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Habitat Selection of Wintering Chinese Merganser, *Mergus squamatus*

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Abstract.- Habitat selection of wintering Chinese merganser *Mergus squamatus* was studied using field surveys that documented merganser occurrence in the Poyang Lake Watershed in eastern China, and GIS analysis. Merganser used the widest reaches of rivers, and islands and shoals habitats that accounted for only a small proportion of overall habitat. Percentage of woodland and farmland along the river bank was large. Chinese merganser apparently adapted to large-scale width variation of the river using vegetation cover to mitigate effects of human activity. Distance between the river, where merganser resided, and artificial land (residence, industrial land and bridge) was relatively far, while the distance between river and motorways was relative short. Chinese merganser preferred habitat which had larger percentage of island and was far away from artificial land. In winter, the Chinese merganser was able to tolerate small degree of disturbance such as small population or traffic flow, but avoided higher levels of disturbance. Effective winter habitat protection for the Chinese merganser should include protecting watersheds from flooding and avoiding excessive human activity particularly on more narrow reaches of rivers that are devoid of vegetation.

Key words Chinese merganser, habitat characteristic, GIS, river width, human interference.

INTRODUCTION

Environmental factors affect an animal's survival and reproduction and determine the distribution of population and species habitat selection (Yang *et al*., 2011). Habitat selection is frequently studied with analysis of information gained by geographic information systems (GIS). For example, remote sensing information from the environment and GIS analysis tool have been used to quantify the influence of water quality, landscape characteristics and disturbances on habitat selection of a variety of wildlife species (Dong, 2006; Zhao *et al.,* 2011). In particular, GIS-based analyses can overcome data deficiency in field survey and provide robust measures of environmental variables with which to assess habitat quality and selection by rare and endangered bird species (Jiang *et al*., 2010). For example, studies using remotely sensed data and GIS have assessed the suitability of habitat for migratory birds in Chongming Dongtan, Shanghai, China (Tian *et al*., 2008), and characterized the distribution and diversity of endangered passerine birds in Hawaii forest, America (Harri and Scheck, 1991).

Chinese merganser (*Mergus squamatus*) is an endemic species restricted to East Asia and is regarded as an endangered species by the International Union for Conservation of Nature (Birdlife International, 2008). It is listed in the first category of the nationally protected wildlife species in China. In China, Chinese merganser is a migratory bird that breeds in Heilongjiang and Jilin Provinces and overwinters along the southern reaches of Yangtze River, with a scattered distribution (He *et al.,* 2006). Chinese merganser annually overwinters (November through March) in Poyang Lake catchment, most commonly in mixed sex group (Shao *et al*., 2012a). The densest and most-stable population of Chinese merganser in this region is found in Yiyang, Taopi, Taiyangsheng and Wuyuan County, Jiangxi Province (Fig. 1), and >200 individuals have been recorded in Poyang Lake catchment (Wang *et al.,* 2010). In recent years, however, this population has declined, likely due to sand mining, fishing, the destruction of riparian vegetation and water pollution (Zeng, 2014; Shao *et al*., 2012a). Pervious studies have mainly focused on describing population and group size (Shao *et al*., 2012a, 2014), wintering behavior (Shao *et al*., 2010), and the factors that threaten it (Shao *et al*., 2012b). A few studies have examined habitat selection by this species (Guan and Wang, 2009). In this paper, we use analyze of GIS data to characterize the winter habitat selection of Chinese merganser. We

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aim to document the main characteristics of wintering habitat of Chinese merganser, and use this information to provide conservation and management recommendations for this endangered species.

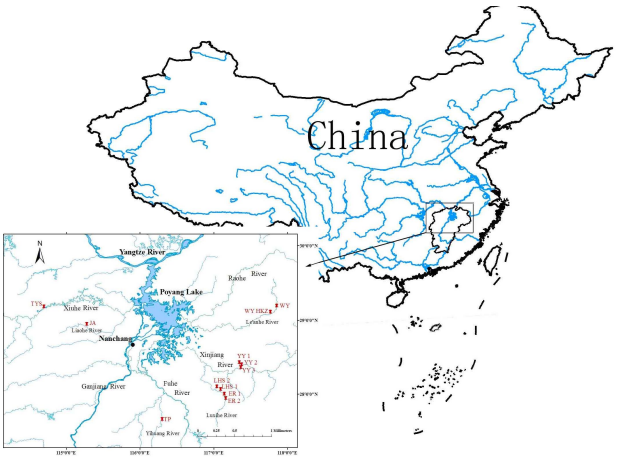

Fig. 1. Wintering sites of Chinese Merganser in Poyang lake watershed.

