



Home Range and Group Characteristics of Wintering Scaly-Sided Merganser *Mergus squamatus* in the Watershed of Poyang Lake, China

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ABSTRACT

Time budgets provide important information for the study of animal behavior. The present study analyzed the daily travel distance, home range and group characteristics of scaly-sided merganser *Mergus squamatus* in Yihuang and Wuyuan counties, Jiangxi Province, China, from December 2012 to March 2013 and December 2015 to March 2016. Results showed that the daily travel distance of scaly-sided merganser was 3100 ± 1313 m; the daily home range was $122,460 \pm 42,019$ m²; and the overall home range was 202,350 m² during the wintering period. No significant difference was detected in the daily travel distance between different months ($F = 0.658, P > 0.05$). Significant differences were detected in the daily home range between January and February, and between February and March. No significant correlation was observed between daily travel distance and home range ($R = 0.256, n = 12, P > 0.05$). The significant correlation between daily home range and daily minimum temperature may be related to energy requirements or prey activities. The average group size of the scaly-sided merganser was 3.91 ± 2.94 individuals, and extremely significant differences existed at different time of day ($F = 25.540, df = 11, P < 0.01$). The largest group size (5.22 ± 5 individuals) appeared at 16:00–17:00, and the smallest at 08:00–09:00 (2.6 ± 1.12 individuals), similar results obtained between December 2015 and March 2016, which was related to the daily habits of this species, such as dispersed foraging, collective maintenance and rest. Group size peaked in February (5.07 ± 4.166 individuals) and was smallest (2.91 ± 1.354 individuals) in December with significantly different group sizes in all months ($F = 35.351, df = 3, P < 0.01$). A total of 57.98% of all groups had a majority of females. A large difference in sex ratios was observed among different months. The actual ratio of [(adult + sub-adult male): (adult + sub-adult female)] was 1:1.44 ($n = 22$) in February. Future studies are necessary, and the main goal should be focused on sex ratio, mortality and sex ratio at birth.

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Authors' Contributions

MS and PC designed the study, MS, BC, BZ and JJ collected and analyzed the field data. MS, BC wrote the manuscript. MS and PC gave the suggestions and revised paper.

Key words

Scaly-sided Merganser, Daily travel distance, *Mergus squamatus*, Daily home range, Group characteristics.

INTRODUCTION

Daily travel distance affects the time budget of animal behaviors, such as foraging and social activities. Therefore, travel distance has an important influence on individual energy expenditure and nutrient balance, and may affect survival and reproduction (Altmann *et al.*, 1993; Wrangham *et al.*, 1993; Chapman *et al.*, 1995; Janson and Goldsmith, 1995). Daily travel distance varies greatly among different species and among individuals of the same species in different habitats and during different seasons (Clutton-Brock, 1977; Raemakers, 1980; Marsh, 1981; Isabell, 1983; O'Brien, 1997). And also varies with the abundance and distribution of food resources over time and space (O'Brien, 1997). An animal's home range is related to its daily travel distance. Home range is the region within

which animal actively carries out essential daily behaviors, such as foraging, mating and the rearing of offsprings (Pan and Zheng, 2003; Liu *et al.*, 2009). Home range externally reflects the intensity of animals' territorial behavior. Both the area of a home range and changes in the home range are important parameters for evaluating habitat quality, estimating habitat load and determining the spatial extent of habitat required to protect a minimum viable population. Hence, home range is an important part in the study of animal behavior and ecology (Wang, 2003). The study of the home range of birds helps researchers to understand how birds use space and select habitats (Zhang *et al.*, 2008). The Eurasian Tree Sparrow *Passer montanus* has a small home range (about 7600 m²), while the Black-necked Crane *Grus nigricollis* has a large one (about 200 km²) (He and Wu, 2000; Pan and Zheng, 2003). The size of the home range of many bird species varies widely in different seasons. For instance, owing to an uneven distribution of food resources in different seasons, Temminck's Tragopan *Tragopan temminckii* has larger home range in winter and

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spring than that in summer and autumn (Shi and Zheng, 1999).

Group formation is one of the most important behavioral adaptations in birds, especially during the entire wintering period for migratory birds. Living in groups can reduce the risks from predators for individual prey, reduce their alert time and allow the individuals to spend more time on other activities to enhance their fitness for survival (Sun and Fang, 1997; Han, 2011). The studies on animal groups usually centered on group type, group size and ecological factors influencing the group. Animals may have an optimal group size in a specific environment (Shao *et al.*, 2012).

