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Seasonal Dynamics and Habitat Selection of Ruddy Shelduck (*Tadorna ferruginea*) (Anseriformes: Anatidae) in Alpine Wetland Ecosystem of Southwest China

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Abstract: For a variety of reasons, the global abundance of Ruddy Shelduck (*Tadorna ferruginea*) has declined dramatically in recent decades. Information on its overwintering ecology, particularly regarding the habitat selection in its overwintering area, is scant. In order to gain a better understanding of the Ruddy Shelduck overwintering ecology, two alpine freshwater lakes and adjacent habitats were surveyed in the Yungui Plateau of Southwest China; the habitats were classified as croplands, vegetable plots, marshlands, aquatic habitats and forests. The abundance of the Ruddy Shelduck in the marshland was significantly higher in winter than in spring (P = 0.039), while the opposite was true in the forest (P = 0.024). No significant seasonal differences were detected in the croplands, vegetable plots and aquatic habitats, respectively (P = 0.302-0.817). The Ruddy Shelduck numbers differed significantly among the five habitat types both in winter (P = 0.000) and in spring (P = 0.005). The aquatic habitats and the vegetable plots showed not only the largest abundances of this species but also the lowest coefficients of variation. The abundance of the Ruddy Shelduck did not vary among different months (χ^2_3 = 1.984, P = 0.576); the observed daily mean numbers, however, revealed a slight decline from December to March. When we explored the relationships between the numbers of the Ruddy Shelduck and the vegetable coverage in the vegetable plots, a multiple regression model (stepwise) indicated that the Ruddy Shelduck abundance was significantly and positively correlated with the radish (*Raphanus sativus* L.) coverage (R^2= 0.619, P =0.000) in winter, and significantly and positively correlated with both the cabbage (*Brassica pekinensis* (Lour.) Rupr.) coverage and the radish coverage (R^2 = 0.555, P =0.002) in spring. The aquatic habitats and the vegetable plots were preferred habitats and the radish was the favorite diet to the Ruddy Shelduck in its overwintering area in Southwest China. Various factors, such as agricultural activities, pollution, boat fishing, human population expansion and urbanization, are all likely to threaten birds and their habitats in Southwest China.

Key words: abundance, Alpine wetland ecosystem, diet selection, overwintering area, Southwest China, *Tadorna ferruginea*

Introduction

The Ruddy Shelduck (*Tadorna ferruginea*) is widely distributed in Southeast Europe and central Asia (Mackinnon *et al.* 2000), overwintering mainly in the Indo-China Peninsula, India, Japan, the Korean Peninsula, Northern Africa (Heize *et al.* 1984), and from the central to south China (Mackinnon *et al.* 2000). The Western Palearctic populations are sedentary or dispersive, while those in Asia are predom-

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inantly migratory, moving latitudinally on a broad front (Birdlife 2010). In China, the species breeds in the northeast, northwest and on the Tibetan Plateau, and winters south of the Yangtze River (HU *et al.* 2000, Mackinnon *et al.* 2000). In our study area, the Ruddy Shelduck is the dominant species during the overwintering period (LUO *et al.* 2012). It is a non-breeding species on the Yungui Plateau and arrives at our study area in late October for overwintering. The species begins to fly away from the Yungui Plateau to its breeding territory in late February, and generally the migration continues for nearly a month. The Ruddy Shelduck is adapted to cold climate and is active mainly in inland wetlands during the non-breeding season; it is infrequently observed along the seashore (Mackinnon *et al.* 2000, Namgail, Yom-Tov 2009).

