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Herpetological paleodiversity: general considerations about the Italian fossil record of modern species

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ABSTRACT

The number of species that inhabit Italy at present was compared with the number of those potentially identifiable on the basis of their skeleton as well as with the number of those that have been so far identified in the fossil record. Although 85 herpetological species inhabit political Italy at present (excluding the non nesting or introduced ones), from an osteological-paleontological point of view only 54 taxa are identifiable (64% of the living ones), 35 of which (42% of 85; 67% of 54) have been identified so far. Thus, the present knowledge of the Italian herpetofauna osteology causes a theoretical loss of paleobiodiversity of nearly one third, whereas the real loss is of nearly 60% of the number of modern taxa and of about 33% of the number of those that are potentially identifiable. Therefore, a major bottleneck affecting the contribution that paleoherpetology can offer to the evolutionary history of the modern herpetofauna is related to the poor knowledge of the skeletal anatomy of several modern taxa.

KEY WORDS: Biodiversity - Paleodiversity - Osteology - Paleon-

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INTRODUCTION

It has been calculated that only 3% of the amphibian and reptile species that populated the planet between Late Devonian and Pleistocene has been described (Riquès, 1992). Although highly approximate, also in the opinion of its Author, such a result clearly and provocatively emphasizes how scarce are the data that we have about the entire fossil record of the amphibians and reptiles, and therefore that 'paleoherpetology should be extremely humble for the moment'.

Since the paleontological record offers the only direct access to the temporal and geographical dimension of the biological events that occurred in the past (Masini *et al.*, 2002), it appears evident how deeply this lack of information affects the knowledge of the evolutionary history of the herpetofauna.

It can be questioned if this poverty is due to taphonomic bias, to lack of research of new fossils and localities, or to problems somehow related with the identification process of the fossil material. All these topics have a different weight depending on whether extinct or modern taxa are concerned. The identification process of extinct taxa is based on the evaluation of characters that in the palaeontologist's opinion can reasonably be proxies of taxonomic status, whereas the identification of modern taxa (or those directly related with the modern ones) is based on the recognition of characters whose phylogenetic validity can be tested on osteological comparison material, that is to say on the 'living' animals. The identification of modern taxa has therefore a more 'natural' character than that of fossil ones and, at least theoretically, should be easier and more mistake proof.

In absence of mathematical estimations of completeness of the herpetological fossil record, as those recently published for the Neogene mammals of Iberia (Alba *et al.*, 2001), it appears evident that the fossil record of the modern herpetofauna is a good material to try to assess which one of the above-mentioned topics biases the knowledge of past diversity.

MATERIALS AND METHODS

In order to directly verify how detailed is our knowledge of the past herpetological diversity, the number of the species that inhabit Italy at present was compared with the number of those potentially identifiable on the basis of their skeleton as well as with the number of those that have been so far identified in the fossil record.

Italy was chosen because its present day herpetofauna is very well known and because the presence of a Neogene-Quaternary taxon/locality database (Delfino, 1997, *Abstract* in Z. Rócek & S. Hart (eds), *Herpetology 1997*, III W.C.H., Prague; Delfino, 2002, Ph.D. Thesis, University of Firenze) represents a practical tool for analysing the fossil record of living amphibians and reptiles, whose ancient roots can be traced back into the Miocene (Rage, 1997). Since the database concerns political Italy only, this analysis takes into account exclusively the modern species inhabiting the same area.

The number of herpetological species here recognized for politi-

cal Italy is 85: 37 amphibians and 48 reptiles. This number was obtained from the lists recently published by SHI (1996) and Razzetti *et al.* (2001); non-nesting or introduced species were not included.

The recognizability of a taxon from an osteological point of view was evaluated not only on the basis of the presence of diagnostic osteological characters (inferred from literature as well as from comparative osteological material) but also on the basis of their applicability to the Italian fossil material; it therefore constitutes a personal evaluation, not necessarily generalizable in each of its aspects (the presence of a question mark indicates operational difficulties in the identification of the taxon concerned). The modern distribution of close taxa was not taken into consideration to evaluate their recognizability, since ranges might have been highly different in the past.

