The Goosander *Mergus merganser* population breeding in the Alps and its connections to the rest of Europe

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Abstract

The main range of the Goosander *Mergus merganser* in Europe stretches from Norway to northern Russia. Outside this main range, breeding populations exist in Iceland, Britain and the Balkans. In the Alps, the birds breed mainly in Switzerland and southern Germany (Bavaria). This paper compiles evidence from different disciplines to determine the conservation status of the Central-West European (Alpine) population of Goosander, in particular whether it is isolated from other Goosander populations. Recoveries of ringed birds showed that the Goosanders breeding in the Alpine region, estimated at *c.* 1,000–1,400 pairs in 1998, are augmented by birds from northern Europe during the winter months. Molecular analysis of female-inherited mtDNA indicated a strong genetic differentiation among European breeding populations, whereas no significant differences were found at nuclear DNA markers, indicating at least some interchange between populations. The evidence from the various studies reinforces the view that the Central-West European (Alpine) population of Goosander should be considered as a separate population and conservation unit.

Key words: conservation status, distribution, genetics, migration, ring recoveries.

The Goosander *Mergus merganser* breeds across northern Eurasia and North America. In Europe, a continuous breeding range stretches from Norway into Russia, extending to areas south of the Baltic Sea (Hagemeijer & Blair 1997). In addition, breeding populations exist in Iceland, Britain, the Alps and the Balkans. Whilst the sedentary population breeding in Iceland and the poorly-known breeding population in the Balkans are considered to be separate populations (Scott & Rose 1996), the same authors attribute the British and Alpine populations to the Northern European population. They did, however, have some doubts especially regarding the Alpine population, as its breeding range is geographically distinct from the nearest birds breeding in northern continental Europe. This geographical separation has

led to speculations as to whether the Goosander population in the Alps is an ice-age relict (Voous 1960). However, in recent years evidence has accumulated to consider this population, now named Central-West European population, as a distinct unit (Wetlands International 2006). This paper presents a synthesis of this evidence. It compiles current knowledge on the movements and structure of the Goosander population in the Alps and other parts of Europe, bringing together results from ringing, waterbird censuses and genetic studies, to justify their treatment as a distinct population separate from others in Europe.

Methods

Data published on Goosanders in small regional journals and in national and regional distribution atlases were collated. The main publications used were the analysis of ringing data from Lake Sempach in Switzerland (Hofer & Marti 1988), overviews of Goosander status in Bavaria (Bauer & Zintl 1974, 1995), a breeding survey carried out in Switzerland in 1998 (Keller & Gremaud 2003), and the genetic study by Hefti-Gautschi *et al.* (2009). Additionally, unpublished or partly published data from the waterbird census and ringing databases of the Swiss Ornithological Institute were included. Data from the national winter waterbird census, which is carried out in mid-November and mid-January, covering all large and medium-sized lakes and the large rivers of Switzerland, were compiled. These data are published in annual reports (*e.g.* Keller & Burkhardt 2009).

A total of 2,083 Goosanders have been ringed since the start of the ringing scheme in 1924 up to the end of 2008 (Laesser *et al.* 2009). Of these, 86% have been ringed since 1972 by Josef Hofer at Lake Sempach, where Goosanders do not breed, and where they were mostly caught in winter (90% of the 1,806 birds ringed in November–February, P. Korner, pers. comm.). Ringing and re-encounter data from Lake Sempach have been analysed previously (Hofer & Marti 1988). That publication covered *c.* 45% of all the data from Lake Sempach. Overall, 266 records of Goosanders ringed or re-encountered in Switzerland up to May 2009 were available for analysis (J. Laesser, pers. comm.). Eight additional ringing recoveries were provided from the ringing database of southern Germany and Austria (W. Fiedler, pers. comm.). All data were analysed with regard to the sex and age of the birds and the season and location of re-encounters. Re-encounter locations were classified as "within the Alpine range" and "outside the Alpine range" on the basis of the known breeding range.

Results

Breeding distribution and population size

The estimated size of the Goosander population breeding in the Alpine region was 1,000–1,400 pairs at the end of the 1990s (Keller & Gremaud 2003). Thus, the breeding population is larger than the populations in Iceland and the Balkans (100–300 and 40–80 pairs, respectively), but smaller than the British one of 2,900–3,600 pairs (BirdLife International 2004). The

large Northern European population is estimated in the same publication at 42,000–68,000 pairs.