China lists Scaly-sided Merganser *Mergus squamatus* as a first-category nationally protected wildlife species and the International Union for the Conservation of Nature regards the Scaly-sided Merganser as an endangered species (IUCN, 2016). The wintering areas of Scaly-sided Merganser widely distributed at the south of the Yangtze River (He *et al.*, 2006) while the area in the north of Jiangxi province provides one of the main wintering grounds for this species in China. This population is mainly distributed along the Xinjiang, Fuhe, Raohe and Xiuhe rivers and their tributaries in Jiangxi (Liu *et al.*, 2008; Fang *et al.*, 2009; Wang *et al.*, 2010; Dai *et al.*, 2014). In recent years, the population of Scaly-sided Merganser has shown obvious declines caused by very high levels of habitat loss. Currently, the breeding population in China is estimated to be only 200–250 pairs (Fang *et al.*, 2009); the wintering population in Jiangxi Province is estimated to be 250 individuals (Wang *et al.*, 2010). Previous studies related to wintering Scaly-sided Merganser mainly analyzed topics such as the distribution of the population, population size, habits of the species, and group characteristics (He *et al.*, 2006; Shao *et al.*, 2010, 2012, 2014, 2015; Wang *et al.*, 2010). However, we did not find any data on daily travel distance and home range for this endangered species. Thus, the objective of this study was to analyze the daily travel distance, home range and grouping characteristics of Scaly-sided Merganser in Yihuang and Wuyuan counties, Jiangxi, China for future conservation efforts.

MATERIALS AND METHODS

Study area

Two study sites were selected, one each in Yihuang and Wuyuan counties. Yihuang County lies in the upper reaches of the Fuhe River in northern Jiangxi Province and has a humid subtropical climate with an annual average temperature between 16 and 18 °C. The average annual precipitation is 1749.4 mm (Shao *et al.*, 2012, 2014). The first study site is along the Fuhe River in Yihuang County

(N: 27°36' 48"~27° 37' 43", E: 116°16' 22"~116° 16' 23") (Fig. 1). Wuyuan County is located in the northeastern part of Jiangxi Province and has a humid subtropical climate with an annual average temperature 16.7 °C. The average annual precipitation is 1816 mm. The second study site is along the Leanhe River in Wuyuan County (N: 29°9' 24"~29° 11' 15", E: 117°50' 01"~117° 51' 06") (Shao *et al.*, 2012, 2014). Table I lists the sympatric waterfowl species of mergansers in this region that typically feed while swimming.

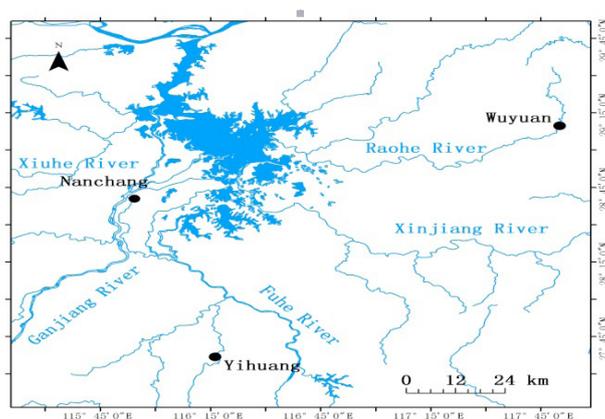


Fig. 1. Map showing the study site.

Table I.- A list of extra swimming birds coexisting with *Mergus squamatus* at Yihuang and Wuyuan.

Species	Yihuang	Wuyuan
Little Grebe <i>Tachybaptus ruficollis</i>	√	√
Spot-billed Duck <i>Anas poecilorhyncha</i>	√	√
Mandarin Duck <i>Aix galericulata</i>		√
Mallard <i>Anas platyrhynchos</i>		√
Falcated Duck <i>Anas falcata</i>		√
Common Teal <i>Anas crecca</i>		√

