

Amphibians in Southern Apennine: distribution, ecology and conservation notes in the “Appennino Lucano, Val d’Agri e Lagonegrese” National Park (Southern Italy)

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Abstract. Italy is the European country with the highest amphibian richness and endemism. However distributional data from some Southern Italy areas are scanty, in particularly for the Basilicata region. In this study, we present the results of field and bibliographic survey on the amphibians of the “Appennino Lucano, Val d’Agri e Lagonegrese” National Park (almost 70,000 ha). We recorded breeding activity of 12 amphibian species in 307 sites, for a total of 493 records. For some endemic species we provide new ecological data, such as new altitudinal limit (*Salamandrina terdigitata*) or expansion of the annual activity cycle (*Bombina pachypus*). Indices of diffusion, density and rarity were applied to test the status of each species in the Park. Correspondence analyses showed a clear aquatic habitat partitioning between anurans and urodelans and, concerning the latter, between newts and salamanders, newts being strictly dependent on artificial water bodies. Our results support the growing idea, recently formalized by the IUCN, that maintaining and restoring artificial water bodies may be fundamental for an appropriate conservation management of amphibian communities in Mediterranean rural landscapes.

Keywords. Amphibians, artificial water bodies, Basilicata, correspondence analyses, distribution, habitat partitioning.

INTRODUCTION

Amphibians are the vertebrate group experiencing the steeper global population decline and species loss (Stuart et al., 2004; Gascon et al., 2007). Baseline data are urgently needed about causes and magnitude of species loss and population declines for effective biodiversity monitoring programs. Italy has the highest amphibian biodiversity in Europe hosting 43 species, of which 15 endemics. Southern Italy and Sardinia are the major Italian hotspots of

herpetological endemicity (Sindaco et al., 2006), even if they were the less investigated areas during the herpetological surveys that led to the publication of the Italian Atlas (Sindaco et al., 2006). In this context, Basilicata is the least investigated region of Southern Italy, and probably of the entire country (see figures 3.4, 3.5 and 3.6 in Sindaco et al., 2006).

In December 2007, the youngest Italian National Park, “Parco Nazionale dell’Appennino Lucano, Val d’Agri e Lagonegrese” (PNALVAL, Fig.1a) was established in Basilicata. This protected area lies between 15,584° and 16,152° N 40,454° and 40,273° E covering 68,996 hectares. The Park covers 26 UTM 10x10 km squares, but 11 of them just marginally (i.e., less than 10% of UTM square included in PNALVAL; Fig.1a), and comprises 12 sites of Community importance (SCI). The altitude ranges from about 290 m a.s.l. to 2005 m (Monte Papa, province of Potenza). The low altitude areas are covered by mesophilous and thermophilous mixed-oak woods (*Quercus cerris*, *Q. pubescens*, *Q. frainetto*, *Fraxinus ornus*, *Carpinus orientalis*) while beech (*Fagus sylvatica*) forests, interspersed with man-made grassland and pastures, are dominant on the mountain tops. Along streams, rivers and valley bottoms the riparian vegetation is dominated by poplars (*Populus nigra*, *P. alba*), alders (*Alnus glutinosa*, *A. cordata*) and willows (*Salix alba*, *S. purpurea*). Typical Mediterranean marquis vegetation dominated by the Holm Oak (*Quercus ilex*) and *Arbutus unedo*, *Pistacia lentiscus*, *Phillyrea latifolia* occurs in the “Murgia San Lorenzo”, the easternmost portion of the park (Aita et al., 1974; Corbetta and Pirone, 1996; Fascetti, 1996; Costantini et al., 2006). The more widespread lithological substrate is given by carbonate units, that gives rise to karstic phenomena, and in particular to underground waterflows. Therefore surface hydrology is reduced and characterized by temporary running and still waters. Man-made artificial water reservoirs and water bodies are also present.

Since there were no baseline data on amphibians, in 2011 a project on their distribution and conservation status was funded by the park administration. The specific objectives of this study were to describe the amphibian richness and distribution, their use of aquatic habitats and to assess the main potential threats for conservation.

MATERIAL AND METHODS

Data collection

The presence of preserved specimens from Basilicata was verified in the collection catalogues of the following Italian natural history museums: Museo Civico di Storia Naturale of Carmagnola (Turin), Museo Civico di Storia Naturale of Genoa, Museo Civico di Zoologia of Rome, Museo di Storia Naturale of Naples, Museo Civico di Storia Naturale of Trieste, Museo di Storia Naturale di Florence, Museo Naturalistico of Alburni Mountains (Corleto Monforte, Salerno). We also checked in the distribution database available in the CKmap 5.3.8 software of the Italian Ministry of Environment, Land and Sea (Stoch, 2000-2005).