STUDY AREAS AND METHODS

The study area comprised four rivers in the Poyang Lake catchment area: the Xiuhe, Fuhe, Xinjiang and Raohe (Fig. 1). The watershed is in the Jiangxi Province (E:114°39′-117°51′, N:27°34′-29°33′), at an elevation of 10-90 m above sea level (Shao *et al*., 2012a). Climate in the study area is sub-tropical, with an average annual temperature of 18°C and annual precipitation 1186 mm (Huang and Guo, 2007; Dai *et al*., 2014). The vegetation in this area was predominantly evergreen broad leaved woodland. Field surveys were conducted from December 2010 to March 2014. Wintering Chinese merganser were counted along transect lines (4-7 km) alongside each of the rivers. When birds were sighted GPS, a monocular telescope and camera were used to record the GPS location.

Based on the interpretation of remote sensing images, we characterized the habitat of Chinese merganser in plots where merganser were present (Used Plots, UP) and in those where merganser were absent (Control Plots, CP). On each plot, the length of river was 2-4 km, and the width of both sides was 0.5 km (Table I). Based on our previous survey field where we identified concentrations of wintering mergansers (Shao *et al*., 2012b, Zeng, 2014), we included one UP in Fuhe River (TP), two plots in Raohe River (WY, WYHKZ) and Xiuhe River (TYS, JA), and seven plots in Xiujiang River (YY1, YY2, YY3, LHS1, LHS2, ER1, ER2). Plot boundaries were finalized using remote sensing images (Fig.1). For each UP we included a CP that was randomly located either upstream or downstream of the UP. All CPs were between 7 and 8 km from a UP, except for CPs of LHS1 and ER2, which were 2–3 km from a UP (to avoid overlaps with other plots: LHS2, ER2).

From remote sensing images, we measured the surface area and proportionate representation of vegetation types, water bodies and artificial surfaces (residence, industrial land and bridge) in each study plot. We also calculated the mean distance of all artificial surfaces to the river using image interpretation software (Table II). Analyses were based on Landsat 8 OLI images from winter 2013 to 2014 and RGB color composite images combined by 7, 6, 4 bands (B7-6-4). We used data from B6-5-2 images to distinguish woodland and farmland areas and B3-4-5 images to distinguish roads and bridges from other land types. Band combination was done by Earth Resource Data analysis system (ERDAS) imagine 9.2 and image interpretation was done using ArcGIS 9.3 (Liang and Schwartz, 2009). Google Earth was used to determine coverage type where this was not possible with images.

Statistical analysis

A Kolmogorov-Smirnov test was used to assess normality of the proportion area data from all UPs and CPs. Independent-samples t-tests and Mann–Whitney U test was used to compare the data difference between UPs and CPs. Independent-samples t-tests were used for analysis when the values fitted normal distribution. Mann–Whitney U test was used when the values did not fit. A Pearson correlation test was used to examine if the river width were correlated with the proportion of other habitat. Results are presented as means (± SD) and p-values <0.05 were considered significant. Statistical analyses were performed in Excel 2013 and SPSS 19.0 (Shao *et al*., 2012b).

Table I.- Information of each study plots.

Plots	Coordinate	Area (km^2)	Population of wintering merganser (the maximum record)+	Landsat Scene Identifier
TP	116°16'26"E,27°37'18"N	$4.30*10^3$	39	LC81210412013278LGN00
WY	117°50'31"E,29°9'46"N	$2.59*10^3$	25	LC81200402014002LGN00
WYHKZ	117°46'11"E,29°5'26"N	$2.49*10^3$		
TYS	114°41'13"E,29°9'48"N	$3.26*10^3$	27	LC81220402013365LGN00
JA	115°14'0"E,28°56'13"N	$2.26*10^3$	10	
YY1	117°20'43"E,28°22'46"N	$3.71*10^3$	30	LC81200402014002LGN00
YY2	117°22'24"E,28°21'39"N	$2.67*10^3$		
YY3	117°21'30"E,28°19'55"N	$4.20*10^3$		
LHS1	117°4'43"E,28°1'59"N	$3.57*10^3$	15	LC81210412013278LGN00
LHS2	117°1'6"E,28°3'37"N	$2.71*10^3$		
ER1	117°7'59"E,27°58'14"N	$2.67*10^3$	9	
ER2	117°8'56"E,27°55'58"N	$2.69*10^3$		

+The population of Chinese merganser was shown in a previous report (Zeng, 2014)

Table II.- Land cover classification system and associated image features used in merganser habitat selection.

