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www.biodiversityjournal.com

ISSN 2039-0394 (Print Edition)
ISSN 2039-0408 (Online Edition)

DECEMBER 2013, 4 (4): 441-584

with the support of

world biodiversity association

FOR NATURALISTIC RESEARCH AND ENVIRONMENTAL STUDIES

Tropidotilla litoralis (Petagna, 1787), Sicily, Italy: male (left), female (right)

The family of Mutillidae (Hymenoptera Aculeata). Velvet ants (Mutillidae) are a family of insects belonging to the order of Hymenoptera and within that to the Vespoidea superfamily of the Aculeata suborder, in which the female ovipositor serves as a sting. Mutillids are known already from Late Cretaceous and Eocene. The family Mutillidae, with about 4200 described species, is among the largest solitary wasp families parasitoids on enclosed hosts at preimaginal stage of other holometabolous insects, buth the estimated number of species is much higher. The mutillid faunas of the Palaearctic, Oriental and Afrotropical regions are the most similar on the tribal and generic levels and represent the nucleus of the world fauna. Velvet ants occur in all zoogeographical regions, but the vast majority of them are found in tropical and subtropical regions of the world being abundant in arid and semiarid areas. There are more than 500 species of mutillids in 54 genera known in the Palaearctic region. About 170 species were found in Europe. A peculiar feature for the family is the extreme sexual dimorphism: the males are winged (rarely brachypterous or apterous) and possess a normal apocritan mesosoma. The females are wingless, and appear to be rather setae, colourful ants. They can easily be differentiated from ants by the lack of petiole nodes, which are present on all ant species. In addition, the mesosomatic (thoracic) segments are completely fused and have at most two segments. The metasoma (abdomen) contains six visible terga (dorsal surface of any body segment) and a "felt line" of dense, closely appressed hairs is located laterally on the second metasomatic tergum. Females are generally densely pubescent and predominantly black, brown, or reddish, often marked with bright spots or bands that are usually white, yellow, or red. Because of their extreme sexual dimorphism, sex associations cannot be made on morphological grounds alone; most species and even many genera are known from one sex only. In most cases the males are so different from the females that only males and females caught in the act of copulation can be claimed to belong to the same species with certainty. It may be revealed in many cases that certain male and female specimens thought to be distinct species may belong to the same species, therefore the number of existing species may be lower than the actual number. Knowledge of the natural history of mutillid wasps is usually restricted to the habitat in which the adults are collected and/or the flowers where are established to feed. Recently it has been estimated that the hosts of only about 2-3 % of the described mutillid species are known, and for some subfamilies there are no records at all. All the species are parasites in the nests of solitary and social bees, wasps, ants or beetles. Females of mutillids are apterous and spend most of the daytime in burrows in ground or under grass turfs. Problems encountered by any female mutillid mainly involve finding suitable host individuals and penetrating their enclosures for egg laying. Solitary hosts are generally scattered and often concealed. Mutillids apparently use odour signals (kairomones) while actively running in suitable locations for finding such hosts, and must spend much time searching, with little prospect of finding numerous hosts. Females search for the ground nests of hosts and deposit their eggs in the brood cells. They usually search for mature larvae (or prepupae) and paralyze the larva with the sting and after that they lay an egg into the brood cell. The mutillid larvae are always ectoparasitoids of host stages which are enclosed in some sort of package (cell, cocoon, puparium, ootheca) and which are not actively feeding. The quantity of accessible food determines the resulting size of the eventual imago. Males are winged and live only a few weeks. They search for virgin females to mate them usually flying not high above the ground. Some mostly tropical species use special dances when males fly and carry females connected on the abdomen within the mating process, otherwise in species living in sand dunes and deserts females carry apterous males on their backs. European mutillids usually have one generation per year (univoltine): both sexes emerge in summer, males die in the beginning of autumn, females overwinter and attack nests of hosts in early or late spring.