The current breeding range of Goosander in the Alps stretches from eastern France to Austria and Slovenia (Fig. 1). The stronghold lies in the Lake Geneva basin in western Switzerland and adjacent France, where a breeding survey in 1998 resulted in an estimate of 566 breeding pairs, about half of the population estimated for the whole of the Alpine region (Keller & Gremaud 2003). The same survey estimated 490–670 breeding pairs for the whole of the Swiss territory (Fig. 1). In France, only a small number of breeding pairs occur outside the Lake Geneva basin (Rocamora & Yeatman-Berthelot 1999). Southern Germany, mainly Bavaria with 250–290 breeding pairs (von Lossow & Fünfstück 2003), and adjacent regions in Austria, with 150–200 breeding pairs (BirdLife International 2004), form the second centre of the Alpine range. South of the main ridge of the Alps only small numbers of pairs are breeding in Italy (estimated at *c.* 30 pairs in 2008, N. Ventolini, pers. comm.), Austria (a few pairs along the river Drau, Dvorak *et al.* 1993) and Slovenia (4 pairs, Geister 1995).

Historical records indicate that the Goosander was not known as a regular

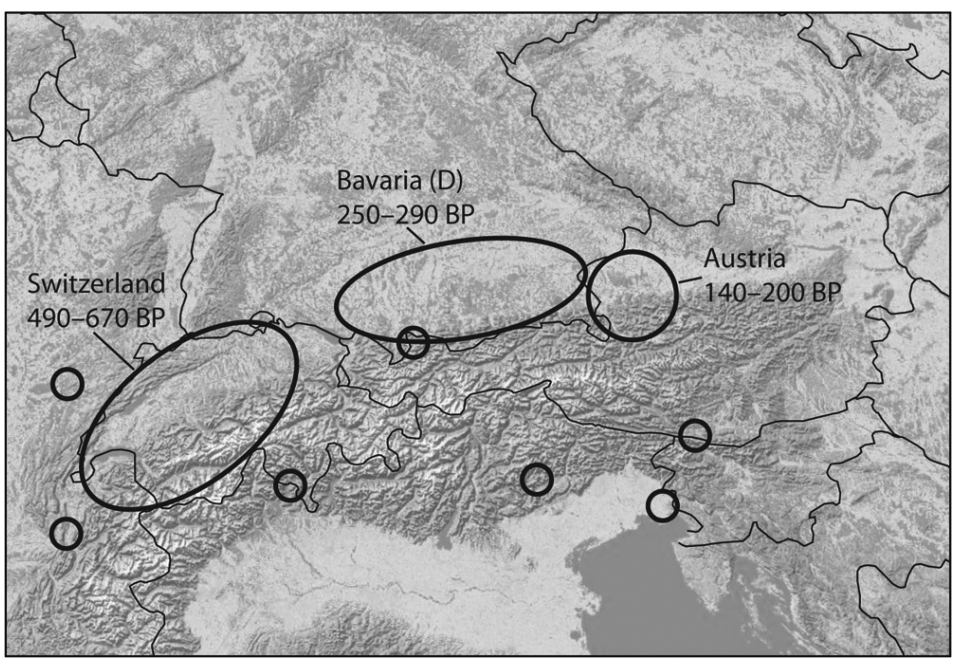

Figure 1. Main breeding areas for Goosander in Switzerland, Bavaria and Austria, and additional sites with small numbers of breeding pairs (BP). Population size estimates according to Keller & Gremaud 2003 (Switzerland), von Lossow & Fünfstück 2003 (Bavaria) and BirdLife International 2004 (Austria).

breeding species before the 19th century. Conrad Gessner in his "Historia animalium" mentions the species as a winter visitor (Springer & Kinzelbach 2009). Published records indicate first breeding in Switzerland around the middle of the 19th century on Lake Neuchâtel, at the end of the century on Lake Morat and the river Saane (Géroudet 1987), and in 1905 on Lake Geneva (Poncy & Meylan 1930). In Bavaria breeding records are known for the 1880s (Wüst 1981). Some isolated breeding records were also reported in the border area between Switzerland and Austria (Bauer & Glutz von Blotzheim *et al.* 1969). In the first half of the 20th century, breeding was recorded at an increasing number of lakes and rivers in western Switzerland. The Goosander expanded its range towards the northeast, as documented by the two Swiss distribution atlases from the 1970s and 1990s (Schifferli *et al.* 1980; Schmid *et al.* 1998). Since then, the range expansion has continued, with new records along the river Rhine and across the Rhine in Baden-Württemberg in southern Germany (Disch 2000; Schneider & Hoffmann 2003), thus narrowing the gap between the centres of distribution in Switzerland and in Bavaria.

