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Sex Ratios and Age Structure of Several Waterfowl Species Wintering at Poyang Lake, China

Mingqin Shao,*[1] Bin Chen,[1] Peng Cui,[2] Nianhua Dai[3] and Hongyu Chen[1]
[1]*College of Life Science, Jiangxi Normal University, Nanchang, Jiangxi, 330022, China*
[2]*Nanjing Institute of Environmental Sciences, Ministry of Environmental Protection, Nanjing 210042, China*
[3]*Institute of Biological Resources, Jiangxi Academy of Sciences, Nanchang, Jiangxi, 330096, China*

ABSTRACT

The sex ratios of four dabbling duck species were investigated by point count method during the wintering period between October and the following April from 2012 to 2014 at 45 survey sites of Poyang Lake. From October 2013 to April 2014, the age structure of the Tundra Swan was surveyed by point count method at 45 survey sites of Poyang Lake. In middle wintering stage (from December to February), the sex ratio of common teal *Anas crecca* (60.66% male, n=361) was male-biased while falcated duck *Anas falcata* (52.10%, n=286), mallard *Anas platyrhynchos* (50.00%, n=90) and Eurasian wigeon *Anas penelope* (49.18%, n=183) were near parity. The male ratio of common teal, falcated duck and Eurasian wigeon all showed a tendency of initially increasing and later decreasing throughout the wintering period while mallard showed a continuous growth trend. The male-biased sex ratios in the common teal may be owing to increased female mortality on both breeding and wintering grounds. The intra-seasonal differences in sex ratios for all the ducks can be partly attributed to earlier arrival of males to wintering areas closer to breeding areas, while females and juveniles head further south. There were greater numbers of females for all the ducks in the early wintering stage (from October to November) and the male ratio increased again in the middle wintering stage, which shows that females arrive at winter areas before males in Poyang Lake. Tundra Swan *Cygnus columbianus* had relative high juvenile percentage (28.27%, n=3130). In the early wintering and spring migration stages (from March to April), the proportions of juveniles were significantly higher than in the middle wintering stage. This may indicate that family groups with young ones arrived at Poyang Lake to winter before those who did not participate or failed to breed, but returned later to breeding grounds, knowledge about this can provide guidance to management task.

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MS designed the study, MS, BC and PC collected and analyzed the field data. MS and BC wrote the manuscript.

Key words
Sex ratios, age structure, several waterfowl species.

INTRODUCTION

Knowledge about the sex ratio within an animal population is important to predict population dynamics, and to understand the relative arrival times of males or females at wintering grounds, and sex ratio allocation strategy (Donald, 2007; Shao *et al.*, 2012a; Clausen *et al.*, 2013). The majority of Anatidae are monogamous (93%), but the sex ratio of most Anatidae is not 1:1. Although males outnumber females by about 30% on the whole (Qian and Zhu, 1980; Ohde *et al.*, 1983; Donald, 2007; Sha, 2011; Humburg, 2015), sex ratios are more balanced for some species (Bellrose *et al.*, 1961; Donald, 2007). Sex ratios are significantly unbalanced among various species, such as the Mandarin Duck *Aix galericulata* (67.74% male), the Baikal Teal *Anas formosa* (14.53–25.93% male), the Spot-billed Duck *Anas poecilorhyncha* (59.55–74.62% male) and the Scaly-sided Merganser *Mergus squamatus* (42.53% male) (Qian and Zhu, 1980; Sun *et al*., 2011; Shao *et al.*, 2012b). The same species inhabiting different areas also have disparate sex ratios; the percentage of male Eurasian wigeons *Anas penelope* is 60% in Denmark and 35–38% in Tai-hu Lake (Qian and Zhu, 1980; Clausen *et al*., 2013), for example. The sex ratio of Anatidae varies depending on competition between sexes and female-biased mortality rate (Ohde *et al.*, 1983; Jorde *et al*., 1984; Owen and Dix, 1986; Sun *et al.*, 2011), maturity or reproductive age (Humburg, 2015), habitat type (Owen and Dix, 1986), weather conditions (Jorde *et al*., 1984) and human hunting (Guillemain *et al.*, 2013; Christensen and Fox, 2014). A biased sex ratio will lead partly monogamous individuals not to participate in reproduction.

