HERPETOFAUNA OF THE MOUNT GUGLIELMO (BRESCIA, ITALY)

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Parole chiave - Anfibi, rettili, distribuzione, transumanza alpina, conservazione, ornitho.it

Riassunto - L'herpetofauna del M.te Guglielmo (Brescia, Italia). Il presente studio fornisce nuovi dati di distribuzione dell'erpetofauna della fascia montana del Monte Guglielmo (1957 m s.l.m.), a una quota superiore a 1000 m s.l.m. In 11 anni (2005-2015) di monitoraggi, sono state raccolte 726 osservazioni. Nell'area di studio sono state ritrovate cinque specie di anfibi (*Salamandra salamandra, Triturus carnifex, Bombina variegata, Bufo bufo, Rana temporaria*) e sette di rettili (*Podarcis muralis, Lacerta bilineata, Anguis veronensis, Hierophis viridiflavus, Natrix natrix, Vipera aspis e Zamenis longissimus*). Le mappe di distribuzione e alcune problematiche di conservazione relative all'erpetofauna locale vengono discusse all'interno dell'articolo.

Key words - Amphibians, reptiles, distribution, alpine transhumance, conservation, ornitho.it

Abstract - The present study provides new distribution data of the herpetofauna of the Mount Guglielmo (1957 m a.s.l., southern Alps, Brescia), above the 1000 m a.s.l contour line. 726 observations have been collected over a 11 years long monitoring campaign (2005-2015). Five species of amphibians (S*alamandra salamandra, Triturus carnifex, Bombina variegata, Bufo bufo, Rana temporaria*) and seven of reptiles (*Podarcis muralis, Lacerta bilineata, Anguis veronensis, Hierophs viridiflavus, Natrix natrix, Vipera aspis, and Zamenis longissimus*) have been found in the study area. The distribution maps and some conservation issues are discussed in the paper.

INTRODUCTION

The global amphibian decline crisis and the increasing awareness concerning the decline of many reptiles species (WAKE & VREDENBURGH, 2008; SINERVO *et al*., 2010; BÖHM *et al*., 2013), require challenging conservation efforts and the monitoring of the trends and distribution patterns of the herpetofauna. A detailed and updated knowledge of the distribution of amphibians and reptiles is a basic tool for the study, conservation, and long-term monitoring of their populations (SILLERO *et al*., 2014). In this context, faunistic studies, even at small geographical scale, represent a small but essential contribution for the conservation of herpetofauna.

The present study provides new distribution data of the herpetofauna of the Mount Guglielmo (southern Alps, Brescia) from a 11 years long (2005-2014) monitoring campaign. The last herpetological survey including this area date back to more than 20 years ago (BENNATI, 1992). Importantly, the area of the Mount Guglielmo is also listed among the "Areas of particular environmental interest" in the regional law (LR 86/83, Lombardy) and is therefore under consideration for the designation of new protected areas. In this context the collection of original data and the identification of the potential threats for the local herpetofauna could be a useful tool to manage the decisional process that could lead to a formal protection of this territory.

MATERIALS AND METHODS

Study area

The Mount Guglielmo (Latitude N: 45.762539°; Longitude E: 10.160150°; 1957 m a.s.l.) is an isolated massif in the southern Alps, between val Trompia and the large prealpine lake Iseo (val Camonica). Mount Guglielmo belongs to the group of the Garda mountains (according to the classification of the Alpine Club; GRASSLER, 1984) (Fig. 1). This massif consists of an imposing calcareous ridge extending in a NW-SE direction surrounded by some minor reliefs. The study area is limited to the upper part of the massif, above the 1000 m a.s.l. contour line and include some of the lower surrounding reliefs, such as Cima Pergua (1198 m), Monte Lividino (1360 m), Monte Aguina (1248 m), Monte Agolo (1366 m), and all the western part of the Montecampione ridge. Althougth they are included in the 1000 m contour line, Punta Almana (1498 m; 4.5 km SW of the Mount Guglielmo peak) and the upper part of Val Palot including Dosso

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della Ruccola (1436 m), Dosso della Pedona (1415 m), and Dosso Camussone (1433 m) have not been covered in the course of the monitoring activities (Fig. 1).