Level 1 classification	Level 2 classification	Indicator	Image features (B7-6-4)
Woodland	Woodland	Natural or semi-natural vegetation, include trees or shrubs, Height=0.3-30m，Coverage >20%	Dark olive green, Dark sea green and light slate gray (light green, medium purple B6-5-2)
Wetland	River	Natural and flowing water	Medium slate blue with linear shape
	Pond	Stationary water	Medium slate blue with square or long strip shape
Farmland	Farmland	Artificial vegetation, Including aquatic and arid crops, sometimes have land disturbance	Lemon chiffon, pale gold en rod, khaki light pink B6-5-2
Artificial surface	Artificial land	Artificial hard surface with square shape	Orchid, plum and white with mottled color or chunks of bright colors
	motorways	Artificial hard surface with linear shape	Orchid with linear shape, pale gold en rod, brighter than the surrounding B3-4-5
Others	Island	The land above the water surface and covered with vegetation	Lemon chiffon, pale gold en rod, light green, in the river
	Shoal	The land above the water surface and no vegetation cover	Plum, in the river or on the riverside

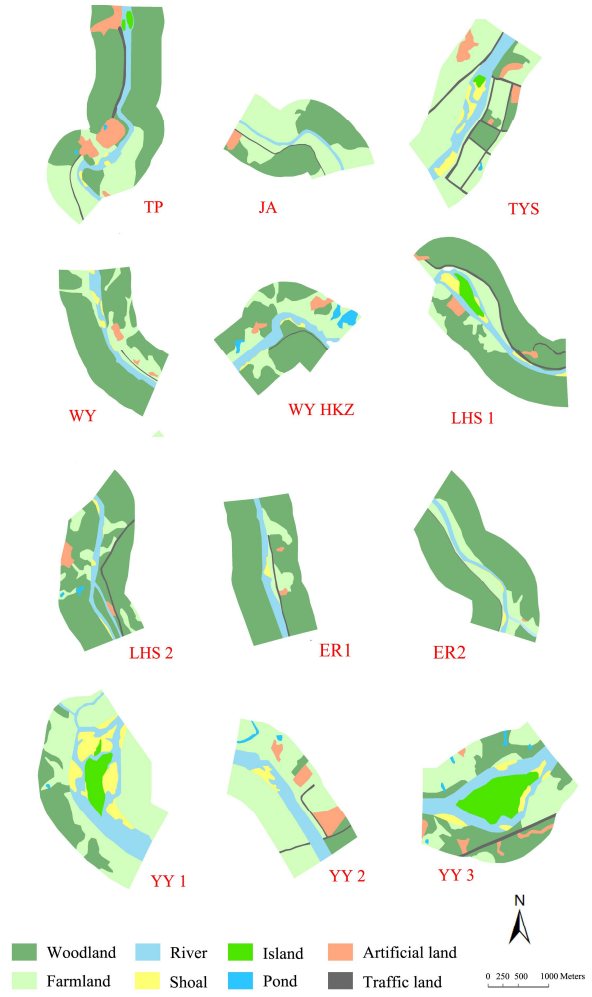

Fig. 2. Classification of wintering habitats of Chinese merganser at 12 study plots interpreted through remote sensing.

RESULTS

UPs were primarily composed of woodland (31.63±20.81%) and farmland (46.31±29.55%), with far small areas of shoals (2.74±3.60%), islands (2.29±4.62%), artificial land (2.50±2.26%), and motorways (1.94±1.72%; Fig. 2). River stretches in UPs were on the average 214.00±202.44 m wide, and located relatively far from artificial land (89.60±69.23m; Table III). River width was positively correlated with the width of the water surface (R = 0.972, $P<0.001$), the proportion of shoal area (R = 0.869, $P<0.001$) and islands present (R = 0.671, $P = 0.017$). River width was negatively correlated with the proportion of upland habitats (*e.g.* woodland and farmland; R = −0.902, $P<0.001$).

Island habitats were significantly overrepresented in UPs as opposed to CPs ($Z = -2.011$, $P<0.05$). The distance between merganser habitat and artificial land in UPs was significantly greater than in the CPs ($t = 2.533$, $P<0.05$). No other environmental factors differed significantly between UPs and CPs (Table III).

DISCUSSION

Chinese mergansers require protection from extensive cover in their habitat. Consequently, we found that a large percentage of their wintering habitat area comprised woodlands and farmlands, which provided visual buffers and secure habitat for resting Chinese merganser. Chinese mergansers also select habitat with extensive cover in the breeding season (Wang, 2009).