Field surveys were preceded by a careful analysis of the maps produced by the Istituto Geografico Militare (I.G.M, 1:25000), in which specific cartographic symbols refer to different typologies of water bodies (springs, running waters, tanks, drinking-troughs, wells, lakes, marshes; see Capello, 1968). Moreover, many hydronyms (in Italian or in local dialect), allow accurate identification of many wetlands. I.G.M. cartographic recognition were implemented by digital orthophotos (scaled aerial photographs) obtained from of the Italian Environmental Ministry (

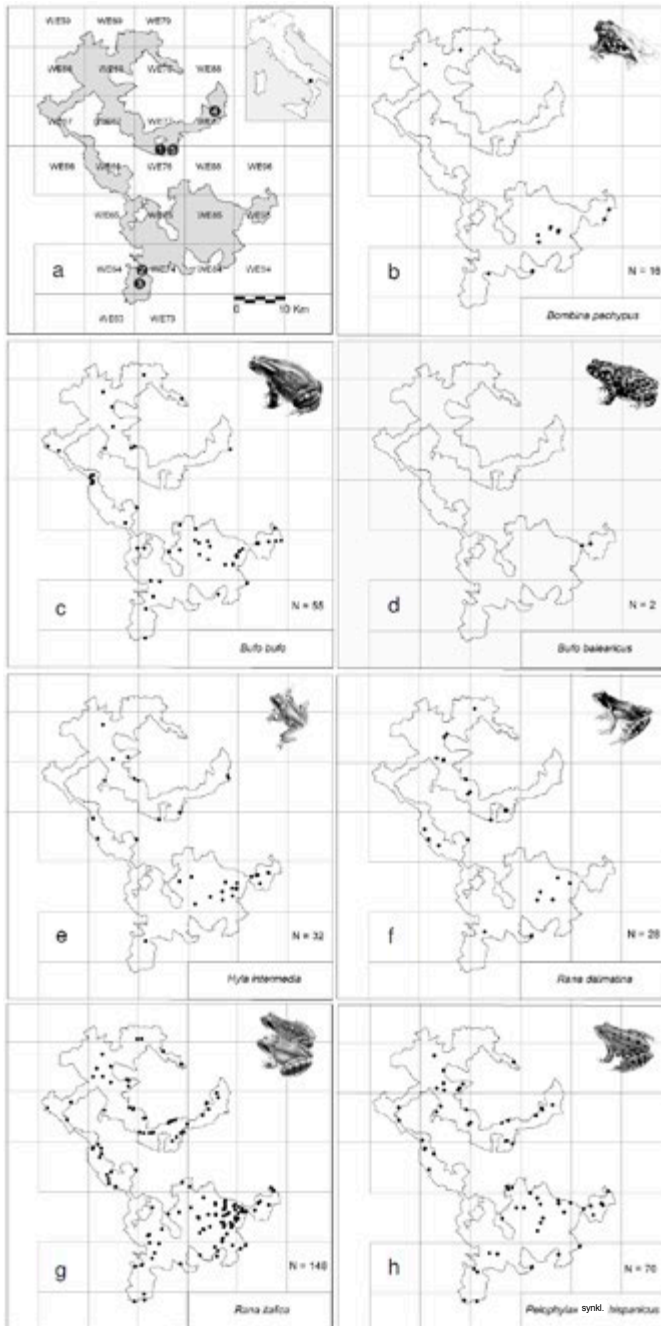


Fig. 1. a. Location of the “Appennino Lucano, Val d’Agri e Lagonegrese” National Park, southern Italy (PNALVAL, grey area), and distribution of amphibians historical data (see Appendix 1 for the correspondance between sites (numerical codes) and species). **b-h.** Distribution of Anura in the PNALVAL. UTM grid (10x10 km) with the alphanumeric code of squares is also shown.

ente.it/GN/). Field surveys were carried out systematically from February to September 2011 (about 5 field sampling days every 7 days for a total of 120 field days) although scattered observations were also obtained from January to October 2009-2010. UTM squares included for more than 10% in the Park were visited 2-10 times. Sampling effort per square was roughly proportional to the number of water points individuated by the cartographic recognition.

As a general rule, amphibian low-altitude populations breed early than higher-altitude ones (Wells, 2007 and reference therein; Lanza et al., 2007). Consequently, sampling efforts were concentrated in late winter and early spring in lowland sites, and in late spring and summer at higher altitudes.

To evaluate species presence, aquatic sites were sampled by twenty dip-nettings, including blind ones (i.e., without previous visual detection of amphibians), although sampling effort was proportional to the complexity or morphology of the habitats (i.e., deep water, dense aquatic vegetation). Road casualties and terrestrial shelters in proximity of aquatic sites were always checked.

Calling Surveys (CS) started 30-min after sunset and were usually completed by 01:00 h (Dorcas et al., 2009). Call survey lasted five minutes, with three minutes of preadaptation before the beginning. When *Hyla intermedia* and *Pelophylax* synkl. *hispanicus* were not detected within five min, we used an acoustic digital (mp3 format) playback stimulus, rate 1 call/20 sec, over an additional 3-minute period to induce call frogs. Each calling species was given a ranked score, known as Index of Calling Surveys (ICS; as for the North American Amphibian Monitoring Program; see Mossman et al., 1998; Weir and Mossman, 2005): 0 = no anurans calling; 1 = not overlapping individual calls; 2 = calls overlapping, but individuals still distinguishable; 3 = numerous anurans heard, chorus constant and calls overlapping.