The study area has a typical mountain and alpine climate, but the western side is influenced by the mitigating effect of lake Iseo. A detailed description of the vegetation cover, dominated by woodlands and pastures, is provided by Bertoli (2010). Mount Guglielmo is an ancient transhumance area and, due to its geology (dominated by calcareous rocks with many karst landforms), surface water is largely absent at the higher altitudes, where water supply for cattle was traditionally obtained by digging watering ponds, representing virtually the only surface aquatic habitat in high altitude pasturelands.

Study period

Overall, 66 surveys were performed between 2005 and 2015 across the study area. Since most of the observations of the present study were collected during a long-term monitoring campaign of the reproductive activity of *Rana temporaria* (Tiberti, 2011; Tiberti, 2015), almost half of the surveys (31) were made in May, when *R. temporaria* breeds in the study area. Just one survey was carried out in March, 13 in April 15, in June, and 6 in July. While the beginning of the activity season for amphibians and reptiles (late April-May) was satisfactorily covered, the late summer and autumn, which are still favorable seasons to observe the local herpetofauna, were poorly or not covered by the present study.

Search of amphibians and reptiles

Surveys have been conducted by walking across the study area, crossing diverse habitats and recording the presence of amphibians and reptiles, including amphibians eggs and larvae and dead animals. Different amphibians life stages (eggs, larvae, neometamorphosed, and adults)

