

# Abundance and distribution of wintering Scaly-sided Mergansers *Mergus squamatus* in China: where are the missing birds?

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## Summary

The Endangered Scaly-sided Merganser *Mergus squamatus* is amongst the most threatened of sea ducks (Mergini), with an estimated population of c.4,600 individuals based on a recent population estimate on the breeding areas in Primorye, Far East Russia, China and DPR Korea. For the first time, we present published and unpublished data on the wintering distribution in China and smaller numbers in Korea. We report 156 sightings during 2000–2011, together with 11 records of wintering sites using geolocation devices, from 16 provinces in China, with greatest concentrations in Jiangxi Province (97 reports from 18 sites). Both sources of data suggest some degree of winter site fidelity to fast-flowing clear water rivers 50–350 m wide, with riffles, islands or sand banks in hilly/mountainous areas with low levels of human disturbance. Surveys located a maximum of 370–770 birds, 8–17% of the estimated total population, confirming our poor knowledge of the species' wintering distribution. There is an urgent need to define the wintering range of this species which is widely dispersed and nowhere abundant, but is threatened everywhere by dam construction, sand and gravel extraction, industrial and domestic pollution and fishing that threaten the integrity of the winter habitat. This also raises important conservation questions about how to protect such a species that is not highly concentrated and may require catchment scale nature conservation actions to effectively safeguard its current distribution.

## Introduction

The Scaly-sided Merganser *Mergus squamatus* is one of the most threatened sea duck species of the tribe Mergini (IUCN 2010) with an estimated global population of less than 3,000 breeding pairs, numbering between 2,500 and 10,000 individuals (Hughes and Hunter 1994, Shokhrin and Solovieva 2003, Solovieva *et al.* 2006, Solovyeva *et al.* 2012). Based on field surveys, a recent estimate suggests that the global population size of this species is c.1,900 pairs, or c.4,600 individuals on breeding areas, which are mainly distributed in the Sikhote-Alin' Mountains and Changbai Mountains (Figure 1; Solovyeva *et al.* in press). But the wintering distribution of Scaly-sided Mergansers remains poorly understood.

Although very small numbers of Scaly-sided Mergansers are thought to winter in Korea, Japan and Taiwan, most of the population is believed to spend the non-breeding season on lakes and rivers in central and southern China (Kear 2005), yet few have ever been located here (He *et al.* 2002), mostly scattered single birds or small flocks, although flocks of up to 100 have been located in north-east Jiangxi (He *et al.* 2006). Recent winter records have mostly been from clear, fast-flowing rivers in hilly and mountainous areas (He *et al.* 2002, Cao and Barter 2006, 2008), apparently broadly similar to those used during the breeding season (Bocharnikov and Shibnyev