Field data collection

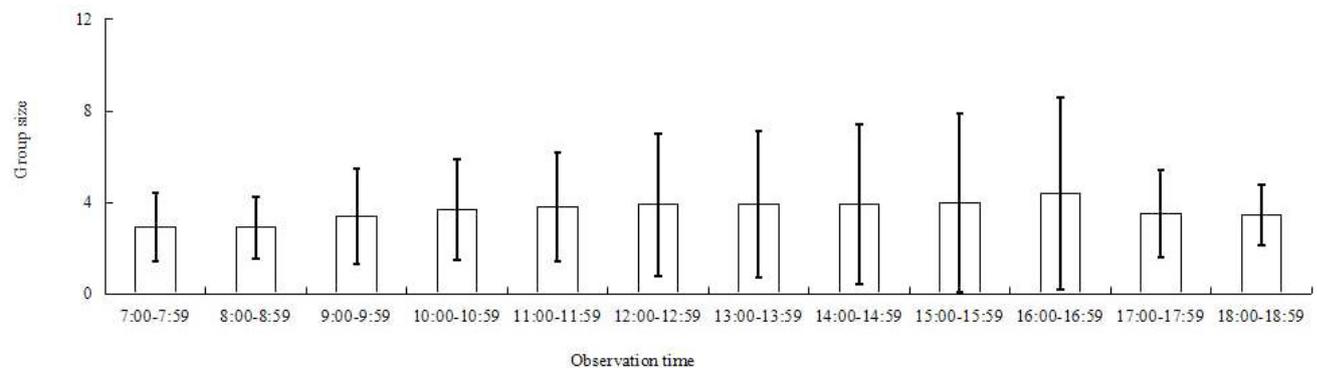
The daily travel distance, daily home range and group behavior of Scaly-sided Merganser were observed from December 2012 to March 2013 in Yihuang County for 30 days. We observed the birds using binoculars to collect data related to travel distance. We were able to track the birds relatively easily because of their small home ranges and the availability of good roads. We observed the group behavior of scaly-sided merganser in Wuyuan County for 29 days between December 2015 and March 2016. We recorded flock location and status (flock size and sex ratio) every half-hour from 7:00 am to 5:30 pm. Riverine reference markers (mileage benchmarks, hydrologic stations, factories, timber inspection stations and shallows)

Table II.- Daily travel distance and home range of *Mergus squamatus* at Yihuang from 2012-2013.

Investigation time	December	January	February	March	Average
The travel distance/m	2257 ± 520 ^a	2725 ± 1610 ^a	3748 ± 1884 ^a	3512 ± 426 ^a	3100 ± 1313
Home range/m ²	139078 ± 18353 ^{ab}	98955 ± 35059 ^b	170010 ± 41520 ^a	95172 ± 9216 ^b	122460 ± 42019

Table III.- The travel distance of *Mergus squamatus* at Yihuang in different time of a day from 2012-2013 (Unit/m).

Time	December	January	February	March	Average
Forenoon (7:00-11:00)	178±117 (95~260)	1138 ± 1 083 (330~2970)	1433 ± 347 (65~1830)	1005 ± 714 (100~1685)	1026 ± 807 (65~2970)
Noon (11:00-14:00)	1261 ± 578 (609~1710)	513 ± 356 (0~930)	948 ± 1 092 (280~2710)	1001 ± 402 (385~1460)	894 ± 677 (0~2710)
Afternoon (14:00-18:00)	905 ± 603 (55~1480)	923 ± 486 (400~1510)	855 ± 542 (140~1395)	1517 ± 398 (1085~1870)	1008 ± 533 (55~1870)

Fig. 2. Group size of *Mergus squamatus* in Wuyuan from 2012-2013.

were used to confirm the flock positions and Google Earth software was used to mark real-time locations and measure travel distance and river width. The travel distance was the linear distance the flock center moved every half hour. Daily travel distance was the sum of the travel distances measured throughout the day (Huang *et al.*, 2003). Daily home range was the product of the average river width in the range of movement and the distance between the two farthest daily activity sites.

When the group was encountered we also record their sex composition. Before sexual maturity a male scaly-sided merganser cannot be differentiated from a mature female in the field. Therefore, birds recorded as “female” in this paper actually include females and juveniles and the sex ratio was the ratio of (females + juveniles) to males (Shao *et al.*, 2012). The largest flock size was used to calculate the sex ratio in the current month.