It is worth noting that the taxonomic rank of the modern taxa is invariably the species while that of the recognizable or recognized taxa corresponds to Operational Taxonomic Units (OTU) represented by species, groups of them, or even genera.

RESULTS

Caudates. 17 species of caudates inhabit Italy at present. Only 9 taxa (53% of 17) can be recognized from an osteo-paleontological point of view because no characters are available to discriminate between *Salamanca lanzai* and *S. atra*, and between *Triturus vulgaris* and *T. italicus*, but mainly because there are no characters suitable for the specific recognition of the 7 *Speleomantes* species. Of these 9 taxa, 6 (35% of 17; 67% of 9) have been identified (Table I).

Anurans. Of the 20 species of Italian anurans, only 13 (65%) species or groups of them could be theoretically recognized because the members of the Tree and Green Frogs have a uniform morphology that limits their identification at group rank. *Discoglossus pictus* and *D. sardus* have been tentatively considered as osteologically

TABLE I - Italian caudates, their osteo-paleontological recognizability and their fossils.

Living	Recognizable	Recognized
<i>Euproctus platycephalus</i>	<i>E. platycephalus</i> (?)	no
<i>Salamandra atra</i>	<i>Salamandra</i> sp. (small size?)	no
<i>Salamandra lanzai</i>		
<i>Salamandra salamandra</i>	<i>S. salamandra</i>	yes
<i>Salamandrina terdigitata</i>	<i>S. terdigitata</i>	yes
<i>Triturus alpestris</i>	<i>T. alpestris</i>	yes
<i>Triturus carnifex</i>	<i>T. carnifex</i>	yes
<i>Triturus italicus</i>	<i>Triturus</i> gr. <i>T. vulgaris</i>	yes
<i>Triturus vulgaris</i>		
<i>Speleomantes ambrosii</i>	<i>Speleomantes</i> sp.	yes
<i>Speleomantes flavus</i>		
<i>Speleomantes genei</i>		
<i>Speleomantes imperialis</i>		
<i>Speleomantes italicus</i>		
<i>Speleomantes strinatii</i>		
<i>Speleomantes supramontis</i>		
<i>Proteus anguinus</i>	<i>P. anguinus</i>	no
17	9 (53%)	6 (35%)

distinct. Fossils of 10 taxa (50% of 20; 77 of 13) have been reported for Italy (Table II).

TABLE II - Italian anurans, their osteo-paleontological recognizability and their fossils.

Living	Recognizable	Recognized
<i>Bombina variegata</i>	<i>B. variegata</i>	no
<i>Discoglossus pictus</i>	<i>D. pictus</i>	yes
<i>Discoglossus sardus</i>	<i>D. sardus</i>	yes
<i>Pelobates fuscus</i>	<i>P. fuscus</i>	no
<i>Pelodytes punctatus</i>	<i>P. punctatus</i>	yes
<i>Bufo bufo</i>	<i>B. bufo</i>	yes
<i>Bufo viridis</i>	<i>B. viridis</i>	yes
<i>Hyla arborea</i>	<i>Hyla</i> gr. <i>H. arborea</i>	yes
<i>Hyla intermedia</i>		
<i>Hyla meridionalis</i>		
<i>Hyla sarda</i>		
<i>Rana bergeri</i>	<i>Rana</i> gr. <i>R. ridibunda</i>	yes
<i>Rana</i> kl.	<i>R. esculenta</i>	
<i>Rana</i> kl.	<i>R. hispanica</i>	
<i>Rana lessonae</i>		
<i>Rana ridibunda</i>		
<i>Rana dalmatina</i>	<i>R. dalmatina</i>	yes
<i>Rana italica</i>	<i>R. italica</i> (?)	no
<i>Rana latastei</i>	<i>R. latastei</i>	yes
<i>Rana temporaria</i>	<i>R. temporaria</i>	yes
20	13 (65%)	10 (50%)

Turtles. The Italian, nesting and not introduced, turtles are represented by 3 species only, belonging to 3 different families that are morphologically quite distinct and therefore easily recognizable (3; 100%). All of them have been identified as fossils (Table III).