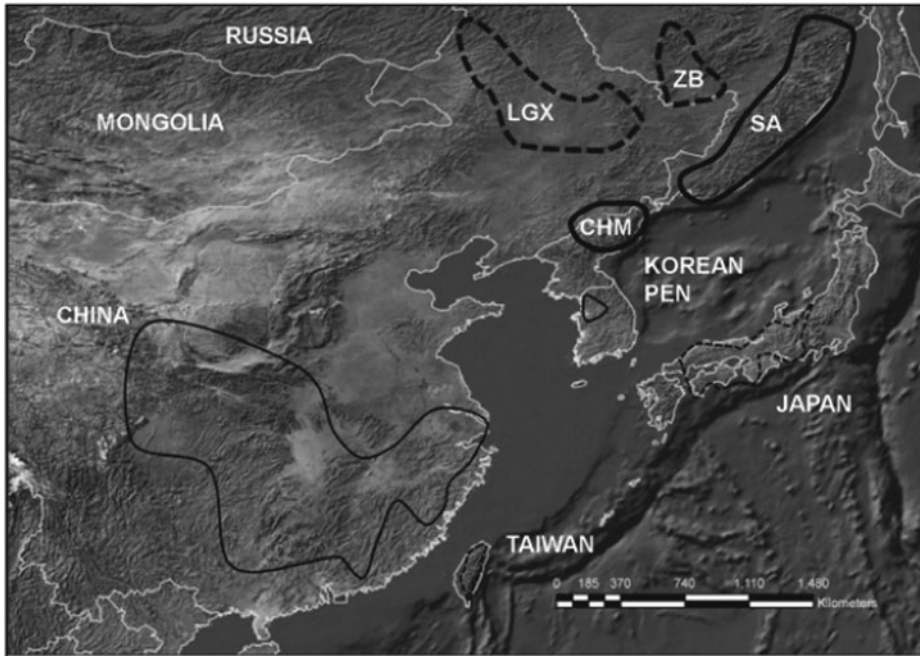


Figure 1. Breeding (defined by solid black line, top right) and non-breeding (defined by thinner black line) ranges of the Scaly-sided Merganser, adapted from map in BirdLife International (2010) and improved by authors. Formerly occupied or low density areas are defined within dotted lines, solid lines indicate current status as breeding/wintering areas. The four known extant or former breeding areas are: SA -Sikhote-Alin' Mountains, ZB - Zeya-Bureya, CHM -Changbai Mountains and LGX - Lesser and Greater Xingan Mountains.

1994, Zhao *et al.* 1994a), and in the autumn in North Korea (Duckworth and Kim 2005) and South Korea (N. Moores *in litt.*).

There has long been an urgent need to locate key wintering areas of the Scaly-sided Merganser (Zhao *et al.* 1994a, Kear 2005, BirdLife International 2010). This paper analyses records of wintering Scaly-sided Mergansers in China since 2000 to identify the current known wintering range and habitat preferences of the species, assesses the proportion of the estimated population that can be accounted for by known sightings and recommends where to focus future surveys.

## Methods

### *Historical sources and publications*

Observations and reports were collected from a wide variety of sources including published papers (mostly in Chinese) and reports, unpublished reports, China Crane News, China Bird Reports, China Birdwatch, internet reports and birdwatcher chat rooms (see Table S1 in the online Supplementary Material, with list of sources).

### *Special surveys*

Based on literature sources, it was evident that most records of Scaly-sided Merganser came from south-east China on moderate to fast flowing rivers in upland landscapes, away from major

centres of human habitation. For that reason, in February 2006 and January/February 2008, we chose to survey rivers and reservoirs that looked potentially suitable for the species based on Google Earth imagery in four provinces (Anhui, Jiangxi, Fujian and Guangdong) over 15 days. We focussed mainly on regions where few or no Scaly-sided Mergansers had been reported previously, covering a total river length of approximately 970 km (involving 22 rivers; Table S2) and visiting 11 reservoirs (coverage ranged from 5% to 80%, averaging 42%; Table S2, Figure 2). A variety of rivers in hilly/mountainous regions ranging from c.20 to 500 m wide (measured on Landsat ETM+ satellite images) and habitats were surveyed; most were fast flowing, many had sand banks and a few had emergent rocks (Figure S1); the majority of reservoirs visited were in hilly and mountainous areas (Figure S2).

Georeferenced Landsat ETM+ satellite images (EROS 2011) were used to locate suitable rivers and reservoirs for survey; rivers with reasonable accessibility were selected in hilly/mountainous regions; reservoirs were chosen that were close to the river survey route. Due to lack of topographic maps we relied heavily on GPS units (Garmin eTrex Summit HC, Garmin Int. Inc., Kansas) with pre-entered site coordinates, using Landsat ETM+ satellite images, to reach survey targets.

Surveys were conducted from roads and on foot along rivers and reservoirs, supplemented by boat hire to visit more remote sections of rivers on occasions and at one reservoir. Reservoir access was generally via the dam wall and was more challenging in hilly/mountainous areas, because of lack of roads, difficult terrain and dense vegetation in this subtropical region.

GPS track logs were recorded so that we could measure lengths of river surveyed and estimate reservoir coverage. Waterbirds were located using Zeiss 12 x 42 mm binoculars and Zeiss 80 mm x 20-60x telescopes; we recorded numbers of all waterbird species seen and their locations, and photographs were taken of Scaly-sided Merganser sites, riverine and reservoir habitats, along with local threats and stressors.