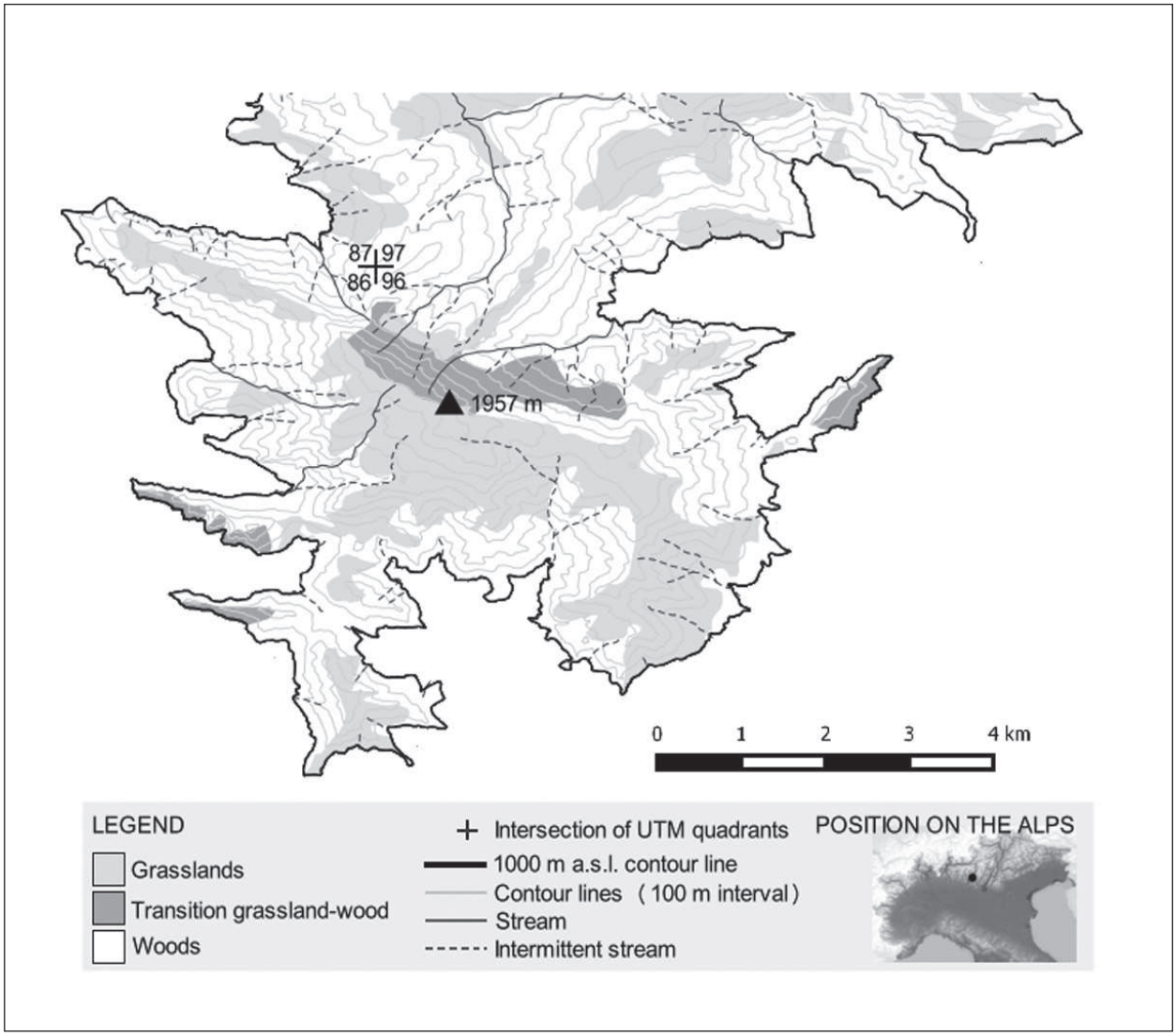

Fig. 1 - Mount Guglielmo area above the 1000 m a.s.l. contour lines and its position on the Alps. The two last numbers of the identification code of the UTM quadrants (32TNR86, 32TNR87, 32TNR96, and 32TNR97) are reported at their intersection (+).