Marcello Romano, Piazza A. Cataldo, 10 - 90040 Capaci (Palermo), Italy; e-mail: marcellr@libero.it

Cover: photos by M. Romano

Biodiversity Journal, 2013, 4 (4): 443-450

Preliminary contribution to the knowledge of Coleoptera Buprestidae from Atlantic rainforest regions of Rio Doce and Itacolomi State Parks of Minas Gerais, Brazil. The genera *Agrilus* Curtis, 1825, *Autarcontes* Waterhouse, 1887, and *Geralius* Harold, 1869

Gianfranco Curletti[1*], Sérvio P. Ribeiro[2] & Letizia Migliore[2]

[1]Museo Civico di Storia Naturale, via S. Francesco di Sales, 188 - 10022 Carmagnola, Italy; e-mail: gianfranco.curletti@yahoo.it
[2]Laboratório de Ecologia Evolutiva de Insetos de Dossel, Departamento de Biodiversidade, Evolução e Meio Ambiente, ICEB, Universidade Federal de Ouro Preto, Campus Morro do Cruzeiro, Ouro Preto, MG, Brasil.
[*]Corresponding author:

ABSTRACT A checklist of species belonging to *Agrilus* Curtis, 1825, *Autarcontes* Waterhouse, 1887, and *Geralius* Harold, 1869 genera found in Rio Doce and Itacolomi Estadual Parks is given. 19 species are listed, 5 of which are new for the science and here described: *Agrilus pirilampo* n. sp., *A. disorientatus* n. sp., *A. coal* n. sp., *A. rarestriatus* n. sp., *A. taediosus* n. sp. Most species were found in one sampling season and reflect a quite favourable rainforest for xylophagous species. The high dominance of Leguminosae large tree species could be related to this pattern.

KEY WORDS Coleoptera; *Agrilus*; *Autarcontes*; *Geralius*; Brasil; Rio Doce; Itacolomi.

Received 19.09.2013; accepted 29.10.2013; printed 30.12.2013

INTRODUCTION

The present fauna has been collected in two State parks covered predominantly with Atlantic rainforest, at upper and mid-basin of the Doce river, in the Central region of Minas Gerais State, Brazil. The forests of these parks have been monitored for insect herbivores and ants for many years. For the Rio Doce State Park, a lowland forest, 13 years of research were accomplished on canopy insects from three distinct geomorphologies, as part of a long term study of natural (lake-forest) and human made (pasture-forest) ecotones, based on insect interactions with the main dominant tree species, *Mabea fistulifera* Mart. (Euphorbiaceae) and *Byrsonima sericea* DC (Malpiguiaceae), respectively. In the montane Park of Itacolomi, another long term research area, comparative entomological studies were set in three permanent plots in distinct successional forests, running since 2006.

Any of those entomological researches showed that, in general, the number of species per sample unit (tree crowns) were below expected for a tropical forests (Campos et al., 2006a; Ribeiro et al., 2008; Fagundes et al., 2012; Neves et al., 2013), and different causes may influence these findings. In Rio Doce, the rainforest may be extremely recent, coming from a xeric habitat that suffered a climatic change no longer than 9 thousand years ago (Overloop, 1981; Werneck et al., 2011). In Itacolomi, the locally cold and unpredictable winter may be related to a severe lack of large tropical invertebrate species (Espírito Santo et al., 2012), along with the loss of connections with other moun-

tain ecosystems due to hundreds of years since first human occupation. Nevertheless, both forests may favour xylophagous insects due to an intense gap dynamic found in both.

The present study shows preliminary results from a first survey on xylophagous, namely Buprestidae species, in both regions.

ACRONYMS AND ABBREVIATIONS. The Natural History Museum, London, England (BMNH); Museo Civico di Storia Naturale, Carmagnola, Italy (MCCI); Musée National d'Histoire Naturelle, Paris, France (MNHN) ; Museu de Zoologia Universitade São Paulo, Brazil (MZUSP); Narodní Muzeum, Prague, Czech Republic (NMPC); Parque Estadual Itacolomi, Brazil (PEIT); Parque Estadual Rio Doce, Brazil (PERD).

Study area

Rio Doce State Park - PERD. This is the largest continuous preserved Atlantic rainforest fragment (35,974 ha) in Minas Gerais State, Brazil (19º48'18"–19º29'24"S, 42º38'30"– 42º28'18"W). Altitude varies from 230 to 515 m above sea level; climate type is Aw (tropical hot semi-humid), with wet seasons from October to March and dry seasons from April to September (Gilhuis, 1986). The predominant vegetation is semi-deciduous seasonal forest, with 20% to 50% deciduous trees (Veloso et al., 1991). Also, this is the largest natural lake system of South America, and 10% of the Park is covered with lakes, result of changes in the Doce river positioning and blocking of old drainages, along with increasing rainfall (see below).

