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The Goosander *Mergus merganser* breeding population expansion and trend in north-western Italy

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Abstract – After first breeding in Italy in 1996 the Goosander has rapidly increased its breeding range in northern Italy: we analyzed the progressive expansion of Goosander in the lakes and rivers in a wide belt covering three-quarters of the sub-alpine Italian area (~45°N Lat). The study period covers the nesting seasons from 2010 to 2017. Each water body was assigned to a local coordinator that oversaw the monitoring operation during the breeding season, through a standardized census realized from the shores of each potential breeding area in the first week of June. Overall we censused a total of 282 broods (or families) in the whole period, distributed over 8 different water bodies, with the bulk of the population concentrated in the largest lakes, Maggiore, Como and Garda. The first census in 2010 estimated 12 broods while the maximum of 51 broods was reached in the last year of the survey (2017) suggesting a still ongoing increasing population trend. The number of chicks per brood ranged between 1 and 19, with a mean value of 6.9 ± 0.22. In literature brood size above 14 chicks are considered as due to brood amalgamation, which may therefore occur in north-Italian lakes. From 2011 the number of families was almost stable on the west of the study area (Lake Maggiore), while a non-significant decrease was revealed in the Lake Como, and a steady increase in the eastern Lake Garda. Overall, our findings describe the occurrence of a successful and still ongoing colonization towards east, possibly harbinger of further expansion.

Key-words: breeding range, population trend, brood size, Italy.

INTRODUCTION

The Goosander breeds in a wide area of central and northern Europe, ranging from latitude 50° to 70° N. Below such limit, in the 70s, the species was confined as a breeder to the Swiss lakes and to the Bavaria region in Germany (Cramp & Simmons, 1977) which host a biogeographically isolated population (Hefti-Gautschi *et al*., 2008). Out of the main breeding area scattered couples are found in France, Slovenia, Ukraina and, in Southern Europe, in Albania and Greece (Hagemeijer & Blair 1997). An expansion process is underway in South (Switzerland and Italy) and Eastern Europe, in the Balkans, from the Carpathian mountains as far as Greece. In the lakes of the Dinaric Alps, in Western Serbia, the first female with chicks was observed in 1987, while in Bosnia-Herzegovina the first brood was registered

in 2005 (Marinković, 2008). Similarly a rapid colonization has been observed in the rivers of the Carpathian Mountains, in several areas and different countries (Czech Republic, Poland, Hungary, Romania), summing up 240 to 360 breeding pairs (Kaitoch & Bobrek, 2014). In the southern Balkans a small breeding population was known to persist from the begin of the twentieth century (Cramp & Simmons 1977, Scott & Rose 1996): in the period 2011-2015 a new census was conducted in the area comprising Macedonia, Albania and Greece, in the Ohrid and Prespa Lakes, that revealed a population of 15-25 breeding pairs (Catsadorakis *et al*. 2016). From '70s onwards, till the beginning of the 21st century, the Alpine population of Bavaria and Switzerland began to grow (BirdLife 2004, Schmid *et al.* 1998). The Swiss population was estimated at 490-670 pairs in 1998 (Keller & Gremaud 2003), further increasing at 600-800 pairs in the 2013-2016 period, when the species spread in the southern and eastern lakes of the country (Keller in Knaus *et al*. in press). The first brood in the Swiss portion of the Lake Maggiore was observed in 2003 (Volet & Burkhardt 2004). In Italy, at the beginning of the twentieth century, the Goosander was considered as a rare vagrant (Giglioli 1889, Arrigoni degli Oddi 1929), appearing only during migration and in winter: the few data were limited to Lake Garda, along the central trait of the Po river and in the Venetian lagoon (Arrigoni degli Oddi 1929). The first pair was found nesting in Italy in 1996, in the small artificial Lake Corlo in the municipality of Belluno in the Veneto Region, north-eastern alps (Zenatello *et. al*. 1997), followed by a new pair on the western side of Lake Maggiore in 1998 (Bordignon 1999). It should be stressed that the two nesting localities are ~ 200 km away, and that many potentially breeding sites, as lakes and rivers, are found in this area. In 2002 the species was found breeding further east in northern Italy, in the Friuli Venezia Giulia region, along the Isonzo river that runs along the Slovenian border (Felcher & Utmar 2004) and, from 2000 to 2008, in small lakes and rivers (Piave and Brenta) of the Alpine sector of the Veneto and the Friuli Venezia Giulia region (Zenatello *et al*. 2009). The Italian breeding cohort of the species, from the beginning of the present century, revealed a positive trend, colonizing other lakes and rivers in northern Italy: in 2003 the first broods were observed in the eastern (Gagliardi *et al*. 2007) and northern (Volet & Burkhardt 2003) sectors of Lake Maggiore, followed by the first brood in 2004 on Lake Iseo (Bordignon*,* Pirola & Viganò, *pers.comm.*) joined in 2005 by the first on Lake Como (Viganò *et al*. 2006). Subsequently, further east, nesting pairs were found in 2010 (Gargioni & Piotti 2013) on the western shore of Lake Garda (the largest lake in Italy), followed respectively in 2014 and 2015, on the northern and eastern shores of the same lake (Sighele *et al*. in press), with scattered pairs in other lakes and rivers of the pre-Alpine area. The Goosander nests in holes utilizing both natural and artificial cavities, preferably located in cliffs and rock walls, though not excluding buildings, abandoned Black Woodpecker's (*Dryocopus martius*) or nest-boxes (Cramp & Simmons 1977). Scarcity of nesting sites may induce females to share the same nest with other females: a reproductive tactic that has been defined as pre-hatch brood amalgamation (Eadie *et al.* 1988) or Conspecific Nest Parasitism (CNP, Pöysä 2006); a CNP threshold value of 14 chicks has been proposed by Eriksson & Niittyla (1985). Similarly to other cavity-nesting ducks such as, for example, the Wood Duck (Jones & Leopold 1967) or the Goldeneye (Eriksson & Andersson 1982, Pöysä & Pöysä 2002): for the Goosander there is evidence of a nest with 39 eggs (Géroudet 1985). The progressive colonization of the species in northern Italy prompted the creation of a voluntary monitoring group in 2010, the "Goosander Group", formed by several ornithologists and birdwatchers in northern Italy, that has since then coordinated the census of the breeding population in the study area. Our main interest was to assess