Statistical analysis

The Kolmogorov–Smirnov test was used to examine whether the daily travel distance, home range and group

size of scaly-sided merganser conformed to a normal distribution. When the data were normally distributed, then one-way analysis of variance was used to test the differences among groups. When the data were not normally distributed, a Kruskal–Wallis H test was used to test the differences between each group of data. Spearman’s correlation test was used to test the correlation between daily travel distance and daily home range. Partial correlation analysis was used to test the correlation between daily travel distance/daily home range and several other factors including day length, daily minimum temperature, daily maximum temperature, month and water level. All the data in the present paper are expressed as mean ± standard deviation ($x \pm SD$). $P < 0.05$ was considered significant. All statistical analyses were carried out in Excel 2010 and SPSS 22.0.

RESULTS

Daily travel distance and home range

The average daily travel distance of scaly-sided

merganser was 3100 ± 1313 m with no significant difference in the daily travel distance between different months ($F = 0.658$, $P > 0.05$). However, the daily travel distance was slightly longer in February than in December (Table II). The average daily home range was $122,460 \pm 42,019$ m² during the wintering period. Significant differences were found in the daily home range between January and February ($F = 2.502$, $P < 0.05$), and February and March ($F = 2.754$, $P < 0.05$) (Table III). The largest daily home range was recorded for February ($170,010 \pm 41,520$ m²).

No significant correlation was observed between daily travel distance and home range ($R = 0.256$, $n = 12$, $P > 0.05$). No significant correlation was found between daily travel distance and any ecological factors (day length, daily minimum temperature, daily maximum temperature, and water level). The daily home range only showed a significant correlation with daily minimum temperature ($R = 0.817$, $df = 7$, $P < 0.01$).

Travel distance and home range in different time periods

Travel distance and home range had large and different ranges. No significant difference was observed in travel distance ($F = 0.188$, $P > 0.05$) and home range ($F = 1.432$, $P > 0.05$) of scaly-sided merganser among forenoon, noon and afternoon during overall wintering period. In addition, no significant differences were found in the travel distance and home range of scaly-sided merganser among forenoon ($F = 2.489$, $P > 0.05$), noon ($F = 0.942$, $P > 0.05$) and afternoon ($F = 0.416$, $P > 0.05$) between different months.

Group size

A total of 456 flocks of scaly-sided merganser were recorded between December 2012 and March 2013. The average group size was 3.91 ± 2.94 individuals and highly significant differences were found in group size between different times of day (Kruskal-Wallis H: $F = 25.540$, $df = 11$, $P < 0.01$). Group size was largest (5.22 ± 5 individuals) during 16:00–17:00 and smallest (2.60 ± 1.12 individuals) during 08:00–09:00 (Fig. 2). Significant differences in group size were recorded in all months ($F = 35.351$, $df = 3$, $P < 0.001$). The largest group size (5.07 ± 4.17 individuals) appeared in February, and the smallest ($2.91 \pm$

1.35 individuals) in December.

A total of 371 flocks were recorded between December 2015 and March 2016. The average group size was 5.75 ± 4.45 individuals and highly significant differences were found in group size between different times of day (Kruskal-Wallis H: $F = 21.668$, $df = 10$, $P = 0.017$). Group size was largest (6.71 ± 4.63 individuals) during 12:00–13:00 and smallest (2.68 ± 1.44 individuals) during 07:00–08:00 (Fig. 3). Highly significant differences in group size were found among all months ($F = 27.867$, $df = 3$, $P < 0.01$). The largest group size (7.08 ± 5.10 individuals) was recorded in December, and the smallest (3.43 ± 2.57 individuals) in January.

Grouping patterns of mixed-sex groups

Most mergansers preferred to live in mixed-sex groups. A total of 326 mixed-sex groups were observed from December 2015 to March 2016. Few single sex groups were observed. Females include females and sub-adults because the separate identification of females, sub-adult females and sub-adult males was not possible. A total of 57.98% of all groups had a majority of females. In addition, 19.02% of all groups had an equal number of males and females/juveniles (Table IV).

Sex ratios

The average ratio of females and males observed between December 2012 and March 2013 was 1:0.46 (Table V). A large difference in sex ratios was observed among different months. The peak percentage of males appeared in March (1:0.71) unlike February (1:0.26). Sub-adult males could be distinguished from February onward because they develop darker feathers on their backs than females although they retain similar feather coloring on their heads. The actual ratio of [(adult + sub-adult male):(adult + sub-adult female)] was 1:1.44 ($n = 22$) in February.