Itacolomi State Park - PEIT. The Itacolomi State Park is a 7,543 ha conservation area, at south of Serra do Espinhaço (20°22'30"S–43°32'30"W). The area is located in a transition between Atlantic Forest and Cerrado, with physiognomies of grassland and montane evergreen forest types, with altitudes between 700 and 1700 m above sea level. The climate is typically seasonal tropical, understanding the types Cwa and Cwb of Koppen, in lowest and highest areas, respectively (SEMAD/IEF/PROMATA, 2007). The studied areas are reported as human disturbed since the colonial times. More recently, it belonged to a farm of tea, *Camellia sinensis* (L.) Kuntze. After the abandonment of the culture about 40 years ago, the species *Eremanthus erythropappus* DC (Asteraceae) colonized the most former plantations, resulting in a monodominant forests, which have been gradually substituted by a more diverse wet forest along time. In deep valleys, a more wet and diverse forest always existed and was preserved due to difficult access and water protection for the farms. Flooded small valleys are dominated by *Myrcia* species and resemble subtropical flood forests.

General ecology and biogeographic evolution

For reasons still under study, these forest canopies tend to have a particularly poorer leaf-herbivore insect fauna than observed in canopies of wet and close equatorial forests (Campos et al., 2006b, Ribeiro et al., 2008). However, the present findings for Buprestidae are astonishingly diverse, especially for Rio Doce State Park. Most species were found in one sampling season and reflect a quite favourable rainforest for xylophagous species. The dominance of large deciduous and semi-deciduous Leguminosae tree species could be related to this pattern. Although this is a wet continuous forests, Rio Doce Park is quite heterogeneous, and the area where most of species were found was probably a drier vegetation type no longer than four thousand years ago (Overloop, 1981; Werneck et al., 2011). The climate shift during the Holocene contributed to the origin of the lakes in the Doce river mid-basin, that define enormously this landscape (Pflug, 1969; Meis & Monteiro, 1979; Meis & Tundisi, 1986; Perônico & Castro, 2008). Hence, adaptations to a climate shifted toward a wetter seasonal ecosystem may be on course, and severe and frequent tree death is normally observed even within natural and well preserved forest spots. Campos et al. (2006a, b) and Ribeiro et al. (2008) suggest that high gap formation influences canopy insect fauna. In addition, Castro et al. (2012) found a highly diverse litter ant fauna, and clearly an intense debris production ought to influence such finding.

MATERIALS AND METHODS

The material was taken by several methods during expeditions in November 2010, March 2012, and September 2012. The priority was the use of entomological umbrella, which was positioned

below branches of trees in the upper canopy or in the foliage in the borders of forest as mentioned above. Systematic samplings by beating on the branches have been developed along both projects on several marked trees. In addition, qualitative and semi-quantitative methods, such as spider net, sticky traps, breeding larvae and direct sampling were added specifically for Buprestidae sampling. The use of sticky traps, contrary to African and Palaearctic faunae, was ineffective, probably because the Neotropical Buprestidae species are not attracted by the colours, surely not by the yellow colour (G. Curletti, pers. obs.).

The specimens collected are preserved dry, after extraction of genitalia. The pictures are made with microscope and assembled with Combine Z4 program.

RESULTS

List of species found in PERD

Geralius furciventris (Chevrolat, 1838)

EXAMINED MATERIAL. 1 specimen female: Brazil, Minas Gerais, Marliéria, PERD, SD - Mab. PL7B - 6.II.2001, Ribeiro S.P. leg.

REMARKS. Species (Chevrolat, 1838: 88 sub *Stenogaster*) known for Argentina, Bolivia, Brazil, Paraguay, Peru. Biology unknown.

Autarcontes mucoreus (Klug, 1825)

EXAMINED MATERIAL. 1 specimen female: Brazil, Minas Gerais, Marliéria, PERD, SD - Mab. PL7B - 6.II.2001, Ribeiro S.P. leg.

REMARKS. Species described of Minas Gerais, Uberaba (Klug, 1825: 428, sub *Buprestis*). Known for Brazil only.

Agrilus* (*Agrilus*) *gracchus Obenberger, 1935

EXAMINED MATERIAL. Three specimens females: Brazil, P. E. Rio Doce, 20.XI.2010, G. Curletti and L. Migliore leg. (MCCI).