1) the current geographic breeding range of the species,
2) the population expansion and trend in lakes and rivers in north-western Italy,
3) the brood size of the families.

MATERIAL AND METHODS

Study area

The survey was conducted from 2010 to 2017 over almost the north western Italy (~ 80,000 km^2) and focusing on 16 lakes and 6 main rivers (Tab. 1) of the Piedmont, Lombardy, and partly of the Trentino Alto Adige and Veneto regions bordering on Lake Garda, stretching from the pre-Alpine mountains to the Po Valley, north of the river Po (Fig. 1). The westernmost tip corresponds to Lake Avigliana (n. 1, Lat: 45.053 N, Long: 7.390E) in the Piedmont region, whereas the easternmost extreme is located at the northern tip of lake Garda (n. 15, Lat: 45.867, Long: 10.876) in Trentino Alto Adige. The northernmost part is located at Lake Mezzola (n. 7, Lat: 46.212 N, Long: 9.445 E), just north of lake Como; the southern one at the Lakes of Mantova (n. 16, Lat: 45.146 N, Long: 10.809E).

The lakes range from very small and shallow, bordered with reed beds and woods, with low depth, to the largest ones in Italy: Orta, Maggiore, Lugano, Como, Iseo and Garda (with the latter having the largest surface: ~370 km^2) which are characterized mainly by mountain rocky coasts, dotted with built up areas overlooking the lake bor-

Table 1. Lakes and rivers that were monitored in the period 2010-2017, ordered from west to east, with mean altitude, surface and length. The main tributaries were also monitored on Lake Maggiore. The asterisk (*) indicates occupied sites.

Lakes			
	sites	**mean altitude**	**surface** (km^2)
1	Avigliana	354	1,5
2	Candia	226	1,52
3	Viverone	230	5,8
4	Orta*	290	18,2
5	Maggiore (*Verbano*)*	193,8	212
6	Lugano (*Ceresio*)	270	48,9
7	Mezzola	200	5,9
8	Como (*Lario*)*	199	145
9	Montorfano	397	0,46
10	Alserio	260	1,23
11	Pusiano	257	5,2
12	Annone	224	5,71
13	Garlate*	198	4,64
14	Iseo (*Sebino*)*	185	65,3
15	Garda (*Benaco*)*	65	370
16	Lakes of Mantova	18	6,21