The Ruddy Shelduck used to be consistently abundant in its overwintering area; e.g., it was commonly-seen in the lower reaches of Yangtze River decades ago (Yu, Man 1994). In 1990, there were approximately 30 thousand individuals in the world, 2834 of which overwintered in China (as recorded by the International Waterfowl and Wetlands Research Bureau (IWRB) in midwinter, BBC 2012). The largest non-breeding aggregation, of about 6000 individuals, was recorded at Chilika Lake in India (Balachandran *et al.* 2005). The Ruddy Shelducks have always symbolized conjugal love and fidelity in India; their nests were found close to residential houses under the socio-religious protection in some Buddhist parts of Asia. However, this socio-cultural protection is diminishing due to cultural erosion (Namgail *et al.* 2011). Globally, the habitat destruction and direct killing (in particular shooting) have resulted in a drastic decrease in their numbers (Yu, Man 1994). Since the Ruddy Shelduck is considered beautiful, and can be used for food and feather insulation, the species has become a widely hunted economic bird (Yu, Man 1994, Meng 2008).

The Ruddy Shelduck is listed under the category "Least Concern" in the IUCN Red List of Threatened animals (Iucn 2008). However, its population is declining, especially in the western Palearctic (Delany *et al.* 2008, Birdlife 2010). Some ecologists and some countries have paid more attention to this species. At present, this species is listed in the Agreement between the Government of Japan and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment (Zhang *et al.* 2011), and included in the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (Namgail *et al.* 2011).

Multi-aspect studies on the Ruddy Shelduck, such as phylogenetic evolution (Mccracken *et al.* 2009), physiological index (Anatskaya *et al.* 2001), intraspecific nest parasitism (Yoram 2001), breeding ecology (Yu, Man 1994), distribution (Real *et al.* 2008) and habitat conservation (Kazanci *et al.* 2004), were performed. In particular, studies focused more on the threat of avian influenza H5N1 (Gaidet *et al.* 2010, Iverson *et al.* 2011) after over 140 Ruddy Shelduck died during the highly pathogenic avian influenza event that exploded in China's Qinghai Lake in May of 2005.

However, some important issues relevant to the Ruddy Shelduck overwintering ecology were little explored [but see Chang *et al.* (1997) and Quan *et al.* (2001)], particularly regarding the habitat selection in its overwintering area. Even a basic understanding of its overwintering ecology, such as its main dietary resource, was lacking. Observations on the Ruddy Shelduck diet from Northern China suggested that the vegetarian forage that the Ruddy Shelduck requires in midwinter came from the aquatic *grass submerged in water* but there was no evidence of grass foraging (Chang *et al.* 1997). In contrast, observations from Southwest China mentioned that the Ruddy Shelduck took a large amount of vegetables and grass on the land during winter (Zhou *et al.* 2012). Our field studies found that Ruddy Shelducks showed obvious habitat preference and frequently consumed vegetables from vegetable plots. Despite these isolated reports, how different habitats affect the species in its overwintering area has never been comprehensively reported. Since habitats affect the spatial distribution of individuals and can alter demographic parameters of populations (Gayet *et al.* 2011), understanding the habitat selection is crucial if managers want to implement protection and management procedures. Furthermore, local peasants are not compensated when birds devastate their crops in our study area. The lack of compensation for conservation value was one of the main reasons that local peasants clandestinely killed birds (Luo *et al.* 2011, Zhou *et al.* 2012). The Ruddy Shelduck population characteristics need to be understood from the perspective of wildlife management. The effective conservation management and the development of conservation strategies depend largely on clear understanding of the ecological data and the population trends (Luo *et al*. 2010). By comparing the species abundance variation between winter and spring and by exploring the habitat preference of the Ruddy Shelduck in relation to the forage status, this paper aimed to: (1) describe the characteristics of the habitats of the Ruddy Shelduck in its overwintering area; (2) explore the seasonal population trends and habitat selection of the Ruddy Shelduck in the overwintering area; and (3) suggest conservation measures.