REMARKS. Species described from Minas Gerais, Mar de Hespanha (Obenberger, 1935: 135); type NMPC. Endemic of Brazil. Biology unknown.

Agrilus* (*Agrilus*) *zikani Obenberger, 1935

EXAMINED MATERIAL. 1 female specimen: Brazil, P. E. Rio Doce, 20.XI.2010, G. Curletti and L. Migliore leg.

REMARKS. Species described from Minas Gerais (Obenberger, 1935: 126); type NMPC. Endemic of Brazil. Biology unknown.

Agrilus* (*Agrilus*) *pirilampo n. sp.

EXAMINED MATERIAL. Holotype female (Fig. 1): Brazil, P. E. Rio Doce, Perd Vinhático, 08.IX.2000, S. Ribeiro leg. (MZUSP).

DESCRIPTION OF HOLOTYPUS. Length 14 mm, elongate. Dorsal color black with green reflections on elytra and two orange spots at the apex. Vertex strongly depressed, as wide as half anterior edge of pronotum. Frons concave with orange round spot at the base. Clypeus small, without carina. Pronotum wider anteriorly, with lateral edges subrounded but sinuate before the base forming posterior angles acute. Anterior edge incise in middle. Disc gibbous, with two round depressions in the medium-anterior part. Sculpture composed by thin and thickened striae. Premarginal carinula absent. Lateral carinae very open ahead, separate at the base. Prosternal gular lobe small, widely sinuate. Scutellum concave, small, with transversal carina nearly visible. Elytra with both apices rounded and microdenticulate. Ventral side black, glabrous, with a lateral orange spot at the sides of the antepenultimate ventrite. Same spot at the corresponding laterotergum. Legs black, with all claws mucronate. Metatarsus shorter than metatibia. First metatarsomere longer than the sum of the following three (1>2+3+4).

ETYMOLOGY. The two yellow spots on elytra are very evident and for this reason *A. pirilampo* n. sp. remember the lights produced by the Elateridae species belonging to the Pyrophorini tribe, named pirilampos by the Brazilian people.

REMARKS. For the dimensions, color and elytral spots, *A. pirilampo* n. sp. appears unique on the South American fauna.

Agrilus* (*Agrilus*) *sedyi Obenberger, 1933

EXAMINED MATERIAL. 1 male: Brazil, P. E. Rio Doce, 19.XI.2010, G. Curletti and L. Migliore leg.

REMARKS. Species described from São Paulo (Obenberger, 1933a: 12), endemic of Brazil.

Agrilus* (*Agrilus*) *luederwaldti Obenberger, 1933

EXAMINED MATERIAL. 1 male: Brazil, P. E. Rio Doce, 19.XI.2010, G. Curletti and L. Migliore leg.

REMARKS. Species described from Santa Catharina (Obenberger, 1933a: 11), endemic of Brazil.

Agrilus* (*Agrilus*) *arnus Gory, 1841

EXAMINED MATERIAL. 1 female, Brazil, P. E. Rio Doce, 19.XI.2010, G. Curletti and L. Migliore leg.

REMARKS. Species widespread (Gory, 1841: 232), quoted from Brazil, Argentina, Colombia. Type in MNHN.

Agrilus* (*Agrilus*) *disorientatus n. sp.

EXAMINED MATERIAL. Holotype female (Fig. 2): Brazil, P. E. Rio Doce, 16.III.2012, G. Curletti and L. Migliore leg. (MZUSP).

DESCRIPTION OF HOLOTYPUS. Length 6.8 mm. Elytra brown with 8 (4+4) spots of yellow pubescence along the suture. Pronotum as wide as 1/3 of anterior edge of pronotum, darker than the vertex, reddish. Frons black, with red reflections at the base, glabrous. Clypeus separate by frons by a transversal small carina. Antennae serrate from IV antennomere. Pronotum wider anteriorly, posterior angles right. Yellow pubescence along the lateral edges; disc with regular, transverse, thin sculpture. Premarginal carinae entire, joined to lateral edge before the half length. Marginal carinae subparallel, separate from base. Prosternal gular lobe rounded; prosternal plate with lateral edges sinuate in middle. Scutellum transversely carinate. Elytra with apex acute, ending by a tip. The pubescent spot are placed respectively in the humeral callus, at 1/3, at 2/3 and before the apex: the basal (humeral) couple rounded, the second elongate, the third oval, the fourth smaller, less visible, reduced to a short line along the suture. Ventral side bronze, with a line of white pubescence in median part of the basal sternite and a round spot at the margins of all remaining. Legs brown like the ventral side; metatarsus shorter than metatibia, with a first article longer than the sum of the following two (1>2+3). All claws bifid, but with the teeth separate.