In few cases we performed Visual Encounter Surveys (VES, following Heyer et al., 1994). Because VES and other unrepeated visual contacts are not appropriate method for determining population densities we did not perform demographic analyses. However for populations who had high numbers of individuals ($n > 20$) detected during one single survey, we have noted their number to provide a minimum size of the those populations. Moreover, since *Rana dalmatina* is an explosive breeder (Sofianidou and Kyriakopoulou-Sklavounou, 1983; Guarino and Bellini, 1993) and each female lays a single egg mass per season, usually fixed to the substrate (Nollert and Nollert, 1992), we used the counts of *Rana dalmatina* egg mass as proxies of the minimum female population size (counting were performed in a unique sampling session), according to the methods proposed by Griffiths and Raper (1994) and Grossenbacher et al. (2002). Among the *R. dalmatina* breeding sites we found, we chose those where populations seemed particularly large and the site typology allowed easy location of the egg masses (i.e., shallow clear waters).

Aquatic sites were assigned, considering their origin, to two main categories (i.e., artificial and natural) each including four different typologies: (i) tanks: concrete quadrangular tanks used for agricultural purposes, (ii) drinking-troughs for livestock grazing, (iii) wells: circular stony wells; (iv) artificial ponds; (v) lakes: lakes and marshes; (vi) running waters: rivers, streams and creeks; (vii) springs, (viii) natural ponds: natural ponds, pools and puddles. Because several sites were very close to each other, two or more aquatic habitats less than 50 meters apart belonging to the same category (e.g., well, pond and so on) were considered as a single breeding site, following the criterion used by Romano et al. (2007, 2010).

Phenological data on the aquatic activity of each species were recorded. However on the basis of data recorded on the field, additional information was inferred (for example, if eggs in an advanced stage of development were found at the beginning of a given month, we assumed adults were in water in the previous month, see Table 1).

Data analysis

Two indices describing species diffusion (W: wide; M: medium; L: limited) and density (C: common; F: frequent; R: rare) are provided; they are obtained from the graphs of the relationship

between the coverage (%) of the UTM grid (10x10 km) and the mean number of observations for a square occupied by each species, according to the method proposed by Doria and Salvidio (1994) and already used in other herpetological studies (Turrisi and Vaccaro, 2004). Furthermore, for each species we calculated an index of specific rarity expressed as percentage: $ISR = (1-n/N)*100$ (Gheu and Gheu, 1980), where n is the number of UTM squares occupied by a given species and N is the total number of UTM squares. We used as N only UTM squares occupied by more than 10% of the Park area (i.e., $N = 23$). ISR ranges from 0 (very common species) to nearly 100 (very rare species).

To identify associations of aquatic habitats with amphibian presence/absence we used a Correspondence Analysis (CoA). Differences in number of amphibian species among the different habitat typologies were examined using Kruskal-Wallis (KW) non-parametric analysis of variance. CoA and KW were performed as in the statistical package PAST (Hammer et al., 2001).

Finally, to determine if our effort provided an exhaustive representation of the amphibian assemblage in the different freshwater typologies, the non-parametric estimator of species richness *Chao2* (Chao, 1987), that controls for the effect of sampling effort (Walther and Morand 1998; Hortal et al., 2006), was implemented with program EstimateS Version 7.5.2 (Colwell, 2004).

RESULTS

The literature reported only eight species within the park boundaries (see Appendix 1): *Salamandrina terdigitata* (Bonnaterre, 1789), *Triturus carnifex* (Laurenti, 1768), *Lissoletriton italicus* (Peracca, 1898), *Bombina pachypus* (Bonaparte, 1838), *Bufo bufo* (Linnaeus, 1758), *Hyla intermedia* Boulenger, 1882, *Rana italica* Dubois, 1987, *Pelophylax* synkl. *hispanicus* (Bonaparte, 1839). The water frog synklepton is formed by two entities which are considered both at species rank (but see also Canestrelli and Nascetti, 2008): the parental species, *P. bergeri* (Gunther, 1985) and its hemiclinal hybrid, the klepton *P. kl. hispanicus*.

All these species presented a extremely localized distribution (they were found mainly in Laudemio lake or on Monte Sirino; see Fig. 1 and Appendix 1). Our investigations confirmed the occurrence of these species and provided first data on the presence of other 4 species: *Salamandra salamandra* (Linnaeus, 1758), *Bufo balearicus* Boettger, 1880 and *Rana dalmatina* Fitzinger in Bonaparte, 1838.

Almost five hundred amphibian records were collected during the field survey (493); breeding activity was recorded in 307 sites from 23 UTM squares, corresponding to 80% of the surveyed potential spawning sites. Species distributions and number of breeding sites of each species in the PNALVAL are given in Fig. 1 and Fig. 2, while Fig. 3 shows the altitudinal range, the aquatic site preferences and the index of species rarity (ISR) of each species. Indices of relative diffusion and density (Fig. 4b) showed that different species ranged from "widespread" to "very common" (upper right corner of Fig.4b and lower values of ISR in Fig.3), while some species had "limited diffusion" (lower left corner of the Fig. 4b and higher value of ISR, Fig. 3). Aquatic phenology is summarized in Table 1: activity ranged from January to October with marked differences among species. The index of Calling surveys (ICS), a very rough estimate of population size, was applied on some anuran species and provided the following values: *Bombina pachypus*, *Bufo balearicus*, *Pelophylax* synkl. *hispanicus* (ICS from 1 to 2); *Hyla intermedia* (ICS from 1 to 3). Estimates of minimum female population size of *Rana dalmatina* in three sites were 42, 58 and 85 females.