Knowledge about the age structure of populations is important for forecasting future population dynamics (Sun, 2001). In general, the juvenile proportion of the Swan (*Cygnus* spp.) ranges from 10% to 30% during wintering period across the species' range (Rees *et al*., 1997; Huggins, 2009; Beekman and Tijsen, 2015). Age structure varies across time, territories and habitat types (Rees *et al*., 1997; Laubek *et al*., 1999; Pacific Flyway Council, 2001; Huggins, 2009; Dai *et al*., 2013; Beekman and Tijsen, 2015). The regional variation in the percentage of juveniles in a population can be correlated with food supply and safety in different habitats (Rees *et al*., 1997). Temporal variation in the percentage of juveniles can also

* Corresponding author: 1048362673@qq. Com
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reflect migration patterns of individuals in different age classes (Rees *et al*., 1997).

In this paper, we monitored the sex ratios of four species of waterfowl (Common Teal *Anas crecca*, falcated duck *Anas falcata*, mallard *Anas platyrhynchos*, and Eurasian wigeon) and the age structure of one species of waterfowl (Tundra Swan *Cygnus columbianus*) wintering at Poyang Lake, Jiangxi Province, China. The common teal mainly breeds in Europe and northern Asia; the falcated duck mainly breeds in southeast Siberia, Russia and northeast Asia; the Mallard and Tundra swan mainly breed in northeastern China; and the Eurasian wigeon breeds in northern Eurasia (Zhao, 2001). Among these species, the falcated duck is classified as "near threatened" (IUCN) and the Tundra swan is currently listed as a Class II protected species under Chinese law (Birdlife International, 2008; Zheng and Wang, 1998). In recent years, the populations of these species all showed moderately declines in China due to very high levels of habitat loss (Birdlife International, 2008). The objectives of this study were a) to identify variation in the sex ratios in four duck species, and the age structure of Tundra swan in Poyang Lake; b) to estimate the time arrival at wintering grounds and departure from wintering grounds of waterfowl species of both sexes at various age stages; and c) to understand and predict future population dynamics in the above mentioned species.

MATERIALS AND METHODS

Study area

Poyang Lake is the largest freshwater lake in China. Located in the north of Jiangxi Province, the lake comprises an average water area of 3900 km^2 and is formed by the Ganjiang, Fuhe, Xiuhe, Xinjiang and Raohe rivers (Shao *et al*., 2012b; Shao *et al*., 2014c). The study area has a subtropical climate, with an annual average temperature of 16.7−17.7 °C, precipitation of 1,400−1,900 mm and sunshine for 1885 h (Dai *et al*., 2014; Shao *et al*., 2014d). Because it is rich in food resources, Poyang Lake is suitable habitat, attracting approximately 500,000 water birds during the wintering period each year (Shao *et al*., 2014c). In this study, we chose 45 survey sites in different areas of Poyang Lake, which included seven sites (such as Banghu, Dahuchi and Shahu) in Poyanghu National Nature Reserve (PYH); eight sites (including Zhanbeihu, Changhu) in Nanjishan Wetland National Nature Reserve (NJ) and adjacent Sanhu and Lingchonghu; 11 sites (including Binhu, Zhongba and Huangjinzui) in Duchang Migratory Bird Provincial Nature Reserve (DC); and 14 sites (including Chemen, Dalianzihu and Roangqicun) in East Poyang Lake National Wetland Park (PY) and Poyang Lake Silver Fish Spawning Grounds Provincial Nature Reserve (YY), and adjacent Jinxihu, Qinglanhu and Junshanhu (Fig.1).

Field data collection

The sex ratios of four dabbling duck species were investigated by point count method during the wintering period between October and the following April from 2012 to 2014 at 45 survey sites of Poyang Lake. From October 2013 to April 2014, the age structure of the Tundra Swan was surveyed by point count method at 45 survey sites of Poyang Lake. According to the migration of Anseriformes in Poyang Lake, we divided the wintering period into early wintering stage (from October to November), middle wintering stage (from December to February) and spring migration stage (from March to April) (Shao *et al*., 2014). Six to 12 searches were conducted at the five subareas during the wintering period. In early wintering stage, NJ was investigated four times, PY and YY were each surveyed three times, PYH was surveyed twice and DC was surveyed once. In the middle wintering stage, PYH and NJ were both surveyed six times, DC was surveyed four times, PY was surveyed three times, and YY was surveyed once. In spring migration stage, DC and PY were each surveyed three times, and PYH, NJ and YY were each surveyed twice.