Materials and Methods

Study area

The study area, which is an important overwintering area and stopover site for migrant waterfowl of Southwest China, is located in the southwest of Weining City of western Guizhou Province, China (Fig. 1). The study area, with an altitude from 2170 m to 2386 m, has subtropical semi-humid monsoon climate. The extreme highest mean air temperature is 17.7°C in July; the lowest mean is 1.9°C in January and annual mean is 10.6°C. The mean annual precipitation is 950.9 mm, and the sum of precipitation in winter and spring is less than 12% of the annual total (Li, Nie 1998).

The study area (Fig. 1) included two plateau freshwater lakes, which were Caohai Nature Reserve (hereafter CNR, 26°47′32”-26°52′52”N, 104°10′16”-104°20′40”E) and Yangwanqiao Reservior (hereafter YR, 26°48′30”-26°52′30”N, 104°07′30”-104°10′20”E). CNR, which was formed 150 thousand years ago and presently abuts to Weining City, is the biggest plateau natural freshwater lake on the Yungui Plateau. The total area of CNR is 96 km^2 and water surface area is 25.6 km^2 in winter. The water area of CNR begins to shrink in the middle of October and to brim in the next June of the rainy season. With a continuous tendency to ebb, the mean water depth in winter is from 2.8 m to 1.35 m. CNR, a national class nature reserve in China, was reclaimed by local people for farmland cultivation in 1958, and this activity continued until 1972 when the lake nearly dried up. In 1982, people restored CNR's water area up to 25.6 km^2. CNR became national class nature reserve in 1992, aiming mainly to conserve alpine wetland ecosystem and threatened waterbirds, such as the Black-necked Crane (*Grus nigricollis*). YR is an artificial reservoir, built in 1958, with a mean water depth of 7 m and a surface area of 4.85 km^2 in winter.

Outdoor survey

Field surveys were carried out on sunny days during winter (December to February) of 2010 and 2011, and during spring (March) of 2011 and 2012. Habitats were classified as croplands, vegetable plots, marshlands, aquatic habitats and forests (Table 1). All the line transects were set 400 m in length and 100 m in width, except for the aquatic habitats.

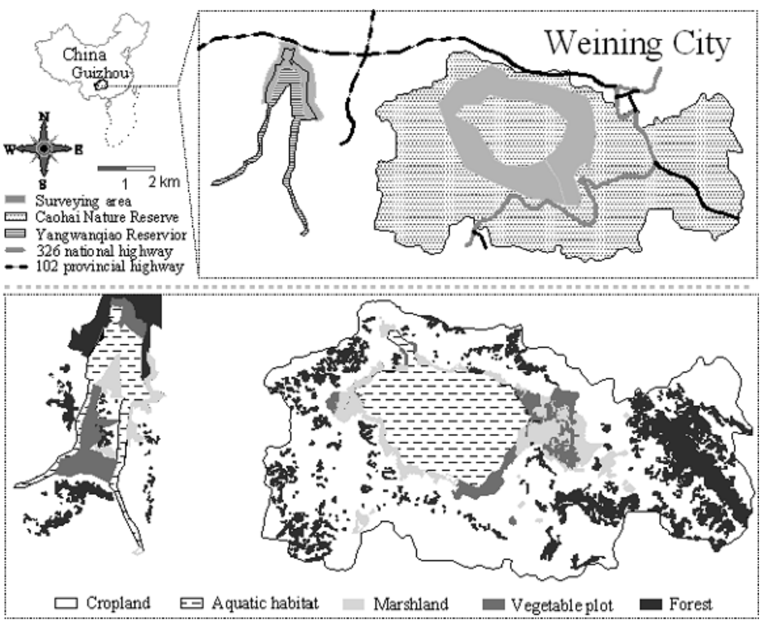

Fig. 1. The habitat distribution status of the study area. The up left shows the location of the study area and the up right shows the surveying site