In Germany, several small clusters of breeding birds were recorded in the 1960s in southern Bavaria, which were assumed to have undergone an earlier decline (Bauer & Zintl 1974; Bezzel 1990). From the 1970s onwards, an increase in breeding numbers as well as a range expansion towards the east was observed (Bauer & Zintl 1995). In adjacent regions in upper Austria the spread and increase in abundance continued (Bauer 1990).

South of the main ridge of the Alps, the first brood was recorded in southern Austria in 1983 (Spitzenberger 1988) and in northern Italy in 1996 (Zenatello *et al.* 1997). Since then, breeding has been recorded at further sites, for instance since 1998 in the border area between Italy and Switzerland on Lake Verbano (Bordignon 1999; Volet & Burkhardt 2004), and numbers are continuing to increase (N. Ventolini, pers. comm.).

Distribution outside the breeding season and migration

In winter, the Goosander is more widely distributed across the lakes and rivers north of the Alps than during the breeding season. Birds are also found on lakes where breeding has not been recorded, such as Lake Sempach in central Switzerland. Here, Goosanders have been ringed in winter since the 1970s, and ring recoveries show that some wintering birds originate from Fennoscandian and Russian populations, whilst others are from Switzerland and Bavaria (Hofer & Marti 1988). The phenology of birds caught at Lake Sempach shows that Goosanders from northern Europe arrive on their wintering grounds in December and January (Hofer & Marti 1988). This corresponds with the results of the national waterbird census in Switzerland, which is carried out in mid-November and mid-January. Numbers in January are always higher than in November (Fig. 2), and numbers in November are on average 68% (s.d. ± 11%, for winters 1991/92–2007/08) of those in January. In 1998, numbers counted in November (2,438 individuals) corresponded fairly well to the total of adult

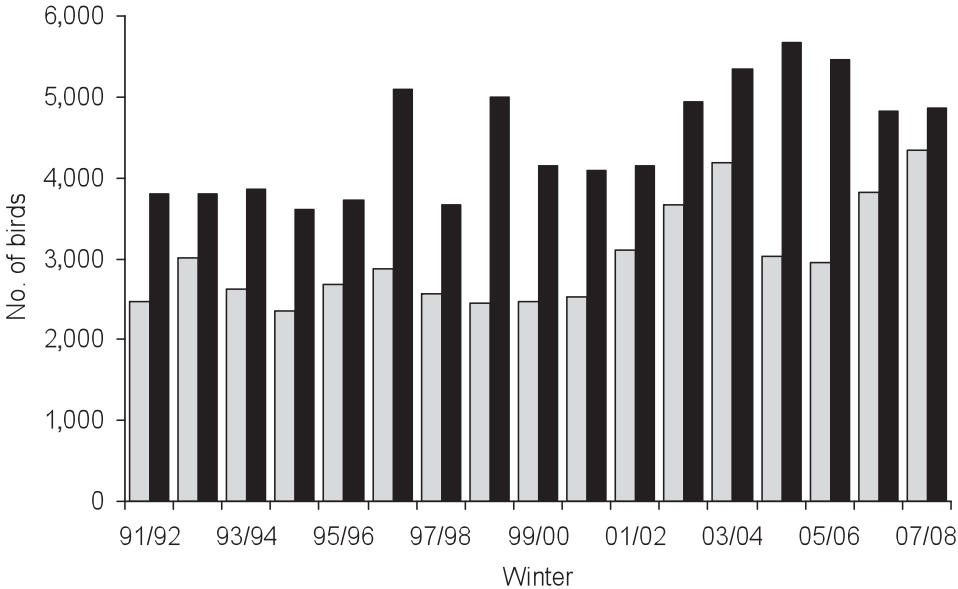

Figure 2. Number of Goosanders in mid-November (grey) and mid-January (black) for Switzerland, including French parts of Lake Geneva and German/Austrian parts of Lake Constance. Data are from the Swiss national waterbird census.

birds estimated during the breeding season plus the juveniles produced in the same year (2,000–2,500 individuals; Keller & Gremaud 2003). This would indicate that around 60–80% of the overall wintering population in Switzerland consists of Alpine-breeding birds. This estimate is similar to that of Hofer & Marti (1988), who put the percentage of northern birds on Lake Geneva (which holds the largest part of the overall Swiss winter population) at 35–43%, on the basis on the migration phenology and the percentage of males in breeding plumage.