Statistical analysis

We calculated the sex ratios and age structure of all Anseriformes and then carried out Chi-squared tests. p-values < 0.05 were considered significant and p-values < 0.01 were considered extremely significant. All statistical analyses were completed in Excel 2003 and SPSS 20.0.

RESULTS

Sex ratios

From a total of 121 surveys, we recorded 771 Common Teals whose sex could be identified. The proportion of males (52.27%) was slightly higher than females. The male ratio showed a tendency of initially increasing and later decreasing throughout the wintering period, and extremely significant differences were in different stages (P<0.001). In the early wintering stage, the ratio of males (22.41%, n=58) was extremely significantly lower than that of females (χ^2=17.655, P<0.001) versus the middle wintering stage (60.66%, n=361; χ^2=16.424, P<0.001). In the spring migration stage, the ratio of males (48.58%, n=352) was similar to that of females (Table I).

From a total of 101 surveys, we recorded 754 falcated ducks whose sex could be identified. The proportion of males (46.29%) was significantly lower than females (χ^2=4.159, P=0.041). The male ratio showed a tendency of initially increasing and later decreasing

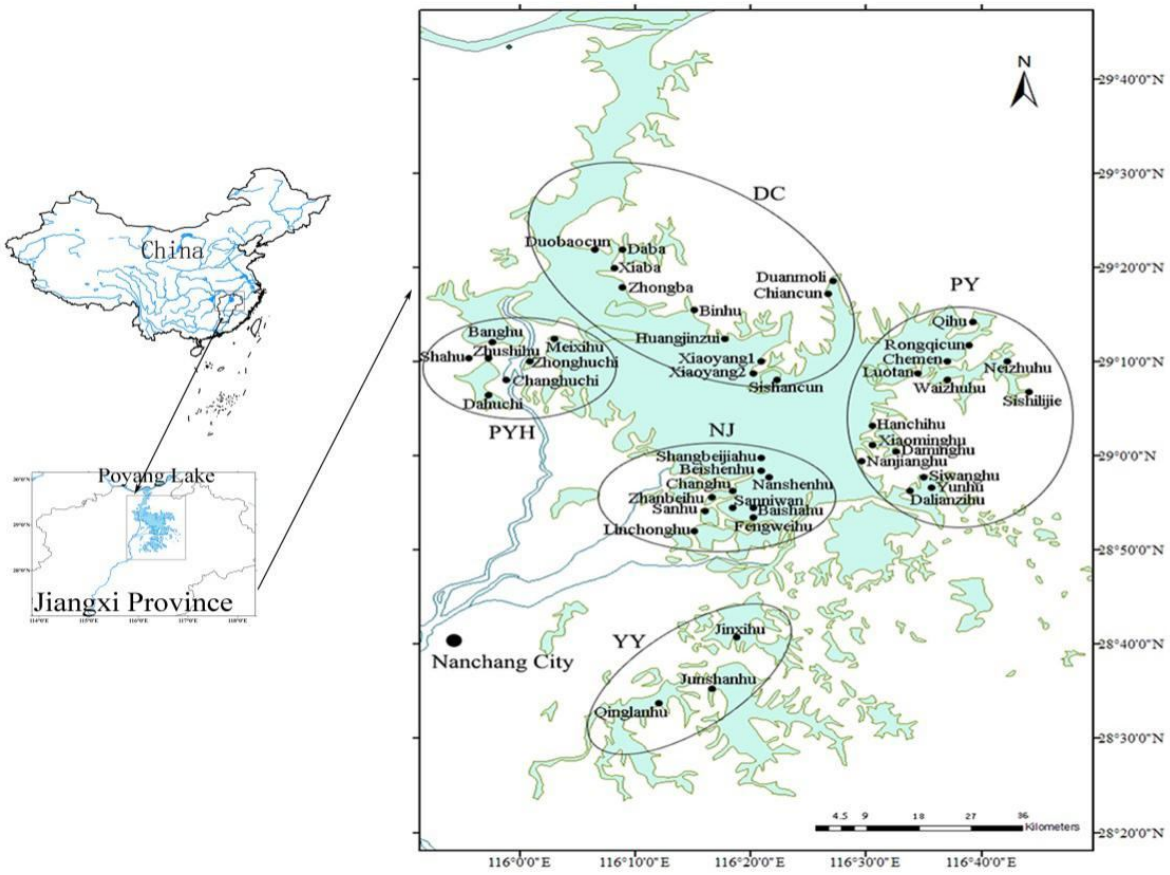

Fig. 1, Survey sites of several waterfowl species around Poyang Lake.

Table I.- Sex ratios of 4 dabbling duck species wintering at Poyang Lake during 2012 to 2014.

Species	Stage	N	% of Male
Common teal (*Anas crecca*)	Early wintering stage	58	22.41%
	Middle wintering stage	361	60.66%
	Spring migration stage	352	48.58%
	Total	771	52.27%
Falcated duck (*Anas falcata*)	Early wintering stage	335	40.60%
	Middle wintering stage	286	52.10%
	Spring migration stage	133	48.12%
	Total	754	46.29%
Mallard (*Anas platyrhynchos*)	Early wintering stage	105	44.76%
	Middle wintering stage	90	50.00%
	Spring migration stage	26	57.69%
	Total	221	48.42%
Eurasian wigeon (*Anas penelope*)	Early wintering stage	9	33.33%
	Middle wintering stage	183	49.18%
	Spring migration stage	0	
	Total	192	48.44%

throughout the wintering period. The percentage of males in the middle wintering stage was extremely significantly higher than in the early wintering stage (P=0.004). In the early wintering stage, the ratio of males (40.60%, n=335) was extremely significantly lower than that of females (P=0.001). In the middle wintering stage, the ratio of males (52.10%, n=286) was slightly greater than that of females. In the spring migration stage, the ratio of males (48.12%, n=133) was slightly less than that of females (Table I).