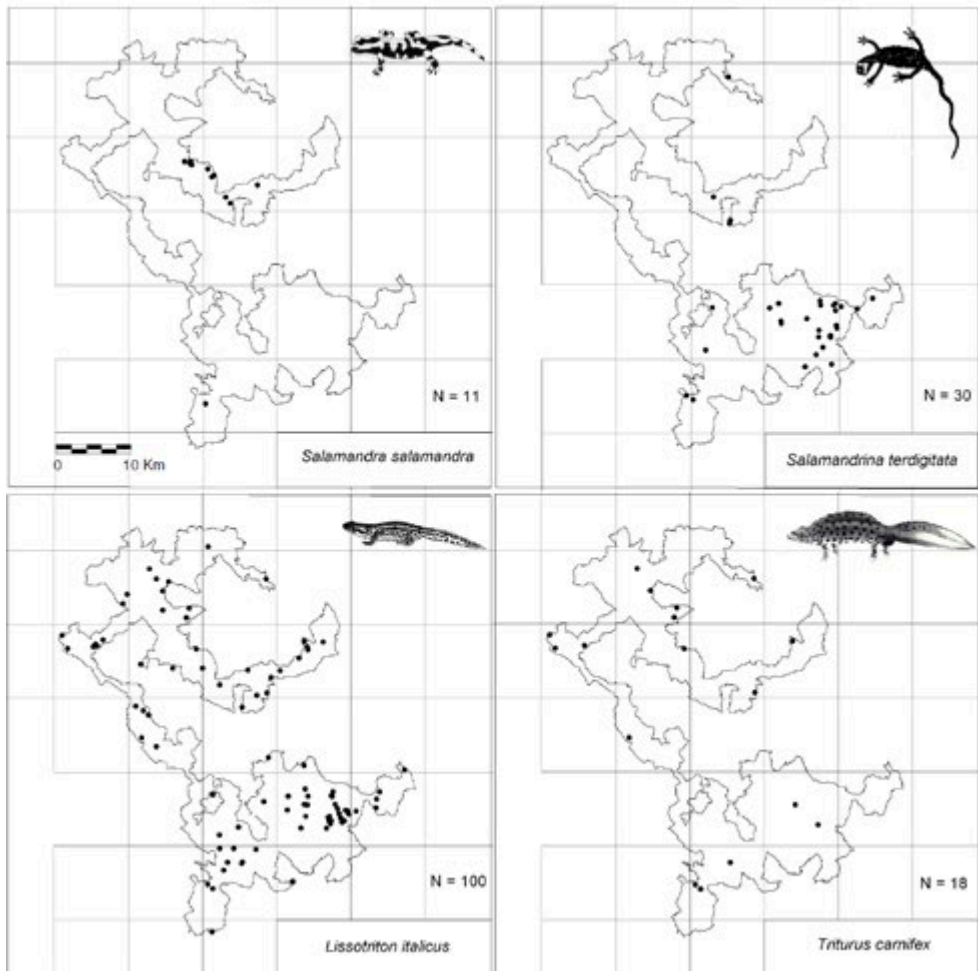


Fig. 2. Distribution of Urodela in the “Appennino Lucano, Val d’Agri e Lagonegrese” National Park (Southern Italy). UTM grid (10x10 km) with the alphanumeric code of squares is also shown.

Water bodies of different typology hosted different number of species: tanks ($n = 38$, mean of species richness \pm SD = 1.74 ± 0.98), drinking-troughs ($n = 53$, 1.49 ± 1.77), wells ($n = 5$, 1.60 ± 0.55), artificial ponds ($n = 30$, 2.23 ± 1.25), lakes ($n = 16$, 2.62 ± 1.86), running waters ($n = 112$, 1.32 ± 0.67), springs ($n = 11$, 2.36 ± 1.28), natural ponds ($n = 46$, 1.54 ± 0.78). The number of species among these height habitat typologies was significantly different (KW, $H = 26.97$, $P < 0.001$). Cumulated species richness values summed across all water bodies of a given typology ranged from 3 to 10 (Fig. 4a). Two different levels of species richness among habitats could be detected. A low level grouped artificial ponds and wells while an intermediary-high level grouped the remaining typologies, where running waters and drinking-troughs emerged as the richest typologies (Fig. 4a). Estimated