Knowledge of the timing of the migratory and breeding cycles is patchy, with March apparently an overlap period for spring migration and the onset of breeding. Observations of Goosanders on lakes where they do not breed and recoveries in northern Europe of birds ringed on Lake Sempach in March both indicate that northern birds, often birds in their second calendar year, may stay on their wintering grounds until the end of March (Hofer & Marti 1988). At this time birds in the Alpine range may already have started to breed. In Switzerland, the first families are usually observed at the end of April, indicating that egg-laying begins in the second half of March (Keller & Gremaud 2003). In Bavaria, the start of egg-laying was recorded mostly between mid-March and the end of April (Bauer & Zintl 1995). Families with newly-hatched chicks are mostly observed in May and the first half of June, exceptionally until mid-July (Bauer & Zintl 1995; Keller & Gremaud 2003). The counts in Switzerland

in 1998 indicated that in July only females with chicks remained on many of the breeding sites, in particular those along rivers (Keller & Gremaud 2003). While these females presumably moult the wings on their breeding sites, females without broods join moulting flocks on large lakes. Such flocks are known from Lake Geneva, Lake Neuchâtel and Lake Constance, with smaller ones at Lake Thun (Géroudet 1987; Hauri 1998). At the delta of the Rhine on Lake Constance, observations of females caught as breeding birds on Lake Geneva confirm such moult movements within the Alpine region (Swiss Ornithological Institute unpubl. data; H. Du Plessix, pers. comm.). In Bavaria, Goosanders mainly disappear from their breeding grounds in June and July, and it is assumed that at least some of these also moult on Lake Constance (Bezzel 1990; Bauer & Zintl 1995). In the United Kingdom, a similar behaviour was found, with females raising chicks moulting on their breeding grounds, whereas females without young join moulting flocks on estuaries (Hatton & Marquiss 2004).

The moulting areas of males of the Alpine breeding population are still unknown. Observers consistently report that males leave the breeding sites between end of May and end of June (Bauer & Zintl 1974, 1995; Géroudet 1985; Bezzel 1990; Hauri 1998). Some authors suspected that males also moulted their flight feathers on Lake Constance (Bauer & Zintl 1995) or Lake Geneva (Géroudet 1985), but Hauri (1998) only exceptionally found males among the large flocks of moulting birds on these lakes. Observations of males in moult always consisted of single individuals or small groups, as documented from the moulting site used from 1975–1987 on Lake Thun, where a maximum of 20 males was recorded (Hauri 1998). The counts in 1998 also indicate that males leave the region of the Alps after mid-May (Fig. 3). Many authors suspect that males moult their wings together with northern breeding birds in the north of Norway, where large numbers of male Goosanders gather every year (Frantzen 1984). Ring recoveries have proved this for males from the British breeding population (Meek & Little 1977, 1980). For birds from the Alpine region such proof does not exist, because hardly any males have been ringed to date during the breeding season.

Connections between populations

Connections between populations can be estimated by studying the movements of marked individuals and by analysing genetic relationships. Evidence from ringing is scarce. A total of 162 ring re-encounters of birds of known sex, mostly recoveries of dead birds, are available for birds ringed from 20 November to end of February (Table 1); 110 of these were males and 52 were females. Overall, 60 birds (37% of re-encounters) were found within the range of the Alpine breeding population and 102 (63%) outside (Table 1), most of them to the northeast of Switzerland (Fig. 4). During the breeding season, birds ringed in Switzerland are mostly females caught on the nest at Lake Geneva and Lake Neuchâtel. Nineteen females were caught at the same sites in later years, indicating a high degree of breeding-site fidelity. Eighteen re-