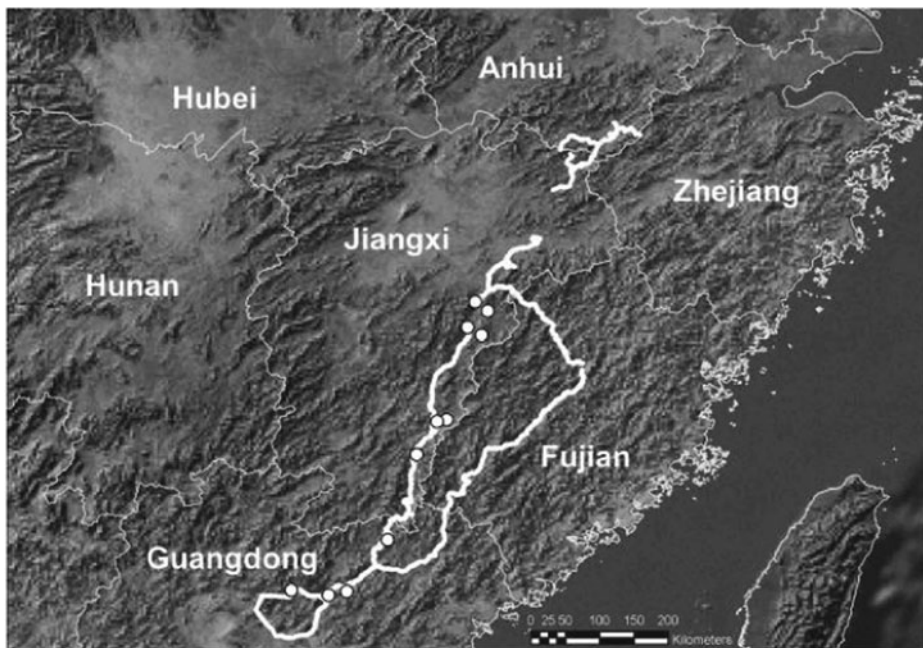


Figure 2. Survey routes followed in January–February 2006 and February 2008 during which a total of 21 rivers was visited; the locations of the 11 reservoirs visited are also shown. See Table S2 in the Supplementary Materials for further details.

We carried large coloured photographs of male and female Scaly-sided Mergansers to show to local people when enquiring whether they had observed the birds in their locality.

### *Geolocator logger data*

Twenty-one breeding Scaly-sided Merganser females at least two years old were fitted with Mk9 light level geolocators (2.5 g, British Antarctic Survey, Cambridge, CB3 0ET, United Kingdom) in 2006–2008 and with Mk11 geolocators (2.5 and 1.5 g, same manufacturer) in 2009 attached to engraved plastic tarsus rings by two cable ties secured through drilled holes (see Solovyeva *et al.* 2012). Birds were trapped at their nests in artificial or natural cavities along a 70-km stretch of the Kievka catchment (43.3°N 133.8°E, 18 females), as well as in the Avvakumovka (43.8°N 135.0°E, 2 females) and Margaritovka (43.5°N 134.7°E, 1 female) catchments in South Primorye, Russia (full details in Solovyeva *et al.* 2012). Some devices were re-used after completing a year of logging on other females after data download and deletion from the device memory.

Geolocators logged maximum measured visible light intensity in 10 min intervals (Mk9) or 2 min intervals (Mk11). Raw data files (containing precise time and light levels) were corrected for clock drift (1–3 min lost during deployment) and analysed using the TransEdit software (Fox 2010) to determine the sun elevation that corresponded with a particular light threshold level. Diurnal cycles were filtered with this software and visually verified to remove obvious anomalous shading events during daylight and lighting events during night. Light threshold levels were set to 32 for both sunrise and sunset, the median between minimum (0) and maximum (64) light levels.

We estimated latitude and longitude coordinates for each date using BirdTracker software (Fox 2010) to determine midnight and noon locations, although we only present data from the winter here. All positions generated by sunrises delayed by 15 min or more and sunsets advanced by 15 min or more compared to the previous and following days (considered unlikely to result from birds moving such distances within a day) were examined visually and deleted from location analyses to remove false “nights” caused by birds experiencing temporary dark conditions.