From a total of 74 surveys, we recorded 221 mallards whose sex could be identified. The proportion of males (48.42%) was slightly lower than females. From a total of 38 surveys, we recorded 192 Eurasian wigeons whose sex could be identified. The proportion of males (48.44%) was slightly lower than females (Table I).

Age structure

From a total of 485 surveys, we recorded were 3130 Tundra Swans whose age could be identified. The juvenile ratio was 28.27%. The proportion of infancy showed

extremely significant declines from the early wintering stage (31.50%, n=635) to the middle wintering stage (P=0.024), then slight increases (P=0.091) from the middle wintering stage (26.92%, n=2221) to the spring migration stage (31.75%, n=274). The percentage of juveniles in the early wintering stage was similar to that in the spring migration stage (P=0.939) (Table II).

Table II.- Changes of age distribution of Tundra Swan *Cygnus columbianus* wintering at Poyang Lake during 2013 to 2014.

Area	Stage	N	Juvenile (%)
PYH [b]	Early wintering stage	219	27.40%
	Middle wintering stage	683	29.43%
	Spring migration stage	1	0.00%
	Total	903	28.90%
DC [b]	Early wintering stage [b]	240	24.58%
	Middle wintering stage [b]	310	26.77%
	Spring migration stage [A]	146	47.95%
	Total	696	30.46%
PY [C]	Early wintering stage [a]	9	55.56%
	Middle wintering stage [B]	568	16.37%
	Spring migration stage [B]	127	13.39%
	Total	704	16.34%
YY	Early wintering stage	32	34.40%
	Middle wintering stage	30	40.00%
	Spring migration stage	0	
	Total	62	37.10%
NJ [a]	Early wintering stage [a]	135	48.15%
	Middle wintering stage [B]	630	33.17%
	Spring migration stage	0	
	Total	765	35.82%
Total	Early wintering stage [a]	635	31.50%
	Middle wintering stage [b]	2221	26.92%
	Spring migration stage [ab]	274	31.75%
Total		3130	28.27%

The juvenile ratio of Tundra Swans showed much variation in different areas. We removed YY for its small sample (37.10%, n=62). The proportion of infancy in PY was extremely significantly lower than in PYH (P=0.000). The infancy ratio in PYH was slightly lower than in DC (P=0.024) and the infancy ratio in DC was significantly lower than in NJ (P=0.005). In DC, the infancy ratio showed extremely significant increases from the middle wintering stage to the spring migration stage (P<0.001). In PY (P=0.002) and NJ (P=0.001), the juvenile ratio showed extremely significant declines from the early wintering stage to the middle wintering stage (Table II).