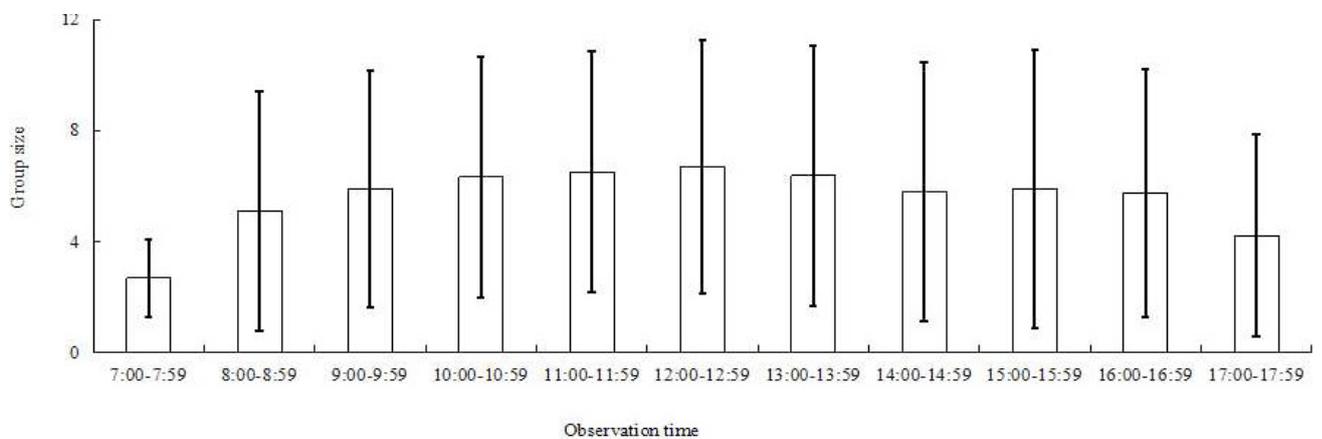
Between December 2015 and March 2016 the male:female ratio was 1:0.32 (Table VI). A large difference in sex ratios was observed among different months. The peak percentage of males appeared in February (1:0.60) compared to January (1:0.21).

Table IV.- The home range of *Mergus squamatus* at Yihuang in different time from 2012-2013 (Unit/ m²).

Time	December	January	February	March	Average
Forenoon	33375 ± 17713 (20850~45900)	74208 ± 28904 (47430~103000)	119310 ± 59677 (60060~179400)	56175 ± 35688 (13200~86320)	69416 ± 42711 (13200~179400)
Noon	66500 ± 1669 (65320~67680)	33484 ± 23980 (990~54990)	59709 ± 45583 (16500~128700)	43806 ± 15282 (16800~52195)	48117 ± 29644 (990~128700)
Afternoon	79254 ± 61079 (16500~155310)	45180 ± 31908 (18430~89856)	63245 ± 40298 (47905~128700)	60810 ± 29306 (28800~67310)	62274 ± 40655 (16500~128700)

Table V.- Statistics of four group types in Mixed sex group of *Mergus squamatus* at Wuyuan from 2015-2016.

Group types	December	January	February	March	Total
Group with one male and one female	10(11.49%)	19(30.65%)	29(21.64%)	4(9.30%)	62(19.02%)
More females	66(75.86%)	39(62.90%)	52(38.31%)	32(74.42%)	189(57.98%)
Less females	1(1.15%)	2(3.23%)	10(7.46%)	0(0.00%)	13(3.99%)
Female equal to male (excluding Group with male-female pairs)	10(11.49%)	2(3.23%)	43(32.09%)	7(16.28%)	62(19.02%)
Total	87(100%)	62(100%)	134(100%)	43(100%)	326(100%)

Fig. 3. Group size of *Mergus squamatus* in Yihuang from 2015-2016.**Table VI.- The sex ratio of *Mergus squamatus* in different months from 2012-2013 and 2015-2016.**

Gender	Dec.	Jan.	Feb.	Mar.	Total
Male	3/4*	5/3*	5/6*	5/4*	18/17*
Female	5/17*	8/14*	19/10*	7/12*	39/53*
(F+Sub):M)	1:0.60 / 1:0.24*	1:0.63 / 1:0.21*	1:0.26 / 1:0.60*	1:0.71 / 1:0.33*	1:0.46 / 1:0.32*

Note, The number with * means data from 2015-2016 contrary to 2012-2013.