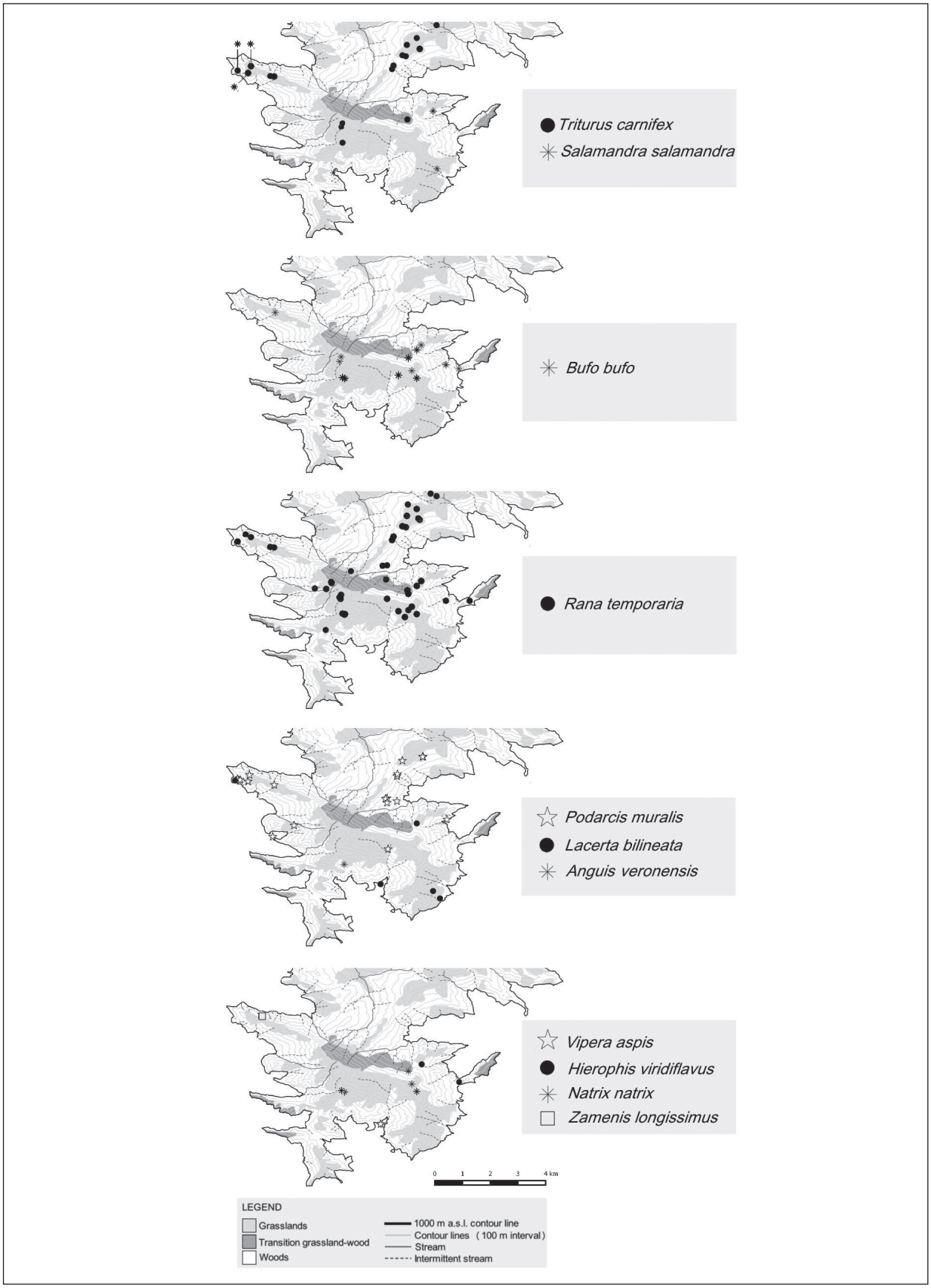

Fig. 2 - Distribution maps of the amphibians and reptiles of the Mount Guglielmo above the 1000 m a.s.l. contour line. The sites of occurrence of *Bombina variegata* were not voluntarily displayed because of conservation concern. *Vipera aspis* was found just outside the study area at 916 m a.s.l.

Species	NO	NL	Alt (m a.s.l.)	Ecological notes
Salamandra salamandra	9	6	1373	Often observed in pastureland ponds
Triturus carnifex	91	17	1776	Always observed in pastureland ponds; threatened by introduced fish
Bombina variegata	4	2	-	Always observed in pastureland ponds; last observation in July 2006
Bufo bufo	74	14	1740	Nearly always observed in pastureland ponds
Rana temporaria	499	47	1860	Nearly always observed in ponds and troughs for cattle; illegally collected for food and affected by mass-tadpoles mortality in 2002-2007
Podarcis muralis	27	17	1478	Always observed in anthropogenic habitats (e.g. buildings, roads)
Lacerta bilineata	8	5	1321	Observed both in wooded and open areas
Anguis veronensis	3	2	1336	Observed both in wooded and open areas
Hierophis viridiflavus	2	2	1286	Observed both in wooded and open areas
Natrix natrix	7	5	1663	Always observed in pastureland ponds
Vipera aspis	1	1	916	Observed in wooded areas
Zamenis longissimus	1	1	1230	Observed in wooded areas

Table 1 - Number of observations (NO) and localities (NL), and upper altitudinal limit (Alt) of the herpetofauna of the Mount Guglielmo

have been separated into different observations. Special attention was devoted to the monitoring of wetlands (mountain ponds for watering cattle, troughs, fountains, springs and streams) as they are potential sites for the reproduction of amphibians. Reptiles and amphibians were also searched under their usual shelters (rocks, logs, metal sheets, etc.) or along woodland margins, roads, fencing walls and streets. All the observations provided in the present study have been uploaded on *ornitho.it* -a web platform for the collection of georeferenced ecological data in Italy- and are therefore available for its institutional purposes.

RESULTS

Overall, 677 observations of amphibians, from 51 sites, and 49 observations of reptiles, from 30 sites, were collected during the study period (Table 1; Fig. 2). Five species of amphibians (*Salamandra salamandra* L. 1758, *Triturus carnifex* Laurenti 1768, *Bombina variegata* L. 1758, *Bufo bufo* L. 1758, *Rana temporaria*) and seven of reptiles (*Podarcis muralis* Laurenti 1768, *Lacerta bilineata* Daudin 1802, *Anguis veronensis* L. 1758, *Hierophis viridiflavus* Lacépède 1789, *Natrix natrix* L. 1758, *Vipera aspis* L 1758, and *Zamenis longissimus*, Laurenti 1768) have been found in the study area. Most of the herpetofauna of the Mount Guglielmo was observed in anthropogenic habitats, such as mountain ponds for watering cattles (see ecological notes, Table 1).