We found that Chinese mergansers choose to overwinter along river reaches that are wider, and more variable, than those they occupy during the breeding season (Guan and Wang, 2009). These river areas were also wider than areas of the three Gorges Reservoir where the Mandarin duck (*Aix galericulata*) chooses to winter (Jiao *et al.*, 2012). Hence, while wintering, Chinese mergansers preferred wide reaches of rivers, they could adapt to large variations in river width. This adaptability would benefit their survival and facilitate dispersal.

Our analyses also revealed that the wintering habitat of Chinese mergansers included some islands and shoals, as has been previously found for Mandarin ducks (Jiao *et al.*, 2012). These findings indicated that islands and shoals provide well-vegetated shelter for resting and preening for Chinese merganser. Red-breasted mergansers (*Mergus serrator*) also prefer vegetated areas within 850 m of the water edge, with a sand-rock substrate (Craik *et al.*, 2011). Indeed, both Chinese merganser and red-breasted merganser undergo wing molt on river islands.

The habitat of water birds includes hidden (sub-surface) vegetation (Guan and Wang, 2009; Yang *et al.*, 2013). We found that plots on wider

stretches of rivers contained greater proportions of islands and shoals, and smaller proportions of

Table III.- Significance of habitat characteristics between plots used by Chinese mergansers and control plots.

Habitat characteristic		US	CP	*P*
Habitat area percentage	Woodland	46.31±29.55%	45.25±28.30%	0.93
	Farmland	31.63±20.81%	30.85±20.67%	0.93
	River	11.46±5.63%	12.12±6.62%	0.79
	Artificial land	2.50±2.26%	9.44±13.56%	0.23
	motorways	1.94±1.72%	0.79±1.03%	0.06
	Shoal	2.74±3.60%	1.31±2.26%	0.26
	Pond	0.57±1.13%	0.16±0.39%	0.14
	Island	2.29±4.62%	0.01±0.05%	0.04*
River channel characteristic	The width of river channel **(**m**)**	214.00±202.44	162.15±107.46	0.44
	The width of water surface **(**m**)**	141.41±91.62	145.67±94.14	0.91
Distance between habitat and interference	Distance between habitat and artificial land **(**m**)**	89.45±65.68	29.40±48.22	0.03*
	Distance between habitat and traffic land **(**m**)**	14.8±22.60	29.29±58.67	0.49

Means significant different.

vegetation coverage in woodland or farmland areas. This finding indicates that islands and shoal habitats can provide adequate protection for Chinese mergansers where vegetation coverage is sparse.

Shorebird distributions can be influenced by the distribution of their food resources. For example, shorebirds residing in the Robbins Passage wetlands of Australia occur at greatest densities at the water's edge and low intertidal stratum where sea grass and, consequently, invertebrates are abundant, and where shorebirds ability to detect and capture their prey is greatest (Spruzen *et al*., 2008). Accordingly, we speculate that the preference of Chinese mergansers for islands and shoals might be driven by the abundance of small fish and invertebrates in these areas. Investigating how food resources drive the local-scale distribution of mergansers is a fruitful area for further research.

Water birds prefer undisturbed habitats, but must adapt to the presence of humans and human activities in their habitats (Guan and Wang, 2009; Jiao *et al*., 2012; Yang *et al*., 2013). Our results revealed that habitats occupied by mergansers were far away from built areas but not away from motorways, or unoccupied habitats. The population may choose habitat closer to smaller (3.91±3.68hm^2, n=31, Fig. 2) rather than bigger villages (7.83±16.04 hm^2, n=41) to reduce disturbance, and because while these areas retain roads and motorways (Qiao, 2012), traffic flow is relatively low volume. Hence, it seems likely that Chinese merganser low anthropogenic disturbance, while avoiding areas of intense human activities (sand mining, fishing and rising domestic duck).

Our work has shown that Chinese mergansers prefer habitats where rivers are widest. Hence, it is critical that these areas be protected in future reserves. In particular, shoal and island areas were preferred wintering sites, and should be protected from flooding and destruction, especially in winter. We found that while Chinese mergansers appear to tolerate some disturbance from small human populations or low levels of traffic flow, they actively avoided areas of intense human activity (*e.g.* sand mining).

Chinese mergansers remained submerged into the water for food (Shao *et al*., 2014a). This feeding way may be affected by the water factors, especially water depth. And the Chinese mergansers may select the water depth for a certain range. However, the river drawdown in Poyang Lake, Yangtze River could affect the merganser's feeding habitat selection. Therefore, the relationship between water drawdown and habitat selection needs be further studied. On the other hand, a study showed that the water in Yangtze River drawdown affected the

vegetation groups (Su *et al*., 2012), which indirectly may affect the Chinese merganser habitat selection because it has a certain requirement of vegetation as mentioned above.

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