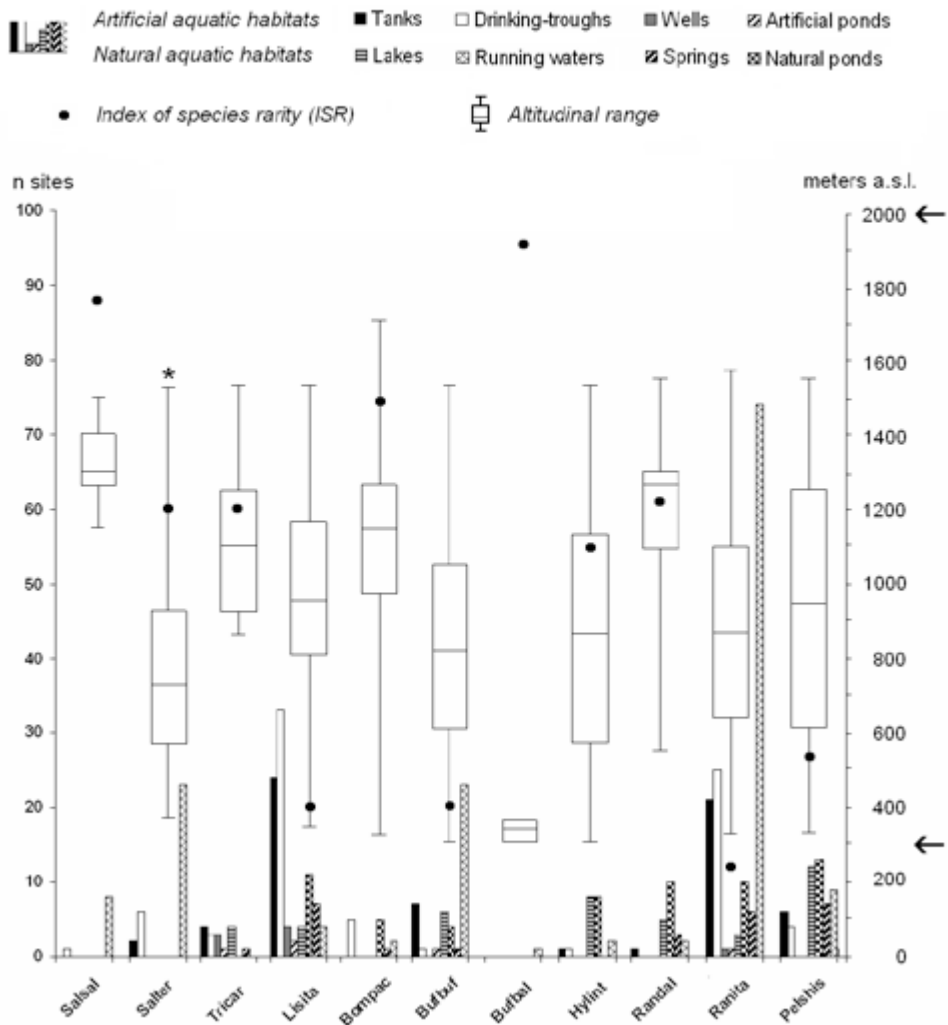


Fig. 3 Altitudinal ranges (box plots; altitudinal level on the right vertical axe), habitat partitioning (histograms, number of sites on the left vertical axe) and Index of species rarity (ISR, black dots, values on the left vertical axe) of the amphibians in the “Appennino Lucano, Val d’Agri e Lagonegrese” National Park (Southern Italy). Boxes represent the 25-75 percent quartiles of altitudinal range and the median altitude is shown with a horizontal line inside the box; the minimal and maximal values are shown with short horizontal lines (whiskers). Horizontal arrows indicate the altitudinal limit of the park. Asterisk indicates the species for which the maximum altitude record in the park is also the upper limit for the species in its whole distribution range. In the ISR, low value indicates common species, high value the rare ones. Salsal = *Salamandra salamandra*; Salter = *Salamandrina terdigitata*; Tricar = *Triturus carnifex*; Lisita = *Lissotriton italicus*; Bompac = *Bombina pachypus*; Bufbuf = *Bufo bufo*; Bufbal = *Bufo balearicus*; Hylint = *Hyla intermedia*; Randal = *Rana dalmatina*; Ranita = *Rana italica*; Pelshis = *Pelophylax synkl. hispanicus*.

and observed cumulated numbers of species were concordant and, for some habitat, the observed species slightly outnumbered of the median of the estimated ones (Fig. 4a). This suggests that observed richness provides a reliable estimate of the actual richness.