Rivers		
	sites	**lenght** (km)
17	Dora Baltea	168
18	Sesia	140
19	Ticino*	110
20	Adda*	164
21	Oglio	95
22	Mincio	75

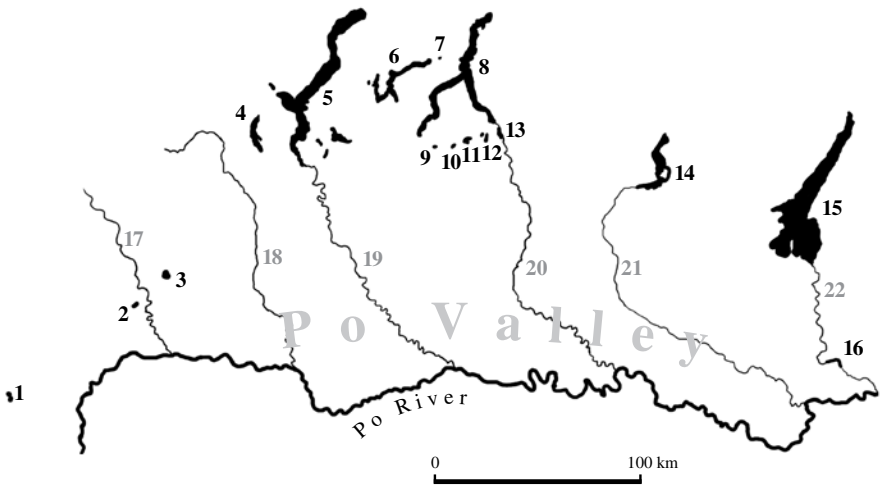

Figure 1. Map of the study area in northern Italy, with the 16 lakes and 6 river numbered progressively from west to east.

ders, with only a small amount of reed beds/woods, generally at the southern tip.

Methods

Our census protocol required a local coordinator for every water body: for the largest ones (Maggiore, Como and Garda), the western and eastern sides were further subdivided between a minimum of two or more local coordinators, to cover the entire length of the suitable shores; in the case of Lake Verbano there was a further subdivision because the northern part is Swiss territory. In each water body the broods were actively searched every year from May to July: this time frame encompasses the main period of the appearance of the females with chicks (a type of group known as "family parties"), in accordance with the census work already carried out in nearby Switzerland (Keller & Gremaud 2003). Every year a simultaneous census of the family parties was conducted at the 22 areas in the first week of June, that was utilized to compare the progress of the colonization in the various water bod-

ies. The shores of lakes and rivers were actively searched (from 8.00 a.m. to 13.00 p.m.) from vantage points with binoculars and telescopes by monitoring groups formed of a minimum of two persons; in some years, on the largest lakes, we also have been supported by local management authorities who made a patrol boat available to scan the shores. During the census the position of every female with chicks was mapped: we consider a brood or family (female with chicks) as those one formed by chicks of the same age, registering different families if the observed age was clearly detectable. The only exception to this protocol regards the Lake Maggiore, on the Lombardy side from 2015 to 2017 (when the patrol boat was no longer available), and the Swiss part from 2010 to 2017, where observations on families were made not only in one day as in the previous years but encompassing the months of May and July. The numeric occurrence data for the Swiss side were resumed from the Ornitho.ch files of the Swiss Ornithological Institute: to avoid the possibility of double counts on different days, for assessing the number of broods we considered only the first observation of a family in the specified 1x1 km cell of the grid, disregarding further observations in the same cell. Following this method, the number of observed families might be slightly underestimated, so that the overall census should be considerate as a conservative estimation. The Italian distribution of the Goosander for the period 2005-2017 was derived from the online map of the Italian Atlas of Breeding Birds (UTM cartographic grid of 10x10 km) available on the web-portal "ornitho.it". The Goosander has synchronous hatching and it has been established that broods may be gathered where numerous so that excessively large broods may originate from more than one female (Cramp & Simmons 1977) and we adopted the threshold value of 14 chicks as proxy for brood amalgamation (Savard 1987, Eadie *et al*. 1988). Every year, at the end of the monitoring session, the counts were transmitted to the project coordinator (Lucio Bordignon) for data storage. Statistical analyses and graphs were made with R software (R Development Core Team 2018, version 3.4.4) using "Stats", "*lme4*", "sjstats" and "ggplot2" packages (Tibco Enterprise 2017, Bates *et al*. 2018, Lüdecke 2018, Wickham & Chang 2016). We used a linear regression model to test the increase of family parties in the years for the whole study area and for the four largest water bodies (lakes Maggiore, Como, Iseo and Garda), displayed with a Kernel Regression Smoother. After fitting the model, we checked the distribution of the standardized residual with a Normal Q-Q plot. To assess whether brood size varied across years, we fitted a Generalized Linear Mixed Model (package "*lme4*") with number of juveniles per brood as the dependent variable, year (entered after standardization) as the predictor, and site as a random factor, to correct for spatially non-independent records. Given that the use of a Poisson error led to an overdispersed model (with residual deviance much higher than residual degrees of freedom, and an overdispersion level significant at $P < 0.001$ according to the 'overdisp' command in the 'sjstats' package), we fitted a negative binomial model, which was not overdispersed ($P = 0.357$ according to the same test). Then, we assessed the significance of the year effect and compared the value of the Akaike's Information Criterion (AIC) of the model with and without year, respectively.