Table 1. Habitat description in the study area

Habitat type	Characteristics
Cropland	Most of cropland was harvested and ploughed corn terrace, and few were potato terrace. Generally there was a small quantity of weeds (<5% in coverage of the whole line transect).
Vegetable plots	Radish and Cabbage (*Brassica pekinensis (*Lour.*)* Rupr.) were the main vegetables, and alfalfa (*Medicago sativa L.*) was cultivated in the vegetable plots as green manure. Other vegetables included the Sweet Pea (*Lathyrus odoratus*), Onion (*Allium cepa* L.), Garlic (*Allium sativum* L.), Spinach (*Spinacia oleracea* L.), Flowering Chinese Cabbage (*Brassica parachinensis* L. H. Bariley), etc.
Marshland	A transition zone between land and aquatic habitat. Most area of marshland was densely covered by Barit (*Leersia hexandra*), and Wild Rice Stem (*Zizania caduciflora*), Wild Rush (*Juncus setchuensis*) and sedges of Cyperaceae. There were many ditches and billabongs in the marshland.
Aquatic habitat	There were many kinds of sedges of Cyperaceae in the shallow water area. The deep water area was open view, with submerged macrophytes, such as Pondweed (*Potamogeton lucens*) and Fox Brush (*Myriophyllum spicatum*) in the early winter, but in midwinter and spring they withered and decayed.
Forest	Trees in the study area were sparse, including mainly the Yunnan Keteleeria (*Pinus yunnanensis*), Huashan Pine (*Pinus armandii*), Fir Wood (*Cuninghamia lanceolata*), Chinese Juniper (*Juniperus taiwaniana*), Poplar (*Populus adenopoda*) and Elm (*Ulmus pumila*). Understory shrub were mainly the Pyracantha (*Pyracantha fortuneana*), Waxberry (*Myrica nana*), Tea (*Camellia oleifera*), etc.

We counted birds with a binocular telescope (BD42 Series Kowa 8×), walking at the speed of 1 $km \cdot h^{-1}$ and scanning for birds within 100 m. To assess the aquatic habitats, we walked along the bank or rowed a boat while counting birds within 100 m. A total of 350 line transects, including 239 in winter and 111 in spring, were surveyed. All the line transects were chosen at random with an interval more than 100 m between each pair of line transects each time, and no line transect was repeated in a season.

In order to detect the relationship between the Ruddy Shelduck and the vegetable coverage in the vegetable plots, we measured the coverage of different vegetables in each line transect with range finder monocular (Bushnell Pro 500).

Data analysis

When comparing the numbers of the Ruddy Shelduck between winter and spring in the same habitat and when comparing vegetable coverage between winter and spring in vegetable plots, the Mann-Whitney U test was used because the data was not normality distributed. When we compared the numbers of the Ruddy Shelduck among the five habitats in the same season and the abundance among different months, the Kruskal-Wallis test was used, also because the normality assumptions were not met. When we detected the relationships between the Ruddy Shelduck numbers and vegetable coverage in the vegetable plots, a stepwise regression was used with the Ruddy Shelduck numbers as a dependent variable, and the radish coverage, cabbage coverage, alfalfa coverage and other plant coverage as independent variables. Since the other plant coverage in winter was not normally distributed, these data were $Log_{10}(X/100 + 1)$ transformed.

All statistical analyses were performed using SPSS Version 16.0 (SPSS Inc.). The statistical data were presented with mean ± S.E.

Results

Seasonal difference and number tendency of Ruddy Shelduck

The Ruddy Shelduck numbers in the marshland were significantly higher in winter than in spring (U = 108.000, P = 0.039, Mann-Whitney U test), while the opposite was true in the forest (U = 229.500, P = 0.024). No significant differences, however, were detected between winter and spring in the croplands (U = 220.000, P = 0.541), vegetable plots (U = 303.000, P = 0.817) and aquatic habitats (U = 389.000, P = 0.302), respectively (Table 2). The abundance of the Ruddy Shelduck was not different among the four months (χ^2_3 = 1.984, P = 0.576; Kruskal-Wallis Test); the daily observed mean numbers, however, revealed a slight decline from December to March (Fig. 2).