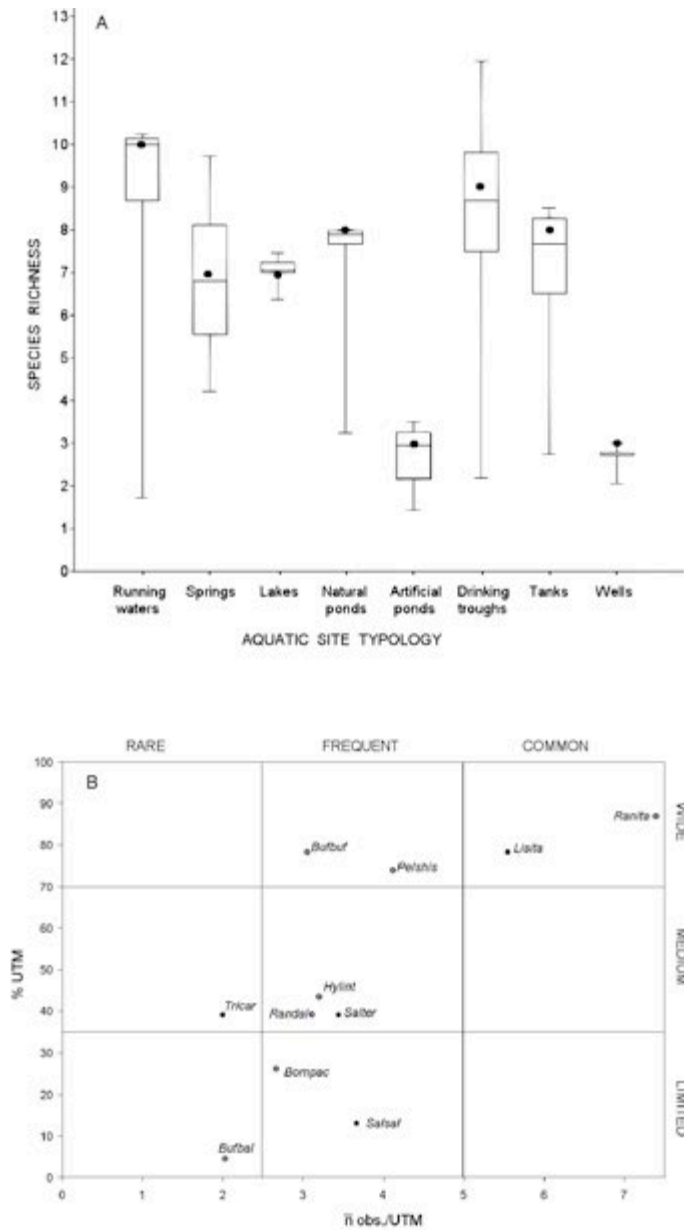


Fig. 4. A. Comparison of amphibian species richness values among the aquatic habitat typologies in “Appennino Lucano, Val d’Agri e Lagonegrese” National Park (Southern Italy), based on empirical data (field richness, black dots) and estimated richness values (*Chao2* estimator, box plot; see text for details). For each aquatic site typology the 25-75 percent quartiles are drawn using a box and the median value is shown with a horizontal line inside the box; the minimal and maximal values are shown with short horizontal lines (whiskers). **B.** Relationship between percentage of amphibian species occurrence in UTM square grids (10x10 km) and mean number of observations per UTM square. Black dots: urodelan species; grey dots: anuran species. Codes of species are as reported in Fig. 3.

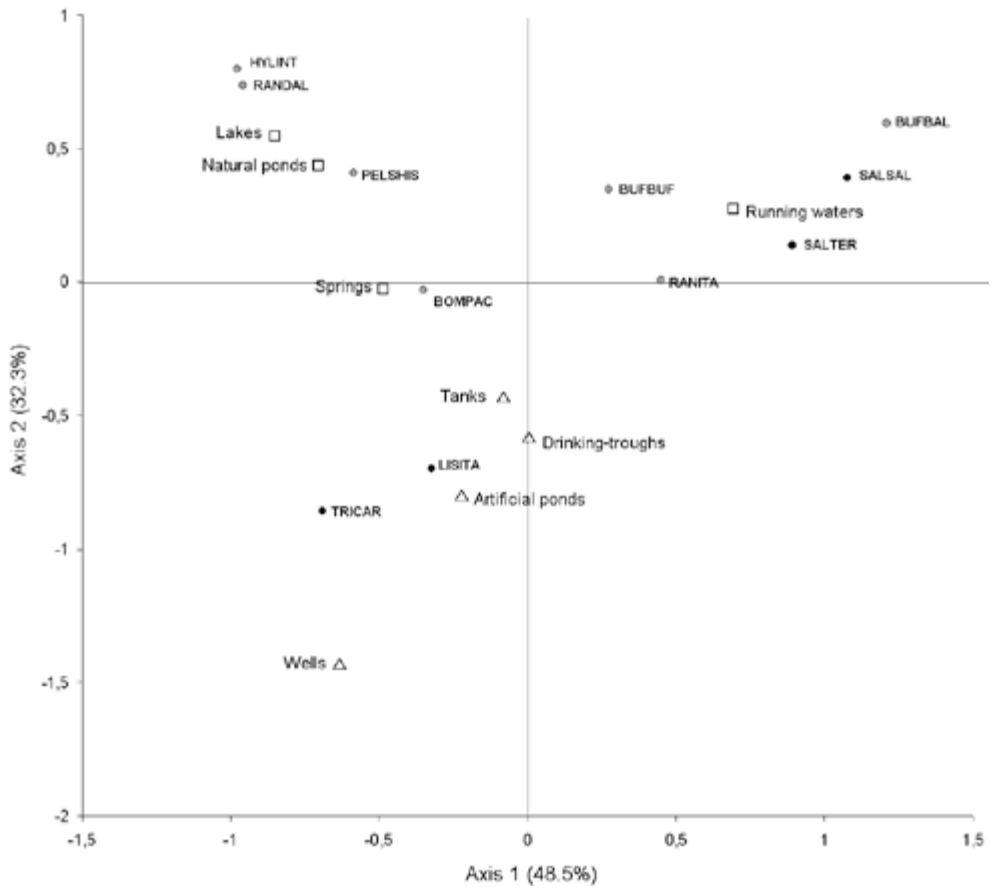


Fig. 5. Correspondence Analysis (CoA) scatter plot illustrating variations of species distribution with aquatic breeding sites. Triangles: artificial water bodies; squares: natural water bodies; black dots: urodelan species; grey dots: anuran species. The percentages of variation explained by each axis are given in round brackets. Codes of species are as reported in Fig. 3.