RESULTS

Overall in eight years of census we found a total of 282 broods distributed in eight water bodies, representing the 36.4% of the monitored sites. The yearly number of family parties showed a steady increase during the study period (Fig. 2) statistically significant (linear model $R^2 = 0.807$; $\beta = 11.66 \pm 2.32$; $t = 5.02$, $P = 0.002$); beginning with 12 families in 2010 and reaching a maximum of 51 in 2017 (Tab. 2). Only the four major lakes (Maggiore, Como, Iseo and Garda) were occupied all the years; in 2013 families were observed for the first time on two rivers (Ticino and Adda, respectively sites n. 19 and 20) and, from 2015 till 2017, on the river Toce that belongs to the water catchment of Lake Maggiore. In 2016 a territorial pair was observed along the Sesia river (n. 18) and again two pairs in

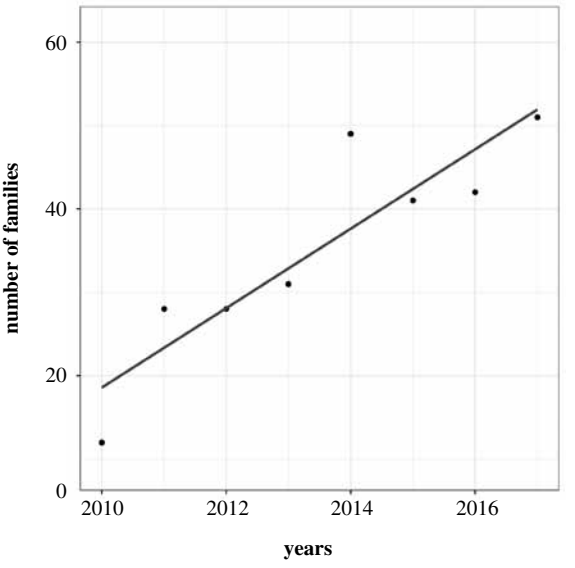

Figure 2. Regression line for the total number of families per year.

Table 2. Counted number of families (female with chicks) per year.

year	2010	2011	2012	2013	2014	2015	2016	2017
n. families	12	28	28	31	49	41	42	51

2017, but no evidence of breeding was discovered in both years. In 2017 one family party was observed respectively on lakes Orta (site n. 4) and another one in Garlate (site n. 13): in the first site already in 2015 a pair was observed without confirming the breeding. Lake Garlate is a small lake, at the southern tip of Como lake, with heavily built-up shores. From 2010 to 2014 the bulk of the population (84.3%) was concentrated in two lakes (Tab. 3), Maggiore (site n. 5) e Como (site n. 8). Lake Iseo (site n. 14) has always hosted a low number of families during the study period, with a maximum of 3 families in 2016, whereas Lake Garda (site n. 15) showed a positive trend (Fig. 3), starting with the first observed brood in 2010, and reaching the number of 16 families in 2017 (linear model $R^2 = 0.83$; $\beta = 4.87 \pm 0.90$; $t = 5.42$, $P = 0.002$); The other three sites (n. 5, 8, 14) do not reveal a statistically significant trend, with fluctuating number of broods, more pronounced on Lake Como in the last two years of the census. The number of chicks per brood ranged from 1 to 19, with a mean value of 6.94 (ES = 0.22; median = 6, N= 282 broods), but the frequency distribution resulted right-skewed so that small broods appeared more abundant (Fig. 4). In the 78.4% of the cases (N = 211) , broods comprised up to 9 chicks, while the 21.6% comprised 10 or more chicks. Only15 broods (5.31% of the total) showed a number of chicks equal or higher than the threshold value stated for Conspecific Nest Parasitism ($\geq$ 14 chicks); the median value of chicks per broods decreased during the first three years stabilizing from 2013 onwards. To analyze temporal variation in brood size we fitted a negative binomial model with year as predictor: the year effect was not significant ($\beta \pm$ ES: -0.01± 0.02; P = 0.579) and the model with year had a higher AIC (Δ AIC=1.87) then the null model.