Ruddy Shelduck abundance in various Habitats

The abundance of the Ruddy Shelduck was significantly different among the five habitat types during the whole migrant period (χ^2_3 = 64.013, P = 0.000; Kruskal-Wallis Test), with the aquatic habitats containing more birds than the vegetable plots, and vegetable plots containing more birds than the croplands, marshlands and forests. Although the numbers of the Ruddy Shelduck were significantly different among the five habitat types both in winter (χ^2_3 = 53.693, P = 0.000) and in spring (χ^2_3 = 14.859, P = 0.005), the abundance mean values in different habitat types in different seasons were different. The abundance of the Ruddy Shelduck decreased from the aquatic habitats to the vegetable plots, marshlands, croplands and forests in winter. In spring, however, the abundance declined from the vegetable plots to the aquatic habitats, croplands, marshlands and forests (Table 2).

The coefficients of variation of the Ruddy Shelduck numbers among the five habitats were quite different, increasing from the aquatic habitats to vegetable plots, croplands, marshlands and forests (Table 3).

Relationships between the Ruddy Shelduck numbers and the vegetable coverage in the vegetable plots

The radish coverage between winter and spring was significantly different (U = 187.500, P = 0.013, Mann-Whitney U test). The cabbage coverage (U = 306.500, P = 0.865), alfalfa coverage (U = 308.500, P = 0.895) and other coverage (U = 273.500, P = 0.421) between winter and spring, however, did not have obvious changes, respectively (Fig. 3).

When we explored the relationships between the Ruddy Shelduck numbers and the vegetable coverage in the vegetable plots, a multiple regression model (stepwise) indicated that the Ruddy Shelduck abundance was significantly and positively correlated with the radish coverage in winter (R^2 = 0.619, P = 0.000; Table 4), while cabbage coverage, alfalfa coverage and other coverage were excluded (Table 5). The Ruddy Shelduck abundance was significantly and positively correlated with both cabbage coverage and radish coverage in spring (R^2 = 0.555, p = 0.002; Table 4), while the alfalfa coverage and other types of coverage were not (Table 5).

Discussion

Seasonal abundance of the Ruddy Shelduck

Differences in the abundance of the Ruddy

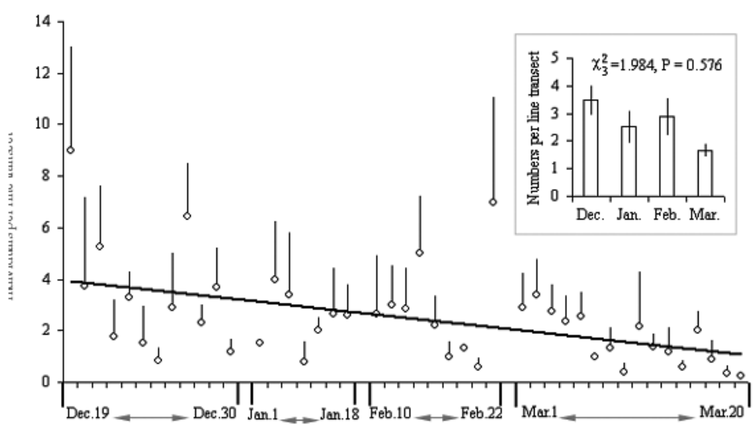

Fig. 2. Daily numbers, population tendency and monthly difference of the Ruddy Shelduck in its overwintering area in the Yungui Plateau, China. (Daily numbers refers to the Ruddy Shelducks on the same date of different years. Daily numbers were shown as mean ± S.E. (◊) if the line transect number (n) in each working day >5, or showed as mean (◊) if n<5)

Table 2. Difference in the Ruddy Shelduck numbers (ind./line transect) during different seasons and in different habitats. n_1 – number of line transects in winter; n_2 – number of line transects in spring; *level at 0.05 and **at 0.01