All geolocators were calibrated on the breeding areas and average sun elevation coefficients were used to process the raw data files using the Locator software (see Fox 2010, Solovyeva *et al.* 2012). It was very evident for all individuals when birds arrived at and departed from their winter quarters, based on sudden daily changes (or lack of these) in longitude, enabling definition of duration of stay and calculation of average winter coordinates.

### *Data treatment*

We have only used sightings and data logger information compiled since January 2000 as we wished to identify the current wintering range of the species; much information on the historical non-breeding range of the species can be found in Zhao *et al.* (1994a), BirdLife International (2001) and He *et al.* (2002). The dramatic increase in birdwatching activity in China within the last decade has increased sightings during this period. On occasions with more than one sighting on the same day at a site, we chose the highest count; if counts were identical we provide one citation.

Data to identify winter sites were limited to November–February because data from 10 females fitted with geolocators in a total of 17 seasons showed mean arrival in winter quarters on 11 November and departure 17 March (Solovyeva *et al.* 2012). A few March records were used where it was obvious that birds had not yet commenced migration. Where locations were given as reference to the nearest town, we used these coordinates to identify the bird’s position, although we consider this source of positional error is minor and has little impact on assessing the wintering distribution.

## Results

### *Wintering distribution and locations*

Between January 2000 and February 2011, we obtained details of 156 different sightings plus approximate positions of 11 records of eight individual birds carrying data loggers from 16 provinces throughout eastern China (Figure 3a, Table S1). The greatest concentrations occurred in south-east China, particularly in Jiangxi Province (where there were 97 sightings from 18 sites, Figure 3b). The records in north-east China confirm that some birds winter in this region. Scaly-sided Mergansers seem to be site faithful, with birds being recorded continuously, although in varying numbers, at several sites over a series of recent years.

Our 2006 and 2008 surveys located 71 Scaly-sided Mergansers at six sites, all on Jiangxi rivers (Table S2). Although these represented just 30% of the total river length surveyed in a total of four provinces, the species was confined to a relatively small area of north-east Jiangxi. Despite the extent of our survey of suitable habitat away from known sites, we only found two new sites (on the An Le He and on the Litan He); the other sightings were in locations at which the species had been previously recorded.

The mean latitude and longitude recorded by the geolocators on the eight females instrumented that provided good winter data are shown in Table S3. Three females gave data for more than one winter and all were within 25–150 km of each other in successive years, suggesting winter site fidelity to catchments if not specific sites.

Very few waterbirds of any species were seen along rivers ( $n = 1,489$ , including the 71 Scaly-sided Mergansers, i.e. about 1.5 birds/km), indicating that these habitats were generally unsuitable for waterbirds, despite long lengths of shallow edges and associated marshy areas.

### *Habitat characteristics*

The common habitat features of the merganser sites were flowing rivers with clear water and low disturbance levels. Interestingly, the three sites where we found the largest flocks, whilst all

