphen (*Porphyrio porphyrio*) is a tropical and sub-tropical species with a large range and is found in the Mediterranean region, Africa, Asia and in a large number of islands of the Australian sub-continent (del Hoyo et al., 1996). It builds nests in shallow water, concealed in thick emergent vegetation, or on platforms of beaten-down vegetation (del Hoyo et al., 1996; Hu et al., 2006). Although some quantitative analyses on breeding habitat and nest-site of the Purple Swamphen were carried out (Helm et al., 1987; Sánchez-Lafuente et al., 1998), little information is available in China (Hu et al., 2006; Wang et al., 2006). Given the small and fragmented local populations (Gao and Jiang, 1999; Hu et al., 2007, 2008) and the need for guiding the protection of "preferred" habitats and vegetation and conducting a basis of conservation measures, it is necessary to study the breeding habitat and understand the nest-site selection of the Purple Swamphen. Therefore, we studied habitat characteristics

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of nest/non-nest sites of this species. Specifically, we took into account the following questions: what are the differences between nest and non-nest sites? What factors are critical for nest-site selection of the Purple Swamphen?

Methods

Study area and subject

Our study was conducted in the Guangdong Haifeng Avian Natural Reserve (22°3′N, 115°23′E), 11590 ha in size and located in Haifeng County, Guangdong Province, China. The reserve is an Important Birds Area (IBA; BirdLife International, 2008a) and is listed as a wetland of "International Importance" by the Ramsar Convention (2010). It is a typical representative of south China's subtropical offshore and coastal wetlands and also an important part of the South China Sea ecosystem (Ramsar Convention, 2010). The area has a humid and sub-tropical maritime climate with distinct seasonal variation. The mean annual temperature is 21.9°C, the annual rainfall 2383 mm, the area has sunlight for 2032 h and the relative humidity is 80%. The reserve is composed of three distinct sections: the Gongping, Dongguan Lian'anwei and Dahu districts. This study was conducted at the core region of the Dongguan Lian'anwei district, approximately 4500 ha in size. Wetlands, including inter-tidal mudflats, shallow water areas, mangroves, man-made shrimp ponds and paddy fields, cover more than 70% of this district. However, large-scale, recent land reclamations have destroyed much of the natural vegetation with only scattered groups of mangrove species and reeds.

The Purple Swamphen is classified as globally "non-threatened" (Least Concern; BirdLife International, 2008b). However, it is indeed a rare species with few field records and an extremely small range in China (Wang et al., 2006). Although specimens/individuals have been successively reported by Swinhoe and Mell in Guangzhou and Xiamen, Cheng (1987) doubted that these individuals might be cage birds. The single individual, registered in Hong Kong in 1988, 1990, 1991, 1993 and 1994, was considered the same bird, a straggler or an escaper (Chalmers et al., 1990; Leven et al., 1994; Carey et al., 1995; Viney et al., 2005). As well, there was no reliable record of the Purple Swamphen in Guangdong Province over one century until the discovery by Gao and Jiang (1999) and Hu et al. (2006). Despite an estimate of local populations, the status of the Purple Swamphen in China is unknown (Wang et al., 2006; Hu et al., 2007). Because of its confined distribution range, cryptic status and deficient common concern, this species is not listed as a national protected wildlife species in China, although it is provincially protected in Guangdong Province (Hu et al., 2006).

Data collection and analysis

We conducted our field work from March to June in 2005 and 2006. We surveyed the distribution of the Purple Swamphen systematically according to the records of individuals and/or traces in 2005 (e.g. Hu et al., 2006, 2007) and then searched for nests within the areas where records were registered in 2006. We recorded the location of each nest with a Global Positioning System (GPS) and marked the nests with natural "flags" about 10 m away from each nest for further investigation.

Due to the small population with 40 individual records during the breeding season (Hu et al., 2007), only 15 nest sites and 15 control sites were surveyed in 2006. Control places were non-nest sites with vegetation (some areas are water bodies without vegetation), picked at random (within 100 m away from the relevant nest site) when each nest site (centered on the nest) was ascertained. For each nest, we used a rectilinear scale to measure the following variables: outer diameter, inner diameter, nest height (from the top edge of the nest to its outer bottom), nest depth (from the top edge of the nest to its inner bottom), height between nest bottom and water surface. Additionally, we documented habitat and vegetation variables in a 1.0 m × 1.0 m quadrat at each nest site and non-nest site. We estimated nine variables for each sample plot: water level, distance to road, distance to the nearest side road, distance to the nearest settlement, distance to vegetation edge, distance to the nearest water edge, herbage density, herbage height and herbage cover.

We analyzed our survey data using SPSS 13.0 (SPSS, Chicago, USA). We used Kolmogorov-Smirnov tests to check normality of data. Non-parametric analyses were used to compare the differences between data sets that could not be normalized. We performed a Mann-Whitney U test and a stepwise discriminant analysis (DA) to identify the differences between nest sites and the random sample plots. Data were presented as mean ± SD and $p \leq 0.05$ was considered statistically significant.

Results

All nests were built above water with a distance of 17.73 ± 2.86 cm between the nest bottom and water. Nests were bowl-shaped or shallow cups, with 11 of them on the hydrophyte cluster of the soft stem bulrush (*Scirpus tabernaemontani*; Fig. 1a, b) and four on common reeds (*Phragmites communis*). The outer diameter of nests was 38.57 ± 3.05 cm, the inner diameter 18.57 ± 0.92 cm, the height of nests 18.17 ± 1.99 cm and the depth 4.49 ± 0.49 cm.