	Croplands (n_1=45, n_2=21)	**Vegetable plots (n_1=35, n_2=28)**	**Marshlands (n_1=29, n_2=22)**	**Aquatic habitats (n_1=79, n_2=21)**	**Forests (n_1=51, n_2=19)**	**Difference among habitats (P)**
Winter	1.489±0.348	3.686±0.986	2.172±0.668	6.456±0.933	0	0.000 **
Spring	1.636±0.592	3.222±0.958	0.333±0.188	2.417±1.062	0.200±0.200	0.000 **
Seasonal Difference (P)	0.541	0.817	0.039 *	0.302	0.024 *	

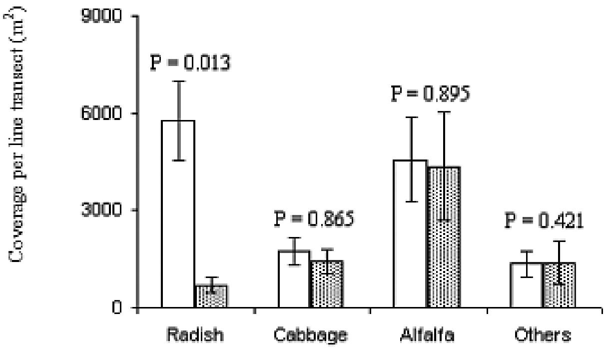

Fig. 3. Difference in the vegetable coverage between winter (□) and spring (▣) in the vegetable plots

Table 3. Degree of variation in the Ruddy Shelduck abundance in the five habitats. S.D. – standard deviation; C.V. – coefficient of variation

Habitat	Mean	S.D.	C.V.
Croplands	1.500	2.248	149.87
Vegetable plots	3.528	5.265	149.23
Marshlands	1.634	3.144	192.41
Aquatic habitats	5.923	7.946	134.15
Forests	0.033	0.256	775.76

Shelduck between winter and spring were directly related to the bird migration. We recorded the species from late December to the following February in winter and in March in spring. However, the Ruddy Shelduck reached our study area in late October for overwintering and departed intermittently during the following March. The migration was one of the most important reasons why the abundance of the Ruddy Shelduck in spring was lower than in winter in the same habitat, although the opposite was true in the forest. We regarded the higher number of the Ruddy Shelduck in the forest in spring compared to that in winter as an occasional phenomenon, because there were only two individuals recorded in the forest in spring. A previous study showed that this species avoids forest habitats (Namgail *et al*. 2011). The Ruddy Shelducks were frequently found to congregate during overwintering period, which cause the abundance recorded to deviate from the normal distribution.

Factors affecting the Ruddy Shelduck population

The Ruddy Shelduck in the aquatic habitats and vegetable plots exceeded those in the other three habitats not only in numbers but also in stability. Although the forage may be the main factor that creates a trade-off for the Ruddy Shelduck in selecting its overwintering habitat, we found that a number of various natural and anthropogenic disturbances also regulated the distribution of the species.

Many wetland ecosystems were lost and fragmented by anthropogenic activities in the last century (Hamdi *et al*. 2008). Agricultural activities had obvious influence on the waterbirds in the Yungui Plateau ecosystem (Li 1999, Luo *et al*. 2011). The radish harvest, which is done mainly in late January in the Yungui Plateau, was an important anthropogenic factor affecting the distribution of the Ruddy Shelduck. When there were few radishes left in spring, the Ruddy Shelduck were found to nibble the exposed part of swollen roots of the radish sporadically distributed in vegetable plots, indicating that the radish is a favorite food for them. The Bar-headed Goose (*Anser indicus*) also takes a large number of radishes in winter but it switches to alfalfa in spring (Zhou *et al*. 2012). Ecological separation of food resources is advantageous in alleviating competition that can lead to food resource limitation (Sun 2001). The Ruddy Shelduck broadened its food menu range when the favorite diet was in short supply during spring. The foraging strategy theory predicts that if an optimal food resource is sufficiently abundant, a predator should choose this single resource over other choices (Sun 2001). Fishing was another human factor found to affect the distribution of the Ruddy Shelduck. We found that a large number of boats were catching fish in CNR in spring but seldom in winter. Fishing nets, new or abandoned shabby ones were easily found here and there. The fishing activities in spring may force the Ruddy Shelduck to leave the aquatic habitat and change the habitat, because predators can adjust their behavior by trading off advantages and disadvantages (SUN 2001). Other agricultural activities, such as the dam development, the establishment of plastic greenhouses that caused plastic pollution, the irrigation and heavy grazing have also caused negative impact on waterbirds in Southwest China.