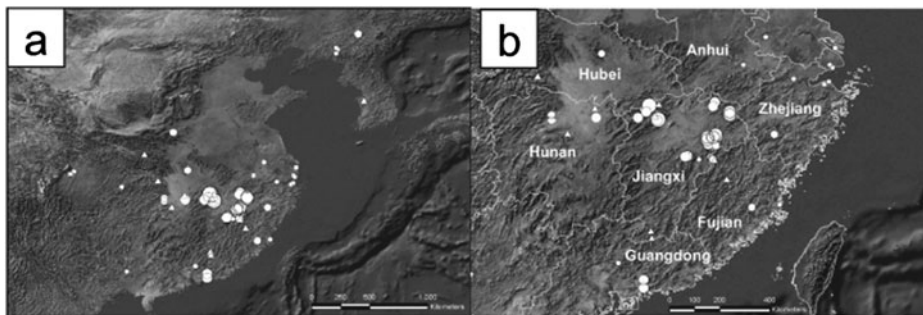


Figure 3. Distribution of wintering Scaly-sided Mergansers: (a) Locations of 126 records of wintering (November–February) Scaly-sided Mergansers reported during the January 2000–February 2011 period (circles) and approximate locations of birds carrying data loggers (triangles). Very large circles: 51–100 birds; large circles: 21–50 birds; medium circles: 6–20 birds; small circles: 1–5 birds. Note that birds occur in hilly and mountainous areas, avoiding the lowlands and major river floodplains; (b) Scaly-sided Merganser locations in Jiangxi and surrounding provinces, China during January 2000–February 2011: sightings – circles; triangles – birds carrying data loggers. Very large circles: 51–100 birds; large circles: 21–50 birds; medium circles: 6–20 birds; small circles: 1–5 birds. Note that birds occur in hilly and mountainous areas, avoiding the lowlands and major river floodplains.

having these habitat features, were quite different in nature: (a) below a dam with a power station (An Le He, 150 m wide), (b) on a pristine, relatively narrow river (Ta He, 80–150 m wide) flowing out of the mountains and (c) on a slower flowing wide river (Xin Jiang, 170–350 m wide) in a relatively flat region. Sites at which we found Scaly-sided Mergansers varied in elevation from 51–89 m asl.

No Scaly-sided Mergansers and, in fact, very few waterbirds were observed on reservoirs ( $n = 135$ ); most reservoirs held no waterbirds (six out of 11). We attribute the absence of birds on reservoirs to the lack of suitable habitat due to steep shores and deep water (Figure S2).

### Threats and stressors

Dams were frequently encountered on rivers, for example, the Wenchuan He had four dams over a river length of 23 km, the Xashi had five dams in 32 km and the Fu Tunxi had five dams in 45 km. Smaller dams were used to create reservoirs, whilst most of the larger ones were associated with hydro-electric power stations. The main impact of the dams was to reduce the length of river that was free flowing due to the formation of an upstream pool; however we twice found Scaly-sided Mergansers directly below dams feeding in the swift current flowing from operating power stations.

Other forms of serious disturbance included the many towns and villages along river banks, foot and motor traffic on riverside roads, widespread electrofishing (workers usually occupied river channels for a long time) and numerous domestic goose and duck flocks; gravel extraction occurs widely on all rivers greatly increasing water turbidity and seriously disturbing river bed morphology; domestic waste water from riverside towns and villages is discharged untreated into rivers, with evident effects on water quality, whilst domestic rubbish is also frequently dumped in rivers, and plastic bags frequently festooned shrubs along the river banks of sites used by the birds.

### Discussion

The locations of published sightings and approximate positions of birds carrying data loggers indicate that Scaly-sided Mergansers winter widely across east China, even into north-east China, but confirm that the major concentrations discovered to date occur in south-east China, mainly in Jiangxi province.

Information on wintering habitats in North and South Korea confirm the species mostly occurred on rivers of 20–60 m, exceptionally 100 m, in width, with fast flowing water over boulders, rocks and sand banks (Duckworth and Kim 2005, N. Moores *in litt.*). In China, we found birds on wider rivers up to 350 m across; of the six discrete sites, four could be classified as fast-flowing and two as slower-flowing; all sites had islands or sand banks, but only one contained rocks. Thus, the habitats used by the species in China appeared to differ slightly to those used in North and South Korea.

Our observations confirmed previous impressions about the extreme wariness of the species; Scaly-sided Mergansers were only present in relatively quiet areas and were very easily disturbed. Most Chinese rivers suffer greatly from many forms of human disturbance, which may explain our low encounter rate, indicating that future surveys should focus on searching rivers with low disturbance levels. Very few waterbirds were encountered at all on rivers during the surveys, suggesting these rivers are not productive, potentially because of the deleterious effects of dam construction (altering river ecosystems), extensive gravel extraction, industrial and domestic pollution, and reduction of fish stocks through electrofishing.

Reservoirs in hilly and mountainous regions did not provide suitable habitat for Scaly-sided Mergansers or any other waterbirds, presumably due to steep shores and deep, but fluctuating water levels. Scaly-sided Mergansers have been recorded from many floodplain lakes, particularly along the Yangtze, and in coastal areas in earlier years (He *et al.* 2002, 2006), but none were found

during very extensive waterbird surveys in inland floodplain lakes and coastal areas of east China in the 2002/2003–2006/2007 winters (Barter and Lei 2003, Barter *et al.* 2004, Barter *et al.* 2006, Cao *et al.* 2010). Given the apparent habitat preferences of Scaly-sided Mergansers, it seems that floodplain lakes and coastal regions may not be important as wintering sites but they could play a role during migration.