Both adults (N=2) and larvae of *S. salamandra* were observed (Fig.2) along the few small streams present above 1000 m, and in or near pastureland ponds (Malga Aguina, from 1148 to 1373 m).

All the observations of *T. carnifex* (Fig. 2) were collected at its breeding sites, in lentic waters. Most of the observations (N=88) come from high altitude pasturelands, where this species breeds in mountain ponds. This species can be easily observed during the breeding season in two areas -Montecampione, NE of the study area, and Malga Aguina-Monte Agolo, NW- probably sustaining two metapopulations. A few more isolated observations (N=4) were recorded in rather distant ponds (the two southern points in Fig.2). In 2011-2012, some brown trouts (*Salmo trutta*) were introduced in the pond of Malga Prato Nuovo. Since then, the number of *T. carnifex* (counted by Visual Encounter Survey while walking along the entire pond shoreline) has drastically decreased from 37.4 (mean value based on 13 observations in the period 2005-2011; range: 1-144) before fish introduction to 0.3 (just two newts observed during 7 surveys in the period 2012-2015) after fish introduction. The pond of Malga Prato Nuovo hosted the most abundant population of *T. carnifex* in the study area (489 adults *T. carnifex* counted during the entire study period -44% of the total- come from this site).

B. variegata was observed four times on the western slope of the study area (municipality of Zone) in June-July at the beginning of the study period (2005 and 2006) and has not been observed in the following years. The maximum number of individuals observed at the same time was five adults in a pastureland pond, but no eggs or tadpoles have been observed at the sites of presence.

Adults, larvae and eggs of *B. bufo* were often observed (73 out of 74 observations) at its breeding sites, which, in the study area, are the mountain ponds for cattle watering (Fig.2). *B. bufo* was always observed in simpatry with *R. temporaria*.

R. temporaria is the most common amphibian in the study area, with the larger number of observations and localities and the higher altitudinal distribution, up to 1860 m a.s.l.,

in correspondence of the highest reproductive site of the study area (Fig. 2). *R. temporaria* occurs in all the aquatic habitats above the 1000 m, in ponds, troughs, fountains and springs, with the exception of running waters. During the post-breeding activity *R. temporaria* probably move to the near foraging grounds (grasslands and open areas), but there is just one observation of an adult frog outside its reproductive site.

Concerning reptiles, the most common is *P. muralis* which is present up to 1478 m a.s.l. in all the suitable habitats, mainly of anthropogenic origin, such as buildings, walls, and roadsides (Fig.2). *L. bilineata*, *A. veronensis*, and *H. viridiflavus* were observed both in wooded and open areas (Fig.2). *N. natrix* was always observed swimming in the pastureland ponds. *Zamenis longissimus* has been observed just once in a wooded area near to Malga Aguina (1230 m a.s.l.). *Vipera aspis* was observed just once a few hundreds of meters outside the border of the study area at 916 m a.s.l. (Fig.2).

DISCUSSION

Check list and distribution

Five species of amphibians (41.7 % of the regional species pool; estimate based on the number of species reported for the Lombard Alpine region by Sindaco *et al*., 2006) and seven of reptiles (63.7 % of the regional species pool) were observed. Some of the absent amphibians, such as *Lissotriton vulgaris*, *Rana latastei*, *Hyla intermedia*, and *Pelophylax* kl. *esculentus* are probably limited at lower altitudes by their ecological constrains, while the range of other species, such as *Salamndra atra* and *Ichthyosaura alpestris*, is restricted to different or marginal parts of the Lombard Alps (Bernini, 2004). However, a few species may have been missed by the monitoring, such as *Rana dalmatina*, reported in the study area by Bennati (1992) (see next paragraphs), and *Bufo viridis*. A specimen preserved in alcohol of *B. viridis* was observed in a private collection of a local resident: the specimen was collected in the woods above Zone (western slope of the Mount Guglielmo), but the date, location and circumstances of its collection cannot be verified. Concerning non-observed reptiles species, there are probably some not-found species, which may be present in the study area. The low number of observed reptiles indicates a low monitoring efficiency (49 observations of reptile vs. 677 of amphibians) and that some species could have been consequently missed (e.g. *Coronella austriaca*, *Zootoca vivipara*, and *Vipera berus*). Further monitoring efforts are probably needed to get an adequate description of the distribution of reptiles in the study area.