Wetland bird assemblage and distribution within the freshwater system is affected by water level and fluctuation, so population demography is regulated by seasonal hydrology (Desgranges *et al.* 2006). The natural ebb and flow in CNR had an influence on the Ruddy Shelduck abundance. The continuous water ebb during the whole overwintering period and consequently a drop of 1.45 m in water level had

Table 4. Multiple regression models (stepwise) for the Ruddy Shelduck numbers (as dependent variable) and the coverage of Radish, Cabbage, Alfalfa and others (as independent variables) in the alpine wetland ecosystem in the Guizhou Province, China in winter and spring, respectively. n – Sum of line transects; R^2- Coefficient of determination; B-values of constant are intercepts; B-values of radish cover and cabbage cover are regression coefficients

Season	n	R^2	ANOVA P	Variable	Partial correlations	B	S.E.
Winter	35	0.619	0.000	Constant		0.050	0.792
				Radish cover	0.787	0.001	0.000
Spring	28	0.555	0.002	Constant		0.175	0.983
				Radish cover	0.529	0.002	0.001
				Cabbage cover	0.597	0.001	0.000

Table 5. Excluded variables from multiple regression models (stepwise) for the Ruddy Shelduck numbers (as dependent variable) and the coverage of radish, cabbage, alfalfa and others (as independent variables) in the alpine wetland ecosystem in the Guizhou Province, China in winter and spring, respectively

Season	Variable	Regression coefficients	P	Partial correlations
Winter	Cabbage coverage	-0.103	0.344	-0.167
	Alfalfa coverage	-0.033	0.783	-0.049
	Others coverage	0.009	0.937	0.014
Spring	Alfalfa coverage	0.002	0.993	0.002
	Others coverage	0.008	0.967	0.011

an impact on the environmental carrying capacity. A continuous subtle decline of the Ruddy Shelduck abundance occurred during the whole survey time span (Fig. 2). The influence of the water depth on the Ruddy Shelduck was probably more significant in CNR than in YR, because YR has much deeper water than CNR.

Food is one of the most important factors that affect bird distribution (Erwin 1983). Avian behaviors, such as habitat choice and feeding, are strongly correlated with available food (Zhao *et al*. 2007). Previous field observations on the Ruddy Shelduck diet from Northern China inferred that the Ruddy Shelduck had taken green grass submerged in water in midwinter from the fact that the fecal matter of the species was green, while no green plants were found on the land (Chang *et al*. 1997). The opposite conclusion, however, was reached in Southwest China (Luo *et al*. 2012, Zhou *et al*. 2012). In our study (Southwest China), we could see the bottom of the lakebed clearly (especially in CNR), and all the grass had withered in the lakes in midwinter. Most likely, all the green forage the Ruddy Shelduck took in our study area came from the vegetable and grass on land but not from the grass submerged in water in late winter and spring. As a generalist predator, the Ruddy Shelduck is likely to select different habitats according to the spatial difference of food distribution between Northern China and Southwest China. Thus, most Ruddy Shelducks were found in aquatic habitats and vegetable plots in Southwest China, while in Northern China the main part was reported to be found on the ice and in water areas (Chang *et al*. 1997). The forages, such as radish and cabbage, are an important factor that regulates the overwintering distribution of the Ruddy Shelduck in Southwest China.