Probably the most serious problem associated with Scaly-sided Merganser habitat was the frequent damming of rivers with which they associated. On surveys, dams were encountered at regular intervals, the distance between them depending on river width. In the middle reaches of rivers they occurred every 5–10 km; and in the upper reaches they could be 2–3 km apart, generally associated with towns and villages. The effect of the dams is to produce long stretches of deep, still water, thus greatly reducing the amount of free-flowing water preferred by mergansers. Sometimes the dams completely stopped water flow, leading to almost dry stretches of river bed immediately below the dam, the river then relying on inflow from tributaries for water. The effect of the long stretches of dammed water is known to impact negatively on the river ecosystem, both upstream and downstream (World Commission on Dams 2000). It is likely that the food, e.g. aquatic larvae, frogs, shrimps, crayfish, fish, etc. (Zhao *et al.* 1994b, Solovieva 2002) taken by Scaly-sided Mergansers would have been adversely affected by these changes in flow. Electrofishing from boats and the shore was widespread everywhere we visited which, according to local people, has drastically reduced fish stocks. Gravel extraction occurred widely on all rivers, which as well as constituting a source of human disturbance, seriously disrupts the river bed and increases turbidity, all of which can be expected to adversely affect Scaly-sided Mergansers. For these reasons, we strongly recommend enforcement of environmental impact assessments of dam, mineral extraction and electro-fishery projects associated with all rivers to determine the presence of Scaly-sided Mergansers and wherever possible to avoid, reduce or mitigate their effects on this sensitive species.

Analysis of the site counts from 2000 to 2011 indicate that between 370 and 770 birds winter at the existing known locations, far short of the estimated population of c.4,600 individuals. So, where are the missing birds? Knowledge of their habitat requirements suggest fast flowing rivers with clear water and low disturbance levels, probably in the range of 50–350 m wide are favoured, implying that the rivers to be searched should be in hilly/mountainous areas generally away from highest human population densities (Figures 3). The accuracy of the geolocators to identify the true positions (as calibrated on the breeding areas) varied between three and 250 km (Solovyeva *et al.* 2012) and so were not accurate enough to identify precise wintering locations. Nevertheless, some of the areas highlighted by instrumented birds were not previously known as wintering areas and therefore constitute new potential areas of search in the future, confirming this technique as a potential way of identifying further areas of search for future ground surveys. We recommend that systematic searches be made of rivers in the arc: Guangxi, Guizhou, Sichuan, Hunan, Hubei, Henan and Shaanxi. Given the large number of rivers that could support Scaly-sided Mergansers it will be necessary to develop a stratified sampling protocol. Based on better survey knowledge, it is important to implement an associated programme of site safeguard, and particularly to integrate Scaly-sided Mergansers into catchment-wide spatial and environmental planning to safeguard their habitat in areas of particular importance outside of nature protection areas. Efforts should also be made at provincial and local levels to enshrine impact assessments of all projects associated with rivers and their catchments in relation to the species where present.

It is important to build on the studies of Duckworth and Kim (2005), Fang *et al.* (2009a, 2009b) and Shao *et al.* (2010) to increase our knowledge of Scaly-sided Merganser wintering ecology, particularly feeding ecology, population dynamics and behavioural studies. This will assist in understanding the extent to which birds are site faithful, important dietary items and habitat features upon which the species depends, as well help better understand how birds use wintering sites to inform conservation management information and site safeguard programmes. This also

raises important conservation questions about how to protect such a species that is not highly concentrated and may require catchment scale nature conservation actions to effectively safeguard its current distribution. A single species flyway management plan would make great strides towards coordinating effort and agreeing priorities in this respect.

## Supplementary Material

The supplementary materials for this article can be found at [journals.cambridge.org/bci](http://journals.cambridge.org/bci)

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