DISCUSSION

Sex ratios

In this paper, we regarded sex ratio in the middle wintering stage as the actual sex ratio for one species because of the effect of the arrival and departure time of males and females in the early wintering and spring migration stages. In Poyang Lake, the sex ratio of the common teal was different from that in Tai-hu Lake, yet similar to that in the US, UK and Denmark, suggesting that the sex ratio of the Common Teal was male-biased. The sex ratio of the falcated duck in Poyang Lake was partly similar to that in Tai-hu Lake, indicating that the falcated duck may favor a more balanced sex ratio structure. The sex ratio of mallards in Poyang Lake was partly similar to that in Tai-hu Lake, but slightly different from those in the UK, US and Denmark, which were male-biased. Although two-thirds of hunted mallards were male in the US, 52.5% of the population in midland during spring comprised males (Humburg, 2015). Some scholars have tried to balance the sex ratio of mallards in Iowa. They removed 117 males and added 45 females, but after a period of time there was no significant influence on sex ratio, which showed that man-made interference had no significant effects on the sex ratio of mallards (Ohde *et al*., 1983). The high-energy requirement and drastic competition for scarce food during wintering may be responsible for the biased sex ratio in Nebraska (Jorde *et al*., 1984). Therefore, the abundant food resources and smaller intraspecific competition may be responsible for the balanced sex ratio of mallards in Poyang Lake. The sex ratio of Eurasian wigeons in Poyang Lake was balanced and had slight differences compared with the female-biased sex ratio in Tai-hu Lake and the male-biased sex ratio in the UK and Denmark (Table I, III).

None of the ducks in this study had breeding populations in Poyang Lake. Biased sex ratios at wintering sites may be caused by a shift in wintering grounds of males and females. The male-biased sex ratios in the common teal may be owing to increased female mortality on both breeding and wintering grounds. Intra-seasonal differences in sex ratios for all the ducks can be partly attributed to earlier arrival of males to wintering areas closer to breeding areas, while females and juveniles head further south. However, the specific mechanism remains unclear; therefore, it is difficult to interpret this data. To achieve the objective of protecting waterfowl species, there are many remaining problems that require further study.

There were greater numbers of females for all the ducks in the early wintering stage and the male ratio increased again in the middle wintering stage, which shows that females arrive at winter areas before males in Poyang Lake. This phenomenon is contrary to the Eurasian wigeon whose males leave breeding grounds before females in Denmark, and the scaly-sided merganser whose males arrive before females to winter areas in

Table III.- Literature data of sex ratios of 4 dabbling duck species.

Species	Area	% of male	References
Common teal	Tai-hu Lake	41.18%,22.48%	Qian and Zhu, 1980
	US	72.9%,57.5%,52.2%	Bellrose *et al*., 1961
	UK	53.50%	Owen and Dix, 1986
	Denmark	56%	Christensen and Fox, 2014
Falcated duck	Tai-hu Lake	48.98%,40.83%	Qian and Zhu, 1980
Mallard	Tai-hu Lake	51.29%,38.65%	Qian and Zhu, 1980
	UK	55.60%	Owen and Dix, 1986
	US	73.54%,61.24%,62.3%,60.8%	Jorde *et al*., 1984
	Denmark	63-68%	Christensen and Fox, 2014
Eurasian wigeon	Tai-hu Lake	35.90% ,37.89%	Qian and Zhu, 1980
	UK	57.80%	Owen and Dix, 1986
	Denmark	60%	Clausen *et al*., 2013

Poyang Lake (Shao *et al*., 2012a; Clausen *et al*., 2013). The reason for this phenomenon might be that males in these species winter closer to the breeding grounds in order to arrive earlier at breeding territories in spring.