DISCUSSION

Daily travel distance and home range of scaly-sided merganser

Scaly-sided merganser is an endangered species and existing populations contain few individuals. Therefore, using launchers to measure the home range of this species involves a high risk to these populations. Scaly-sided merganser has a relatively small home range during the entire wintering period, so this provides an opportunity to monitor the travel distance and home range of these birds

without using launchers. The overall home range of Scaly-sided Merganser was about 0.2 km² during the wintering period, and this was similar with Hazel Grouse *Tetrastes bonasia*, (0.293–0.417 km²) and Green Peafowl *Pavo muticus*, (0.313–0.557 km²) (Sun and Fang, 1997; Yang et al., 1997). Scaly-sided merganser has a relatively constant home range in other locations in Jiangxi with a size of about 8 km². This fact may be related to the lack of suitable habitat and the specific ecological requirements of the species. Birds living in land environments have different constraints on food resources to those of aquatic birds. For example, mergansers consume local fish resources on a small scale and fish from other riverine reaches resupply the local food source quickly. Therefore, the scaly-sided merganser can thrive in a comparatively small home range during the overwintering period. Further studies should focus on the relationship between so small home range and its endangered status. The significant correlation between daily home range and daily minimum temperature may be related to the energy requirements of mergansers or to prey activities. Understanding the relationship between habitat selection of scaly-sided merganser and food resources will require further research.

Daily travel distance and home range showed the temporal variations in our study. The largest daily travel distance and home range were recorded in February, probably because of the increased frequency of human activity during spring festival celebrations in China. Human activities have an effect on the foraging time and flushing distance of these birds (Yang *et al.*, 1997), which could markedly reduce foraging time. To meet daily energy requirements, Scaly-sided Merganser has to fly to areas where there is less human activity, which unavoidably leads to longer flushing distances, daily travel distances and home ranges (Baines *et al.*, 2005; Yang *et al.*, 2005).

Group characteristics of scaly-sided merganser

Large flocks of scaly-sided merganser were less frequently observed than small flocks. Being in small flocks may reduce competition among individuals and ensure that every individual acquires the largest possible benefit from flocking behavior (Sun and Fang, 1997). Throughout the day, the group size of scaly-sided merganser showed extremely significant differences, which were inseparable from its ecological habits, such as dispersed foraging, collective maintenance and rest. Scaly-sided Merganser was found foraging in small dispersed flocks at 7:00–9:00. Large flocks were recorded while resting and loafing at 12:00–13:00 and 16:00–17:00. Foraging in small flocks can reduce the competition among different individuals. And rest in large flocks can reduce the alert time and the probability to be predated (Sun and Fang, 1997; Shao *et al.*, 2012).

In the mixed-sex groups the percentage of groups with more females and juveniles was higher in the early wintering period (December) and late wintering period (March) compared with the middle wintering period (Table V). This differs from the results reported by Shao *et al.* (2010) and (2012). The sex ratio of Scaly-sided Merganser was also different in different months. The sex ratio we observed in February was similar to the results reported as 1:0.61 by Liu *et al.* (2008) and 1:0.63 by Shao *et al.* (2010) in December. The general rule about sex ratio perhaps needs more long-term data in the future. Future studies are necessary, and the main goal should be focus on sex ratio, mortality and sex ratio at birth.

CONCLUSION

This study provided the first detailed description of the daily travel distance, home range and group characteristics of scaly-sided merganser in Yihuang and Wuyuan counties. Our results determined the average daily travel distance, home range and found no significant difference for the daily travel distance in different months. We found

significant differences in the daily home range in different months. The significant correlation between daily home range and daily minimum temperature may be related to energy requirements or prey activities. We determined the group size of the scaly-sided merganser and found the significant differences existed at different time of day, which was related to the daily habits of this species, such as dispersed foraging, collective maintenance and rest. We found significant difference in group size in all months. The main group of the scaly-sided merganser is group with a majority of females. The actual ratio of [(adult + sub-adult male): (adult + sub-adult female)] was 1:1.44 (n = 22) in February. This study provided basic data for future conservation efforts of this species.

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Conflict of interest statement

We declare that we have no conflict of interest.

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