Waterbirds have sometimes been forced to evacuate from wetland habitats (Li 1996, Liu *et al*. 2008) in response to heavy pressures from environment change and the intensification of human activities in the alpine wetland ecosystem of China (Kong *et al*. 2008, Xu *et al*. 2009). Some waterbirds, such as the Ruddy Shelduck, the Bar-headed Goose, the Grey Crane (*Grus grus*) and the Black-necked Crane, often appeared in croplands and vegetable plots but not in wetlands in the alpine ecosystems of China (Li *et al*. 1997 and 1998, Li 1999, Luo *et al*. 2012) because many wetlands in the alpine ecosystems had shrunk and degraded (Tian *Et Al*. 2004, Pan *Et Al*. 2007, Bai *et al*. 2008). Higher coefficients of variation indicated greater variation in the degree that the species appeared in the habitat, suggesting that the species abundance had a lower stability (Luo *et al*. 2010). The aquatic habitats and the vegetable plots supported comparatively more Ruddy Shelducks, and the species in these two types of habitats were more stable than in the other three types. Feeding and resting behaviors of the Ruddy Shelduck were frequently observed in the aquatic habitats and vegetable plots, especially in winter. Thus, these two types of habitats were probably preferred ones for the Ruddy Shelduck to overwinter.

The human population expansion and urbanisation has directly destroyed wetlands (Li, Ma 2000) and affected avian behavior (Zhou *et al*. 2012) in our study area. There were more than 30 thousand residents living in the nature reserve (CNR), and some directly in the core area. Furthermore, Weining City encroached on the top north wetland of CNR for city expansion and construction of highways that intersect the study area (Fig. 1). The Black-necked Cranes have moved their overnight site from the mudflat neighboring Weining City to sites with lower human population density. The Ruddy Shelduck and the Bar-headed Geese always congregate with the Black-necked Crane during night roosts (Li *et al*. 1997). The change of roost site by the Black-necked Crane suggests that the Ruddy Shelduck may soon display similar behavior.

Summarily, the Ruddy Shelduck in Southwest China is faced with menaces from alteration of the natural environment and a series of disruptions by human beings, although there are few menaces in YR. The prognosis for waterbirds protection in our study area is poor at present.

Management implications

Our study area is one of the poorest regions in China. The per capita income was only 6.5% of the average level of the whole country in 2003 (Yashigawa *et al*. 2006), and 80% population of peasants is in an extremely poor state (Li and Zhou 2000). Primary agricultural products are the main source of income for most local laborers (Li *et al*. 1997). Many birds often seek forage such as radish, cabbage, tomato and other crop seeds in our study area (Li *et al*. 1997, 1998, Li 1999). Birds destroyed crops and vegetables in the Yungui Plateau and brought enormous economic damages to local peasants (Hu *et al*. 2002). Local peasants always complained about these birds, and harmonizing the needs of humans and birds was one of the main management barriers to local nature reserve management bureau (Li *et al*. 1997).

Unfortunately, the local peasants were not compensated for their losses caused by the wild bird foraging, which has reduced the impetus for local people to protect birds and exacerbated the "human-bird" conflict (Hu *et al*. 2002). Local people killed birds surreptitiously (Luo *et al*. 2011, Zhou *et al*. 2012). Some policies and measures, such as eco-compensation and reverting cultivated land to wetlands, were recommended as best practices for improved wildlife management (Li *et al*. 1998, Li 1999, Liu, Li 2004, Li *et al*. 2009, Xu e*t al*. 2009). But we deem that the eco-compensation could only solve the dilemma temporarily from a species conservation angle. Comprehensive management measures, such as mitigating intense agriculture, pollution, boat fishing and so on, should be constituted and executed, and most importantly the human birthrate should be strictly controlled.

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