Age structure

In this survey, the juvenile ratio of Tundra swans was slightly less than the wintering period between 2012 and 2013 in Poyang Lake (29.04%) (Dai *et al*., 2013) but more than the *bewickii* subspecies in the UK and Ireland (17.57%), Europe (Poland, Germany, Denmark, Holland, Belgium and UK) (13.9%) and northern US (11.5–12.7%) (Huggins, 2009; Beekman and Tijsen, 2015). A higher proportion of juveniles may suggest a stable or growth trend of this population in Poyang Lake in the future.

In the early wintering and spring migration stages, the proportions of juveniles were significantly higher than in the middle wintering stage. This may indicate that family groups with young arrived at Poyang Lake to winter before those who did not participate or failed to breed, but returned later to breeding grounds (Rees *et al*., 1997). A variety of cranes in Poyang Lake also showed such characteristics, such as the common crane *Grus grus* whose juvenile ratio in the early wintering stage (October: 45.45%; November: 26.91%) was significantly higher than in middle wintering and spring migration stages (Shao *et al*., 2014a). In the spring migration stage, the juvenile ratio of the Siberian crane (42.86%) and the hooded crane (40.00%) was significantly higher than in the early wintering and middle wintering stages (Shao *et al*., 2014b).

In our surveys conducted during the wintering period between 2012 and 2013, the number of Tundra swans in PY accounted for over 56% of the overall populations in Poyang Lake, which indicates that PY is an important wintering habitat for this species in Poyang Lake (Dai *et al*., 2013). However, our results showed that the juvenile ratio of PY in the middle wintering stage (16.89%) and spring migration stage (13.40%) was significantly less than other areas and showed continuous decline during the wintering stage. This shows that the population of Tundra swans in this area is fragile, and that protective measures should be adopted to protect this species.

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REFERENCES

Beekman, J.H. and Tijsen, W., 2015. *International annual bewicks swan age count 2013*, 7-8 December 2013. www.birdwatching.pl/userfiles/file/Antoni Marczewski/ International Annual Bewick.

Bellrose, F. C., Scott, T. G., Hawklins, A. S. and Low, J. B., 1961. Sex radios and age radios in northern American ducks. *Natural History Survey Division*, **26**: 404-408.

Birdlife International, 2008. Anas falcate. In: *IUCN2009. IUCN red list of threatened Species.*

Christensen, T. K. and Fox, A. D., 2014. Changes in age and sex ratios amongst samples of hunter-shot wings from common duck species in Denmark 1982-2010. *Eur. J. Wildl. Res.*, **60**: 303-312.

Clausen, K. K., Dalby, L., Sunde, P., Christensen, T. K., Egelund, B. and Fox, A. D., 2013. Seasonal variation in Eurasian wigeon *Anas penelope* sex and age ratios from hunter-based surveys. *J. Ornithol.*, **154**: 769-774.

Dai, N.H., Shao, M.Q., Jiang, L.H., Du, J.H., Jiang, J.H. and Zeng, B. B., 2013. A preliminary investigation on the population and behavior of the Tundra Swan (*Cygnus columbianus*) in Poyang Lake. *Acta Ecol. Sin.*, **33**: 5768-5776.

Dai, N.H., Shao, M.Q., Jiang, J.H. and Guo, H., 2014. The preliminary study on bird diversity during non-breeding period of Poyang Lake region in Gongqingcheng City. *J. Jiangxi Norm. Univ.(Nat. Sci. edition)*, **38**: 19-25.

Donald, P. F., 2007. Adult sex ratios in wild bird populations. *Ibis*, **149**: 671-692.

Guillemain, M., Fox, A. D., Pöysä, H., Väänänen, V. M., Christensen, T.K., Triplet, P., Schricke, V. and Nievergelt, F. K., 2013. Autumn survival inferred from wing age ratios: Wigeon juvenile survival half that of adults at best?. *J. Ornithol.*, **154**: 351-358.

Huggins, E., 2009. *Productivity surveys of geese, swans and brant wintering in North America 2009*. Department of the Interior U. S. Fish and Wildlife Service and Division of Migratory Bird Management Arlington. Virginia:

Humburg, D., 2015. *A variety of factors influence the proportion of males and females in waterfowl populations.* www.ducks.org/conservation/waterfowl-biology/waterfowl-sex-ratios.