Saurians. The largest Order of the Italian herpetofauna is that of the saurians: 25 species are present. Relatively low (11, 44% of 25) is the number of the identifiable taxa because of the absence of reliable characters allowing the distinction of all the small lacertids as well as of some recently split species (*Lacerta viridis* - *L. bilineata*; *Chalcides chalcides* - *C. striatus*). Nearly all the identifiable taxa have been described as fossils (9; 36% of 25; 82% of 11; Table IV).

TABLE III - Italian turtles, their osteo-paleontological recognizability and their fossils.

Living	Recognizable	Recognized
<i>Emys orbicularis</i>	<i>E. orbicularis</i>	yes
<i>Testudo hermanni</i>	<i>T. hermanni</i>	yes
<i>Caretta caretta</i>	<i>C. caretta</i>	yes
3	3 (100%)	3 (100%)

TABLE IV - Italian saurians, their osteo-paleontological recognizability and their fossils.

Living	Recognizable	Recognized
<i>Cyrtopodion kotschy</i>	<i>C. kotschy</i> (?)	no
<i>Euleptes europaea</i>	<i>E. europaea</i> (?)	no
<i>Hemidactylus turcicus</i>	<i>H. turcicus</i>	yes
<i>Tarentola mauritanica</i>	<i>T. mauritanica</i>	yes
<i>Anguis fragilis</i>	<i>A. fragilis</i>	yes
<i>Algyroides fitzingeri</i>	Lacertidae indet. (?)	yes
<i>Algyroides nigropunctatus</i>		
<i>Archaeolacerta bedriagae</i>		
<i>Archaeolacerta horvathi</i>		
<i>Lacerta agilis</i>		
<i>Psammodromus algirus</i>		
<i>Zootoca vivipara</i>		
<i>Lacerta bilineata</i>	<i>Lacerta</i> gr. <i>L. viridis</i>	yes
<i>Lacerta viridis</i>		
<i>Podarcis filfolensis</i>	<i>Podarcis</i> sp. (?)	yes
<i>Podarcis melisellensis</i>		
<i>Podarcis muralis</i>		
<i>Podarcis raffonei</i>		
<i>Podarcis sicula</i>		
<i>Podarcis tiliguerta</i>		
<i>Podarcis wagleriana</i>		
<i>Timon lepidus</i>	<i>T. lepidus</i>	yes
<i>Chalcides chalcides</i>	<i>Chalcides</i> gr. <i>C. chalcides</i>	yes
<i>Chalcides striatus</i>		
<i>Chalcides ocellatus</i>	<i>C. ocellatus</i>	yes
25	11 (44%)	9 (36%)

Snakes. Italian snakes are represented by 20 species. Their skeletal anatomy, mainly the cranial one, allows discrimination between many of the species (18; 90% of 20), but fossils referred to 7 taxa only (40% of 20; 44% of 18) have been reported so far (Table V). The reason for this low number of recognized taxa is probably the extreme rarity of fossil cranial elements and the difficulty of properly allocate isolated vertebrae.

DISCUSSION

Even if a component of subjectivity slightly biases the recognizability of the modern taxa and hence some of the reported results could be notably modified by a different analysis, the general relationships among the categories concerned should be informative enough to allow some general considerations to be expressed.

Eighty-five herpetological species are nowadays present in Italy but this number drops to 54 taxa only, that is to say 64% of 85, if we try to identify the modern species from their bones. This number (54) represents the highest number of Operational Taxonomic Units that could be identified in the fossil record if all the modern taxa had good probability of fossilisation; since taxa that inhabit, among others environments, high-alti-

TABLE V - Italian snakes, their osteo-paleontological recognizability and their fossils.