With respect to the "Atlas of Italian amphibians and reptiles" (Sindaco *et al*., 2006) -which uses the Universal Transverse Mercator (UTM) projection coordinates system (Fig.1)- the present study provides 6 new observations (*B. variegata*, *R. temporaria*, and *Zamenis longissimus* in the quadrant 32TNR87; *N. natrix* and *H. viridiflavus* in the quadrant 32TNR96; *P. muralis* in the quadrant 32TNR97).

The only existing herpetological studies covering the study area are Bennati *et al*. (1975) and Bennati (1992) reporting respectively one and 19 records of amphibians presence referable to the study area. The first study is a review of the poor existing historical literature on the herpetofauna of Brescia and reports the presence of *S. salamandra* on the Mount Guglielmo. The second is an original research on the distribution of amphibians in Val Trompia and includes both the slopes of the Mount Guglielmo massif. Apart of several data concerning the presence of *R. temporaria* and *T. carnifex* in a series of breeding sites which have been confirmed in the present study, Bennati (1992) reports the presence of *R. dalmatina* in the study area (which was not confirmed in the present study), and the first observation of *B. variegata* (dating back to 1991, probably found in the same sites of the present study, but the author had in turn declined to indicate the exact location). The presence of *R. dalmatina* cannot be excluded, however all the adult frogs directly observed or heard chorusing during the present study were identified as *R. temporaria* and one of the sites of occurrence for *R. dalmatina* reported by Bennati (1992) no longer exists because of the drying up of the pond (Malga Lividino). Concerning the presence of *B. variegata* (Bennati, 1992), the nearest populations are reported on the western side of the Lake Iseo (Bernini, 2004), representing an important ecological barrier for this species. *B. variegata* was observed for the last time at the beginning of the present study (2005-2006) confirming its presence 15 years after the study of Bennati (1992). However just a small number of individuals were observed (possibly indicating a small population) and no signs of reproduction (paired individuals, eggs or tadpoles) were observed. Along with the long time passed since the last observation, these details call into question the survival of the population. Not to further endanger this extremely isolated population, the exact locality of the observations was not provided in the present study.

Conservation and threats

Mount Guglielmo host two species (*T. carnifex* and *B. Variegata*) included in the Annex II of the Habitat Directive (Council Directive 92/43/EEC), whose conservation requires the designation of Special Area of Conservation included in the Natura 2000 Network, managed in accordance with the ecological requirements of the species. Mount Guglielmo is listed among the "Areas of particular environmental interest" in a regional

law (LR 86/83) and is therefore considered as a possible area for the designation of new protected areas, by enlarging the Regional Natural Reserve "Piramidi di Zone" (designated by the DCR 1844/1984) to create a new Regional Park (according to the draft of the "Regional Plan of Protected Areas" of the Lombardy region, yet to be approved). However, at the moment there are no special environmental constrictions devoted to the conservation of the herpetofauna.

Thanks to the long study period, several local threats were identified. These threats have to be added to the global and regional ones, generally threatening herpetofauna (Wake & Vredenburgh, 2008; Sinervo *et al*., 2010; Böhm *et al*., 2013).