DISCUSSION

The European population of the Goosander is estimated at 66,800-103,000 pairs, with the stronghold of the specie being hosted in Finland (20,000-30,000 pairs or 30% of the European population) and Sweden (27,000-42,000 pairs or 41% of the European population). The Goosander is not a threatened species and the regional assessment, in the frame of the IUCN Red List Status, defines the species as Least Concern (LC, BirdLife International 2015). In the long (1980-2012) and short-term (2001-2012), the trend of the EU population is defined as "decreasing", mainly on account of the negative trend of the Estonian and Finland population, with a magnitude that ranged from 31 to 49%. In this context emphasis must be placed on the assessed positive short-term trend of the majority of the central and eastern European countries, that is similar, but smaller in size, to that observed in the southern countries (BirdLife

Table 3. Total number of broods counted in the four major lakes, mean (ES) and median. R^2 value for the linear model for the 8 years trend, with P value.

	Maggiore (site n. 5)	**Como** (site n. 8)	**Iseo** (site n. 14)	**Garda** (site n. 15)
2010	6	4	1	1
2011	14	12	1	1
2012	9	15	2	2
2013	10	14	2	2
2014	22	21	2	4
2015	11	19	2	7
2016	13	15	3	10
2017	14	15	1	16
total	**99**	**115**	**14**	**43**
mean	**12.4**	**14.4**	**1.6**	**5**
ES	**± 1.68**	**± 1.79**	**± 0.25**	**± 1.89**
median	**12**	**15**	**2**	**3**
R^2 - Linear model	0.18	0.43	0.17	0.83
P value	0.295	0.077	0.31	0.002

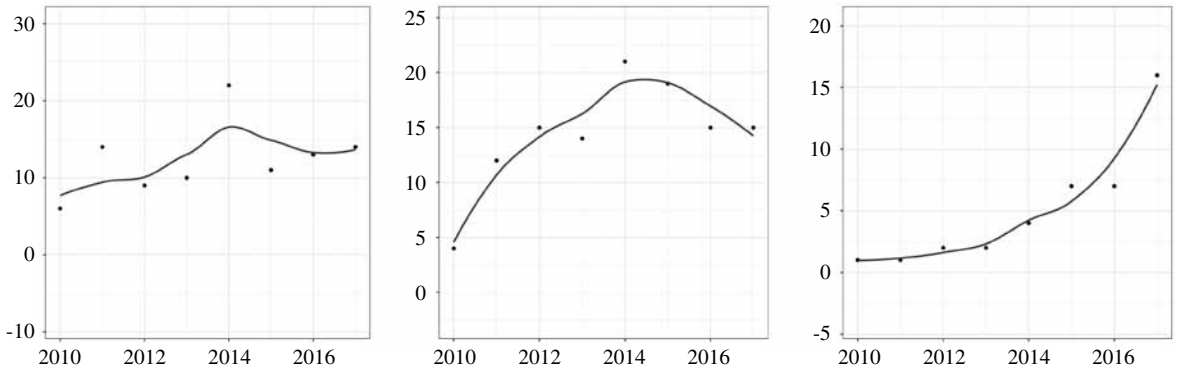

Figure 3. Smoothed trend-lines of the number of families on lakes Maggiore, Como and Garda.