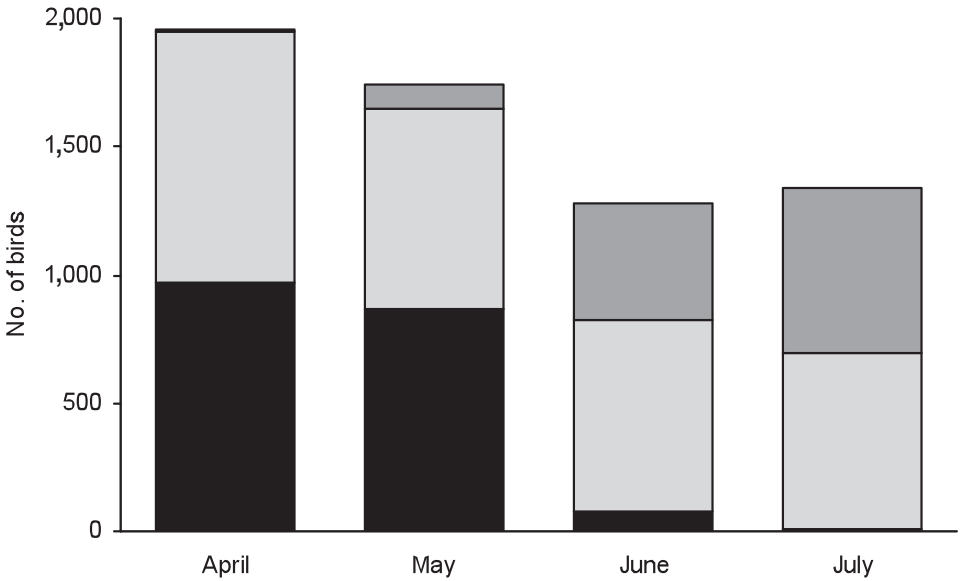

Figure 3. Number of Goosanders counted in Switzerland during four standardised counts from mid-April to mid-July (from Keller & Gremaud 2003). Black = males, light grey = females, dark grey = juveniles.

Table 1. Re-encounters (*i.e.* sightings, captures and recoveries) of 162 Goosanders ringed in Switzerland from November–February 1972–2008. Birds re-encountered at the ringing site were excluded.

Time period of re-encounters	**Re-encountered within range of Alpine breeding birds**			**Re-encountered outside range of Alpine breeding birds**		
	Males	**Females**	**Total**	**Males**	**Females**	**Total**
November–March	32	9	41	16	3	19
April–July	9	9	18	20	18	38
August–October	0	1	1	33	12	45
Total	41	19	60	69	33	102

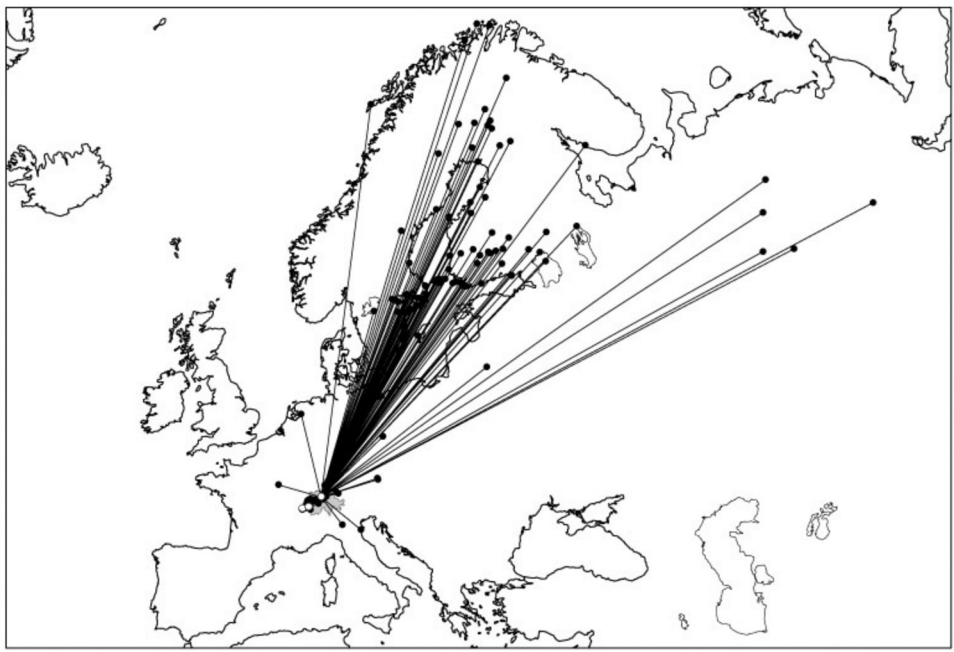

Figure 4. Re-encounter locations of Goosanders ringed in Switzerland between 20 November and end of February (excluding birds re-encountered at the ringing site). White dots = ringing sites, black dots = re-encounter sites.

encounters of birds ringed from April to July and recovered or seen away from the breeding site are available. Only two of these were found outside the Alpine range (Table 2, Fig. 5); the first, a male, was caught at Lake Geneva on 2 April 1989 and found in Ueckermünde (northeast Germany) on 13 November 1996; the second, a second-calendar year female, was caught at Lake Sempach on 15 April 1996 and found dead in Finland on 2 June 2002. Both of these birds may have been late-migrating birds from the northern European population.