One of the most clear features of the herpetofauna of the Mount Guglielmo is its link to the pastoral activities and in particular to the alpine transhumance (the seasonal transfer of livestock to the high altitude pastures during the summer), with many species depending on anthropogenic habitats (e.g. mountain ponds and pasturelands; see the ecological notes in Table 1). Mountain ponds and troughs for watering cattle represent the only breeding site for *R. temporaria*, *B. bufo*, and *T. carnifex*, and *N. natrix* and *B. variegata* were observed only in these habitats. The connection between wildlife and transhumance creates a close link between the conservation of nature and that of traditional activities. The ongoing abandonment of transhumance all over the Alps (Cernusca *et al*.,1999) is often considered with concern for the likely negative consequences for alpine biodiversity due to land-use change (*e.g*. Bunce *et al*., 2004; Laiolo *et al*., 2004; Herzog *et al*., 2005), in particular at lower altitudes, where pastures, in the absence of grazing, turn into shrub and forests. Certainly an abandonment of transhumance in the Mount Guglielmo area would produce serious consequences for the local herpetofauna. For example, without a regular maintenance (e.g. removal of vegetation and sediments), most of the mountain ponds are doomed to disappear within a few year/decades, due to their progressive burial or to the infiltration of water at the clay bottom. However, in the Mout Guglielmo area, transhumance still produce an actual water demand for cattle and a good part of the ponds are maintained quite regularly: ten pond restorations were counted in 11 years, including re-waterproofing of the bottom of dried ponds (Tiberti, 2015). However in the last decades, water demand was sometimes satisfied replacing traditional ponds - much more suitable as breeding sites for amphibians (see Tiberti 2015)- with large pools with their bottom made of waterproofing polymers (six of these pools have been constructed in the study area). Sometimes, due to their steep shore, these pools turn out to be a lethal trap for amphibians and other animals (Bennati, 1992; Tiberti, 2015). A realistic conservation measure could be remodeling the shores of these pools to make them less dangerous for amphibians and other animals.

On the other hand there are other human activities potentially threatening amphibians and reptiles. An important characteristic of Mount Guglielmo is the impressive number of hikers (ca. 50.000 per year; Bertoli, 2010). Such a massive touristic exploitation can potentially disturb the local herpetofauna. In the study area, *R. temporaria* is also commonly used for food and illegally collected during the breeding season. As a matter of fact, frog capture is a long lasting practice in the study area and, probably, *Rana temporaria* is able to withstand this threat. However when the local populations are rarefied, for example due to diseases or natural fluctuations (Tiberti, 2015), poachers could exacerbate the demographic consequences of epidemics. Given the short duration of the breeding season, a stronger vigilance by the police authorities would be a realistic effort to contrast poachers.

Fish introduction is a major threat for alpine herpetofauna (Eby *et al*., 2006), potentially leading the populations of amphibians to extinction (Tiberti & von Hardenberg, 2012), and it is sustained by anglers for recreational purposes. Shallow and eutrophic mountain ponds for cattle are usually unsuitable for fish and, excluding some releases of pet fish (e.g. *Carassius auratus*; e.g. Denoel *et al*., 2005), they are generally not interested by fish introduction. However when the ponds are clear and well oxygenated (e.g. fed by springs) fish can be successfully introduced. In the study area , the introduction of brown trouts (*Salmo trutta*) in the mountain pond of Prato Nuovo had a huge impact on the local population of *T. carnifex*. This is particularly worrying for the conservation value of *Triturus carnifex* and for the likely strategic importance of this pond in sustaining a larger metapopulation, displaced in the surrounding ponds. An eradication plan would be an important and relatively simple conservation measure.

Finally, the present monitoring campaign was actually born because of a conservation issue related to the spread of massive die-offs among the tadpoles of *Rana temporaria*. Mass die-offs have been ascribed to bacterial infections caused by *Aeromonas* sp., often associated to Red-Leg disease (Rigney *et al*., 1978), and have not been reported since 2007 (for further information and detailed description of the symptoms see Tiberti, 2011). *Aeromonas* sp. is an opportunistic pathogen (Carey, 1993) whose pathogenicity is facilitated by other factors, such as amphibians overcrowding (see Meyer *et al*., 1998), environmental stress, and the presence of other, not detected, pathogens (Tiberti, 2011) or parasites (see Tiberti and Gentilli, 2010 for

the description a leech attack on the population of *Rana temporaria* from the Mount Guglielmo). However, the population of *Rana temporaria* increased over the last decade (Tiberti, 2015), suggesting that *R. temporaria* has capacity to withstand high larval mortality.

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