Living	Recognizable	Recognized
<i>Coronella austriaca</i>	<i>C. austriaca</i>	yes
<i>Coronella girondica</i>	<i>C. girondica</i>	no
<i>Elaphe lineata</i>	<i>Elaphe</i> gr. <i>E. longissima</i>	yes
<i>Elaphe longissima</i>		
<i>Elaphe quatuorlineata</i>	<i>E. quatuorlineata</i>	yes
<i>Elaphe scalaris</i>	<i>E. scalaris</i>	no
<i>Elaphe situla</i>	<i>E. situla</i>	no
<i>Haemorrhois hippocrepi</i>	<i>H. hippocrepi</i>	no
<i>Hierophis gemonensis</i>	<i>H. gemonensis</i>	no
<i>Hierophis viridiflavus</i>	<i>H. viridiflavus</i>	yes
<i>Macroprotodon cucullatus</i>	<i>M. cucullatus</i>	no
<i>Malpolon monspessulanus</i>	<i>M. monspessulanus</i>	yes
<i>Natrix maura</i>	<i>N. maura</i> (?)	no
<i>Natrix natrix</i>	<i>N. natrix</i>	yes
<i>Natrix tessellata</i>	<i>N. tessellata</i> (?)	no
<i>Telescopus fallax</i>	<i>T. fallax</i>	no
<i>Vipera ammodytes</i>	<i>V. ammodytes</i>	yes
<i>Vipera aspis</i>	<i>V. aspis</i>	yes
<i>Vipera berus</i>	<i>Vipera</i> gr. <i>V. berus</i> (?)	no
<i>Vipera ursinii</i>		
20	18 (90%)	8 (40%)

tude coniferous forests or areas with soils that have developed on acid rocks have little probability of fossilisation, the number of taxa identified in the fossil record will most likely be lower than 54. In fact, the number of modern taxa so far identified in the Italian fossil record is 36, that is to say 42% of 85 and 67% of 54 (Table VI).

This means that even if all the modern taxa were perfect candidates for fossilisation, if the paleoherpetologists could sample all the paleoenvironments of the country, study all the recovered material and properly identify it, paleobiodiversity could never reach the level of the modern one, since the number of identifiable taxa is nearly one third (36%) lower than that of the liv-

TABLE VI - Summary of values and percentages at Order rank.

	Living	Recognizable	Recognized
Caudata	17	9 (53%)	6 (35%)
Anura	20	13 (65%)	10 (50%)
Testudines	3	3 (100%)	3 (100%)
Squamata (Sauria)	25	11 (44%)	9 (36%)
Squamata (Serpentes)	20	18 (90%)	8 (40%)
Total	85	54	36
% living taxa		64%	42%
% recognizable taxa			67%

ing ones. Actually, the number of taxa identified as fossils is rather low at present: approximately 60% lower than that of the living taxa, but only 33% lower than that of the identifiable taxa. Nowadays a relevant amount of fossil amphibians and reptiles is recovered as a by-product of the active search for micromammals (that are highly informative for biochronological inquiries) and, therefore, it is reasonable to predict that, with the development of the Italian Cenozoic paleoherpetology, the number of identified taxa will increase and nearly reach that of the identifiable taxa, although it is highly unlikely that it will reach such a number because of the taphonomic bias of some peculiar environments (for example, the above-mentioned high-altitude forested areas).

To conclude, since the Pleistocene-Holocene herpetofauna is largely represented by modern taxa, the present knowledge of the osteology of Italian herpetofauna causes a relevant loss of Quaternary paleobiodiversity and, therefore, that a major bottleneck affecting the contribution that paleoherpetology can offer to the evolutionary history of modern herpetofauna is related to the poor knowledge of the skeletal anatomy of several modern taxa. Such a result could also suggest that the difficulty of recognising species by their skeleton, and therefore by their fossil, could have a relevant role in decreasing our perception of paleobiodiversity where extinct taxa are concerned.

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