Distance to road for nest sites (75.67 ± 7.42 m) was significantly larger than that for non-nest sites (48.67 ± 7.63 m; $Z = 6.43$, $p < 0.05$). Again, dis-

Fig. 1 The study area. (**a**) Softstem bulrush habitats in the wetlands of Dongguan Lian'anwei district in Guangdong Haifeng Avian Natural Reserve, China; (**b**) Nest and eggs of Purple Swamphen (*Porphyrio porphyrio*). Photos by Junhua Hu.

tances to water edge for nest sites (12.33 ± 1.67 m) were significantly larger than those for non-nest sites (2.32 ± 0.99 m; $Z = 26.61$, $p < 0.01$), while there were no significant differences for the other seven variables (Table 1). Concurrently, based on the results of the stepwise DA, distance to water edge and distance to road were found to be the main variables for distinguishing nest sites and non-nest sites. The result of Fisher's linear discriminant function revealed that the accuracy of these two variables was near 88%.

Discussion

Nest concealment, or visibility, is a common adaptation for reducing the risk of nest predation (Gotmark et al., 1995). Tall, dense vegetation may confer protection by creating visual barriers, as does increasing the number of available nesting sites and hindering the movement of avian (Jones and Hungerford, 1972; Dijak et al., 1990) and mammalian predators (Martin, 1993). Many species appear to select nest sites providing better concealment than nearby (randomly selected) sites (Collias and Collias, 1984; Gotmark et al., 1995). However, herbage coverage, herbage density and herbage height, which represent aspects of nest concealment, were not significantly different between nest and non-nest sites in this study. These three habitat characteristics may not determine the suitability of a particular location for Purple Swamphen nests, even when well concealed (Fig. 1a, b).

Nest success could increase with distance from habitat edge (Filliater et al., 1994) and water (Crabtree et al., 1989), since predators actively search for prey near such edges (Gates and Gysel, 1978; Traylor et al., 2004). Both distance to water edge and distance to road in this area reflect human disturbance to habitat and are important for determining nest-site selection by the Purple Swamphen. Although nesting adults would be expected to select nest-sites that would maximize their fitness, this was not always the case in human-altered environments (Lusk et al., 2006). It also suggests that human disturbance could decouple habitat suitability (Misenhelter and Rotenberry, 2000; Remeš, 2003). In our study, the Purple Swamphen was under pressure of a prosperous aquaculture industry. Wide ranges of wetland are divided into man-made shrimp ponds for aquaculture. Human activities may have an important impact on nest-site selection of the Purple Swamphen. This may explain the difference between our results and those of Sánchez-Lafuente et al. (1998), which showed nest sites closer to open areas, less concealed and more accessible than non-nest sites. Consequently, the question: "how do Purple Swamphen respond to human disturbances?" deserves further research.

Water levels may also lead to nesting failure via the effect of predation, mainly from small mammals (Craig, 1980; Hoover, 2006). Sánchez-Lafuente et al. (1998) indicate that if small mammalian predators follow some olfactory cues, the water could obscure these chemical signals and, at relatively high water levels, a soft, muddy ground may discourage them. However, water levels of nest sites in this study were lower than those of non-nest sites. Some more indi-

Table 1 Variables characterizing nest sites and non-nest sites of Purple Swamphen (*Porphyrio porphyrio*) in Guangdong Haifeng Avian Natural Reserve, China

Variables	Nest site ($n = 15$)		Non-nest site ($n = 15$)		Mann-Whitney U-test Z	p
	Mean	SD	Mean	SD		
Water level (cm)	29.30	7.44	40.20	8.05	0.982	0.330
Distance to road (m)	75.67	7.42	48.67	7.63	6.433	0.017*
Distance to side road (m)	30.53	5.01	36.00	5.68	0.521	0.476
Distance to settlement (m)	88.87	23.60	88.47	13.61	0.000	0.990
Distance to vegetation edge (m)	4.53	3.18	3.93	2.34	–0.652	0.515
Distance to water edge (m)	12.33	1.67	2.32	0.99	26.610	0.000**
Herbage density (ind·m^{-2})	682.00	44.10	492.27	82.34	4.130	0.050
Herbage height (cm)	127.20	7.32	117.00	8.66	0.810	0.380
Herbage coverage (%)	75.87	4.57	71.40	5.72	0.370	0.550

* $p < 0.05$; ** $p < 0.01$.

rect variables related to nest-site predation (e.g. the level of human influence) should be considered in the future.

Like many rare bird species, the sustainability of the Purple Swamphen in China depends on the conservation of wetlands and maintenance of suitable nesting and foraging habitat and the assurance of food availability. Given existing threats and limiting factors, we suggest that researchers should cooperate with the local reserve and villagers and pay more attention to suitable habitats of the Purple Swamphen.

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广东海丰紫水鸡的巢址选择

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摘要：紫水鸡（*Porphyrio porphyrio*）在中国是分布范围极小的稀有物种。我们于2005年和2006年3–6月在广东海丰鸟类自然保护区对紫水鸡的巢址选择进行了研究。巢多建于水葱（*Scirpus tabernaemontani*）丛中，呈碗状或盘状。距道路距离和距所处水面边缘距离在巢址与非巢址样方间存在显著差异；基于逐步判别分析，这两个变量也是决定营巢位置的重要因子。我们建议，恢复并保护好现存营巢生境对有效保护中国境内的紫水鸡至关重要。

关键词：海丰湿地，巢址选择，紫水鸡（*Porphyrio porphyrio*），保护