On the two dimensional CoA scatter plot (Fig. 5) the first two axes explained 80% of the variation in amphibian species composition among habitats. As expected there was a high associations between species and aquatic site categories. Urodelans are clearly separated in two groups, the newts (left lower quadrant) associated to artificial habitats and the salamanders (*sensu* Titus and Larson, 1995; right upper quadrant) associated to natural running waters. Also anurans shows two groups distributed along the first axis, with species associated to lentic waters (left upper quadrant) and others to running waters (right upper quadrant). *Bombina pachypus* and *Rana italica* shows an intermediate association with artificial water bodies and natural ones.

DISCUSSION

Distribution

Species distribution data, together with information on their ecology and environmental contexts, are essential to investigate global population declines and to assess the threat status of a given taxon (see the criteria used by the IUCN for the species assessment process). The PNALVAL has a rich amphibian fauna because all those expected to be present (12 species), on the bases of ecology and biogeography, were found during the intensive survey. The results give insights on distribution pattern and aquatic habitat partitioning of amphibians (Fig. 4a). Within the PNALVAL, two species are rare, *T. carnifex* with medium diffusion (Figs. 3, 4b) and *B. balearicus* with a limited diffusion (Figs. 1d, 3, 4b), possibly because of the rarity of clay or sandy soils at high altitude (Sindaco et al., 2006). Some other species, even if with limited diffusion, are locally frequent (e.g., *B. pachypus* and *S. Salamandra*). The distributive gap of *S. Salamandra*, *S. terdigitata* and *B. pachypus* (in the northern part of the Park, Figs. 2a, 2b, 1b) could be partially filled by further research, because many suitable habitats still have to be intensively sampled in the park. Moreover these are species that probably have low probability of being detected when breeding at low densities (Tanadini and Schmidt, 2011)

About the hypothetical presence of the Alpine newt *Ichthyosaura alpestris* (Laurenti, 1768) in Basilicata, its presence in Mount Sirino lakes, that fall within the boundaries of the PNALVAL, was reported in the past (Bruno, 1996), but the species is now considered absent from the region (Sindaco et al., 2006). The Alpine newt has a very sparse distribution in southern Apennine (Sindaco et al., 2006) with relict populations in Calabria (60 km southward from Mount Sirino) and Latium (330 km northward from M. Sirino). The populations from Calabria occur in small glacial lakes, ecologically similar to those in Monte Sirino. However in these lakes we found other amphibians species but the Alpine newt. Consequently, the possible occurrence of a relict population of Alpine newt on the Sirino Massif, in our opinion, have to be almost certainty excluded

Ecology

Considering the diversity of breeding sites and their altitudinal range (Fig. 3), *L. italicus*, *B. bufo* and *R. italica* can be classified as euryecious species, while *S. Salamandra* is a strictly stenoecious species. The remaining species are moderately euryecious, sometime showing opposite trends, in particular in the increased or decreased frequency related to altitude. As expected, there is a strong association between species and aquatic site categories. Clearly, the first axis of the CoA scatter plot (Fig. 5) represents differences in waterflow intensity while the second axis roughly expresses differences in size and possibly in temperature of water bodies. True salamanders (*sensu* Titus and Larson, 1995) with stream-type larvae (Griffiths 1996, Pough et al. 2001) were strictly associated to natural sites characterized by running waters, where also the two anurans *Bufo bufo* and *Rana italica* often spawn. Newts (*sensu* Titus and Larson, 1995) with pond-type larvae, were found in strict association with man-made aquatic sites characterized by low intensity of

water flow. Artificial aquatic sites also play a role, in addition to natural lentic waters, as breeding habitat for *Bombina pachypus* (Figs. 3, 5). Other anurans are strictly associated with lentic natural waters (Figs. 3, 5).