Very few nestlings have been ringed in Switzerland and Bavaria. Two birds ringed in Switzerland and four ringed in Bavaria were later found on other lakes north of the Alps. Two Bavarian nestlings ringed in 1976 were found dead in October 1978 in northern Finland and in October 1983 in Poland, respectively (Zintl 1979; Bauer & Zintl 1995). Unfortunately, the sex of these birds is unknown. If they were males, they may have been pairing with a female from the northern European population, or the recoveries may be a further indication of a moult migration of males towards northern Europe.

The genetic structure of Goosander populations has been studied using samples collected during the breeding season for the Alpine breeding population (Switzerland, Germany and one sample from Italy), from

Table 2. Re-encounters (*i.e.* sightings, captures and recoveries) of 18 Goosanders ringed in Switzerland from April–July 1938–2007 (excluding birds re-encountered at the ringing site).

Time period of re-encounters	Re-encountered within range of Alpine breeding birds			Re-encountered outside range of Alpine breeding birds		
	Males	Females	Total	Males	Females	Total
November–March	0	3	4	1	1	1
April–July	1	8	9	0	1	1
August–October	0	4	4	0	0	
Total	1	15	16	1	1	2

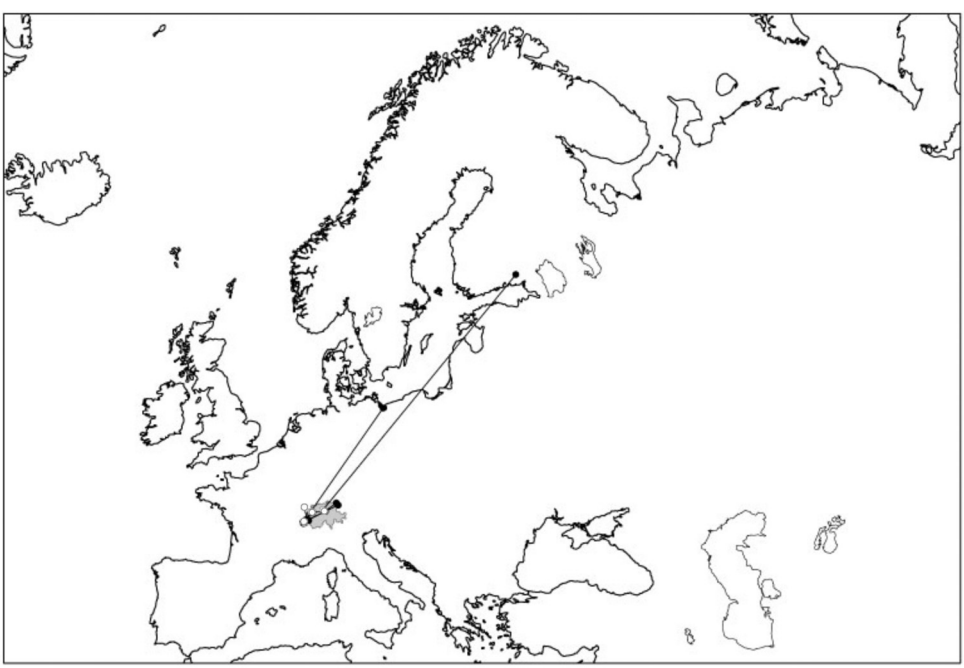

Figure 5. Re-encounter locations of Goosanders ringed in Switzerland from April to July (excluding birds re-encountered at the ringing site). White dots = ringing sites, black dots = re-encounter sites.