International 2015). Concerning the relatively recent colonization of Italy Gustin *et al.* (2016) did not provide a Favourable Reference Value for the Goosander in Italy. The European guidelines aimed at evaluating and monitoring the conservation status of the species, require that all the Member States, as a long-term objective that takes into consideration the population size, range and habitat, provide a "Value" that may represent a favourable status of species. This "Value" may be translated as numbers of pairs per unit area for those specie regularly breeding in Italy and Gustin *et al*. (2016) indicates a Minimum Viable Population of 300 pairs as a long-term conservation objective. The recent Italian known breeding range of the species, as results from the map available from the ornitho.it data-base (www.ornitho.it; accessed on 28 February 2018, for the period 2005-2017), regards only the northern part of the country, from River Toce and Lake Orta on the west (site n. 4), up to the Slovenian border on the east, with observations regarding 88 10x10 km atlas square, of which 55 are related to breeding individuals. Only in 2017, in our study area we had a minimum of 51 females with chicks, corresponding to 21 10x10 atlas square with successful nesting, matched in north-east Italy (outside our study area) by 9 atlas square with a minimum of 10 families: hence we obtain a minimum of 60 nesting pairs. From these data we can estimate a minimum of 80-150 nesting pairs for Northern Italy, a three to five-fold increase of the previous published reference that assessed 22-29 pairs for the period 2008-2012 (Nardelli *et al*. 2015). The results of our survey reveal that the bulk of the Goosander's population is still concentrated in the three largest lakes (Maggiore, Como and Garda), with smaller lakes and rivers being colonized by a low number of pairs. Since 2014 onwards the breeding records on Lake Garda rose to the same level of Lakes Maggiore and Como, but the spreading of the nesting pairs on Lake Garda appears to be more rapid than the first two. From 2015 onward the breeding population in the western lakes (Maggiore and Como) appears to be stable: in the first lake the Goosander is becoming increasingly frequent in the southern part of the water body, that presents different characteristics to those of the northern sector, where the rocky shore is predominant. In the southern part, partly urbanized, the species is also more frequent (Saporetti 2018) in the reeds areas of the Special Protection Area " IT2010502 Canneti del Lago Maggiore", a marshland-woodland site, where the first brood was observed in 2017. Other broods were observed, from 2015 to 2017, both inside and outside our study area, demonstrating the continuous colonization process that involves smaller rivers. The mean number of chicks per brood observed in the present survey is 6.9 (ES ± 0.99) and this value is similar with

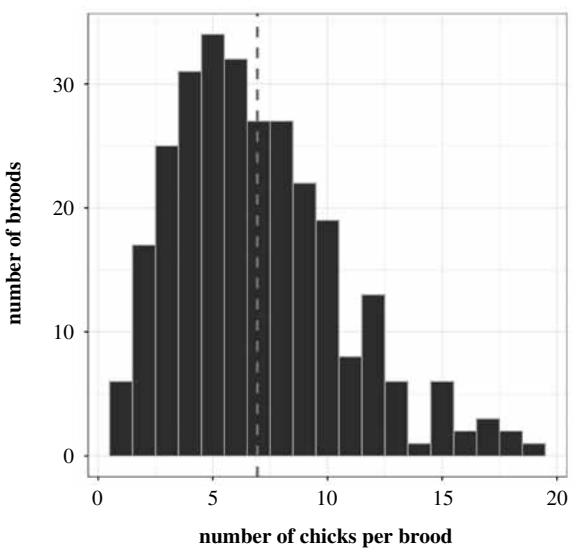

Figure 4. Frequency distribution of the number of chicks per broods with mean (indicated by dashed line).

Table 4. Values of mean brood size available in literature and during the present study.

paper	country	mean brood size	ES	number of families
Bauer & Zintl (1974)	Germany (Bayern)	7		44
this paper	Italy	6.9	± 0.99	282
Catsadorakis *et al.* (2016)	Albania F.Y.R. of Macedonia Greece	6.4	± 0.56	38
Keller & Gremaud (2003)	Switzerland	6.3 6.5	± 0.40 ± 0.41	min. 241 max. 255
Marinkovic *et al.* (2008)	Serbia Bosnia-Erzegovina	6.5		126
Zenatello *et al.* (2009)	Italy	7.4	± 3.02	6

those available from literature, whose values ranging from 6.3 to 7.4 (Tab. 4). The expansion of the breeding range is matched by the trend of the wintering individuals as obtained by IWC census data, despite a relatively recent discovery of a north-east range shift in wintering individuals (Musilová *et al.* 2009, Lehikoinen *et al*. 2013) connected with climate change. On this aspect we may assume a different wintering behaviour between the Alpine population and the north-European population. Indeed, the wintering numbers in the Lombardy region, passed from 11 individuals in 2002 (Vigorita *et al*. 2002) to a maximum of 371 in the year 2016 (Longoni & Fasola 2016), taking into account a period of 15 years.

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