Jorde, D.G., Krapu, G. L., Crawford, R.D. and Hay, M.A., 1984. Effects of weather on habitat selection and behavior of mallards wintering in Nebraska. *Condor*, **86**: 258-265.

Laubek, B., Nilsson, L., Wieloch, M., Koffijberg, K., Sudfeldt, C. and Follestad, A., 1999. Distribution, numbers and habitat choice of the NW European whooper swan *Cygnus cygnus* population: results of an international census in January 1995. *Vogelwelt-Berlin*, **120**: 141-154.

Ohde, B. R., Bishop, R.A. and Dinsmore, J. J., 1983. Mallard reproduction in relation to sex ratios. *J.Wildl. Manage.*, **42**: 118-126.

Owen, M. and Dix, M., 1986.Sex ratios in some common British wintering ducks. *Wildfowl*, **37**: 104-112.

Pacific Flyway Council, 2001. *Pacific flyway management plan for the western population of tundra swans.* Pacific Flyway Study Comm., Subcomm. on Tundra Swans. Unpubl. Rept. [c/o USFWS], Portland, OR. 28 pp.+ appendices.

Qian, G. Z. and Zhu, J. X., 1980. A community study on wild ducks wintering in Tai-hu Lake with referauce to seasonal succession and basis of community kinetic. *J. E. China Norm. Univ. (Nat. Sci.)*, **26**: 39-57.

Rees, E.C., Kirby, J. S. and Gilburn, A., 1997. Site selection by swans wintering in Britain and Ireland; the importance of habitat and geographic location. *Ibis*, **139**: 337-352.

Sha, J. B., 2011. *Time budget and activity rhythm of breeding gadwall (*Anas strepera*) during day and behavior differences between genders*. Haerbin: Northeast Forestry University.

Shao, M.Q., Jiang, J.H., Dai, N.H. and Liao, Z. Y., 2014a. Population sizes and flocking features of wintering common cranes and white-naped cranes in Poyang Lake. *J. Ecol. Rural Environ.*, **30**: 464-469.

Shao, M. Q., Guo, H. and Jiang, J. H., 2014b. Population sizes and group characteristics of Siberian crane (*Leucogeranus leucogeranus*) and hooded crane (*Grus monacha*) in Poyang Lake Wetland. *Chinese Zool. Res.*, **35**: 373-379.

Shao, M. Q., Jiang, J. J., Guo, H. and Zeng, B. B., 2014c. Abundance, distribution and diversity variations of wintering water birds in Poyang Lake, Jiangxi Province, China. *Pakistan J. Zool.*, **46**: 451-462.

Shao, M. Q., Shi, W. J., Zeng, B. B. and Jiang, J. H., 2014d. Diving behavior of scaly-sided merganser, *Mergus squamatus* in Poyang Lake watershed, China. *Pakistan J. Zool.*, **46**: 284-287.

Shao, M. Q., Zeng, B. B., Shang, X. L., Chen, L. X., You, C.Y. and Dai, N. H., 2012a. Group characteristics of Chinese Merganser (*Mergus squamatus*) during the wintering period in Poyang Lake watershed, Jiangxi Province. *Acta Ecol. Sin.*, **32**: 3170-3176.

Shao, M. Q., Zeng, B. B., Tim, H., Chen, L.Y., You, C. Y., Wang, H. B. and Dai, N. H., 2012b. Winter ecology and conservation threats of scaly-sided Merganser *Mergus squamatus* in Poyang Lake watershed, China. *Pakistan J. Zool.*, **44**: 503-510.

Sun, R. Y., 2001. *Principle of animal ecology (Third edition)*. Beijing Normal University Press, Beijing.

Sun, Y. H., Bridgman, C. L., Wu, H.L., Lee, C.F., Liu, M., Chiang, P. J. and Chen, C.C., 2011. Sex ratio and survival of mandarin ducks in the Tachia River of central Taiwan. *Waterbirds*, **34**: 509-513.

Zhao, Z.J. 2001. *A handbook of the birds of China.* Jilin Science and Technology Press, Changchun.

Zheng, G. M. and Wang, Q. S., 1998. *China red data book of endangered animals (Aves).* Science Press, Beijing.