During this study, we found the highest breeding site (1525 m a.s.l.) known for *S. terdigitata*. The biological cycle and the activity patterns of *S. terdigitata* are poorly known and are often derived from those of the sister species *S. perspicillata* (Angelini et al., 2007). In PNALVAL *Salamandrina terdigitata* breeds in different categories of sites, both natural and artificial (Fig. 3, 6). The earliest spawning was recorded in early March 2011 and females entered in water in the late February (Table 1). However the breeding peak was in May and decreased until the June, when it apparently stopped. Abundant populations, with dozens of females simultaneously in water for spawning, were recorded in spring in the catchment of the Agri River, in small Mediterranean streams. *Bombina pachypus*, that in Basilicata reaches its altitudinal limit (1710 m a.s.l. in this study, 1930 m a.s.l. by Talarico et al., 2004) is active from April to October (Sindaco et al., 2006). However in other sites at low altitude, *B. pachypus* was found in water earlier, already at the beginning of March (Table 3) but possibly also in February as observed for other populations near the park boundaries (EF unpublished data). *Bufo balearicus* has been found only along the Agri River, but populations were relatively large (ICS = 2) and produced thousands of tadpoles and hundreds of neo-metamorphosed in late summer. *Triturus carnifex* had a medium diffusion (Fig. 4b) but homogenous distribution (Fig. 2d). Almost all of its aquatic habitats were near-permanent (*sensu* Boulton and Brock, 1999) or permanent and moderately deep (1-3 m) or deep (depth > 3 m) artificial sites (Figs. 3, 6). Our data only partially agree with the findings of Andreone and Marconi (2006), who considered plains and moderately elevated areas as the most suitable habitats for this species. However their results are primarily mainly on observation in central and northern Italy. The elevation range of the *T. carnifex* breeding sites in PNALVAL (Fig. 3), showed that in Southern Italy this species prefer hilly and mountainous areas as already stated (Talarico et al., 2004; Romano et al., 2010).

In the whole, we suppose that the occurrence of many ecologically diverse aquatic sites and the wide altitudinal range (300-1400 m a.s.l.) in UTM squares WE85 and WE95 can be responsible of the concentration of amphibian findings in these UTM (Fig. 1b, 2b), also of stenozonal and moderately euryzonal species.

Conservation

Number of syntopic species and species richness among the different breeding habitat types showed a reverse pattern. Lakes and artificial ponds had the highest level of syntopy but they hosted a restricted variety of species. Conversely, running waters and drinking-troughs, with a low degree of syntopy, were the habitats hosting the highest amphibian biodiversity. How and where to invest limited resources to achieve effective conservation of the biodiversity is often a difficult but obligatory choice. Knowing when which habitat provide a differential contribution to the maintenance of biodiversity is an essential information for implementing effective conservation strategies.

In general, animal conservation may be regarded at two different levels: conservation of rare species at local level and conservation of populations that deserve particular

attention due to the situation of their species at global level (Wells et al., 2010). These two levels may overlap or not, being both taxon- and local distribution-dependent. The familiar slogan “Think globally, act locally”, that has been used in various contexts, fits perfectly with an appropriate strategy for the amphibian conservation (Gascon et al., 2007) that, to be effective, must take place synergistically at all levels from local to global (Andreone, 2008).

In PNALVAL the area with the highest amphibian richness is the upper and middle section of the Agri Valley. This area maintains a continuous and well preserved forest cover, that has not been exploited recently and may be considered the most relevant for amphibian conservation. However some parts of the Valley are experiencing desertification and land abandonment, and the potential effects of global warming now threaten other parts of the Park (Geeson et al., 2002) which are highly exposed to desertification risk (Povellato and Ferraretto, 2005; Brandt and Geeson, 2011). Although *Bufo balearicus* is not an endangered species in the core of its Italian distribution range (it is considered as Least Concern by the IUCN; Sindaco et al., 2009), it is the rarest species in the study area and the preservation of these populations plays an important role in the conservation of amphibians biodiversity for this protected area. Conversely, *Bombina pachypus*, with relatively healthy populations in the park, is considered Endangered by the IUCN at species level (Andreone et al., 2009), with dramatic declines in many areas and populations (Guarino et al., 2007 and references therein). Therefore conservation of PNALVAL populations transcends the local interest and assumes a key role in the conservation of the species at a global level. The conservation goals could be better achieved through conservation projects such as creating ecological corridors (even in areas outside the park) and new potential breeding sites. In fact, the protection, restoration and increase of aquatic sites is an essential tool in the amphibians conservation strategy. In the PNALVAL almost all amphibians use traditional artificial aquatic habitats as breeding sites (Fig. 3). For some species (*T. carnifex*, *L. italicus* and *B. pachypus*), the knowledge of the association with man-made aquatic sites (Fig. 5) is a basic tool for any sustainable and effective conservation strategy planning. In Italy, rural artificial water sites are often neglected (see also Romano et al., 2010) in the context of the abandonment of agricultural land and of traditional silvo-pastoral practices in European mountainous areas (Torta et al., 2004 and references therein; Denoël and Ficetola, 2008; Curado et al., 2011). Although the Basilicata region retains a widespread agricultural and silvo-pastoral vocation (Fucella et al., 2010; PSR, 2007), about 20% of the artificial or semi-natural water bodies we censused were destroyed or abandoned, and therefore unusable for amphibians reproduction. Therefore, restoring these sites will contribute to maintain the traditional rural landscape, will give socio-economic benefits to local stakeholders and will also enhance the conservation status of a rich amphibian fauna. Indeed, the Mediterranean basin, and in particular in Southern Italy, preservation and management of artificial aquatic sites used for rural purposes is a prerequisite for effective conservation measures of amphibian populations (Temple and Cox, 2009 and reference therein). We provide here strong evidence in support the hypothesis that conservation of biodiversity in Mediterranean must necessarily pass through the proper planning of rural development and landscape management.

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SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found at: <www.unip.it/webshi/appendix>. Manuscript number 10503: Appendix 1.

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