the northern European population (Norway, Sweden, Finland, Denmark, Poland and Estonia) and from the Icelandic population, with samples also obtained from birds in Canada (Hefti-Gautschi *et al.* 2009). Most samples came from feathers of birds caught alive at the nest or from egg skins. No samples were available from Britain. In addition, feathers from birds shot in Switzerland in winter were analysed. Genetic structure was assessed by examining two nuclear marker systems (microsatellites and Single Nucleotide Polymorphisms, SNP) and mitochondrial (mtDNA) control region sequence variation. The analysis showed that the geographically isolated Goosander population in Iceland is also genetically distinct. For the population breeding in the Alps it revealed a strong genetic differentiation based on female-inherited mtDNA but not on biparentally inherited nuclear markers. The number of haplotypes in the samples from Bavaria and Switzerland was very low in comparison to those from northern Europe, with two haplotypes in Switzerland and two different ones in Bavaria. The more common type from Switzerland was also found in the single sample from Italy. The samples collected in Switzerland during winter revealed haplotypes found in the breeding areas in Switzerland and northern Europe, with around half of the samples containing the "Swiss" haplotypes.

Discussion

The combination of the data from different sources provides some insight into the status of the Alpine breeding population. The results of the genetic study are consistent with knowledge of the biology and movements of Goosanders within Europe. Pair formation takes place in winter (Bauer & Glutz von Blotzheim *et al.* 1969), and it is thus likely that at least some males from the northern European population mate with resident Alpine females. This would explain the lack of genetic differentiation based on nuclear DNA. The degree of interchange between the populations was not estimated (B. Hefti-Gautschi, pers. comm.). The strong differentiation of mtDNA indicates a high degree of site fidelity in females, supported by females being caught at the same breeding sites in subsequent breeding seasons. The low mtDNA variability in Switzerland and Bavaria could perhaps be explained by a founder effect (Hefti-Gautschi *et al.* 2009). The differences in haplotype composition between Switzerland and Bavaria and the historical breeding records could indicate two centres of colonisation, one in western Switzerland and a second in Bavaria. However, sample size for Bavaria in the genetic study was very small and further analyses would be needed to confirm this.

The increase and the spread of the Alpine breeding population in the second half of the 20th century could have been favoured by protection from hunting. At Lake Geneva, both wintering and breeding numbers strongly increased following the protection of the species in Switzerland in 1962 and the introduction of a general hunting ban in the canton of Geneva in 1973 (Géroudet 1987). The placement of nest boxes may have favoured colonisation

in some places but the spread is continuing despite nest boxes having been removed in some areas (Bauer & Zintl 1995). In Switzerland, Goosanders are increasingly breeding in towns, where they nest in cavities such as the niches of historical buildings or in chimneys (Hauri 1998; Keller & Gremaud 2003). Today, the Goosander breeding population does not seem to be increasing in the core areas of its Alpine range (Keller & Gremaud 2003) but the species is still extending its range in peripheral areas such as along the Doubs in eastern France (Paul 1997) and in northern Italy (N. Ventolini, pers. comm.). The Goosander is also spreading in other regions of continental Europe (Musil *et al.* 2001; Kraatz 2005), thus reducing the geographic gaps between the Alpine and northern European populations. This is in contrast to results of models predicting a widening gap between the Alpine and the northern breeding ranges due to climate change (Huntley *et al.* 2007). Climate change is, however, likely to reduce the number of Goosanders migrating from northern Europe to winter north of the Alps, which might eventually reduce gene flow between the northern and Alpine breeding populations.

It is likely that the Alpine region was colonised by northern European birds wintering in the region. Nesting in the Alpine region by northern species has been recorded for other species known as winter guests, such as the Red-breasted Merganser *Mergus serrator* and Common Eider *Somateria mollissima* (Schmid *et al.* 1998). However, these species have so far not established larger breeding populations. The presumed colonisation by birds from northern Europe makes it likely that males, like British birds (Little & Marchant 2002), have kept their traditional moulting sites in northern Europe. This is supported by the absence of males in summer but proof of this moult migration is still lacking.

The consideration of the Alpine breeding population of Goosander as a separate population (Wetlands International 2006) is thus well justified and it should therefore be treated as a distinct conservation unit. Switzerland and Germany (Bavaria), holding the largest parts of the Alpine breeding population, have a high responsibility to conserve this small and thus vulnerable population. The classification as "Vulnerable" on the red list of threatened breeding birds in Switzerland (Keller *et al.* 2001) based on the small population size is well justified, as is the classification in a similar category on the Bavarian list (Fünfstück *et al.* 2003). The recognition of the Goosander as a species of conservation concern is important for wildlife managers in particular in view of resolving conflicts with anglers.

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Photograph: Female Goosander at Lake Biel, Switzerland, by Verena Keller.