ETYMOLOGY. *Disorientatus* = out of bearings. The specimen was found in a dead branch of *Platymenia foliosa* Benth incised and killed by *Oncideres* sp. (Cerambycidae). All specimens had already come out from the wood; only this specimen, still alive, was in the pupal cell, destined to a sure death because it was turned to the inside of the branch.

REMARKS. Several South-American species have four spots on elytra, but *A. disorientatus* is unique for the shape of the apical acute apex.

Agrilus* (*Agrilus*) *consentaneus Kerremans, 1897

EXAMINED MATERIAL. 3 specimens, 2 males and 1 female, found in PERD the 07-15.II.2011, L. Migliore leg.

REMARKS. To this species (Kerremans, 1897: 89) we attribute the specimens collected.

Agrilus* (*Agrilus*) *gileti Obenberger, 1933

EXAMINED MATERIAL. 1 male: Brazil, Minas Gerais, PERD, 19.XI.2010 G. Curletti and L. Migliore leg. (MZUSP).

REMARKS. Species described from São Paulo (Obenberger, 1933a: 19); type in NMPC.

Agrilus* (*Agrilus*) *coal n. sp.

EXAMINED MATERIAL. Holotype male (Figs. 3, 4): Brazil, P.N. Rio Doce, 19°45'48''S–42°37'54''W, 18.XI.2010, 288 m, G. Curletti and L. Migliore leg. (MZUSP).

DESCRIPTION OF HOLOTYPUS. Length 5.6 mm. Pronotum and elytra black. Vertex as wide as 1/3 of anterior edge of pronotum with punctiform sculpture. Frons golden, flat, glabrous. Clypeus without transversal carina. Antennae serrate from article IV, black at the base, gold from antennomere V. White pubescence on the cheek. Pronotum wider in the middle of length, with lateral margins rounded but sinuate before the base forming acute angles. Disc with two elongate small depressions in middle, after the vertex and before the scutellum. Sculpture formed by transversal striae alternate to interstriae composed by other more superficial and thin striae in number of 3-5 every interstria. White pubescence little visible along the lateral edges. Pre-

marginal carina entire, joined to the edges before the half length. Marginal carinae subparallel, separate from the base. Prosternal gular lobe entire but not rounded. Scutellum transversely carinate. Elytra glabrous; apex hardly denticulate with median tooth bigger and stumpy. Ventral side bronze with lateromarginal spot of white pubescence on the ventrites. Legs with all claws bifid, but with internal median and posterior teeth shorter and squat. Metatarsus shorter of metatibia; first metatarsomere longer than the sum of the following two (1>2+3). Aedeagus fusiform, median lobe acute (Fig. 4).

ETYMOLOGY. After the black colour.

REMARKS. For the shape, color, abdominal pubescence, *A. coal* n. sp. is similar to *A. lestageanus* Obenberger, 1935 from Brazil (type in NMPC). This last differs especially for having different pronotum sculpture, apical apex, frons green.

Agrilus* (*Agrilus*) *rarestriatus n. sp.

EXAMINED MATERIAL. Holotype female (Figs. 5, 6): Brazil, Minas Gerais, PERD, 19.XI.2010 G. Curletti and L. Migliore leg. (MZUSP).

DESCRIPTION OF HOLOTYPUS. Length 5.8 mm. Pronotum dark green like the vertex, but reddish along the sides, elytra black. Vertex as wide as the half of anterior edge of pronotum. Frons glabrous, red wine brilliant. Clypeus without transversal carina. Antennae brief, serrate from antennomere IV. Pronotum wider anteriorly, sinuate before the posterior angles that are acute. Anterior edge protruding in middle, between the eyes. Disc with superficial striae, with unusual structure remembering the afrotropical *A. buani* Curletti et Vayssieres, 2007, but more rarefied (Fig. 6). Premarginal carina absent; marginal carinae joined at the base. Prosternal gular lobe cut in middle of anterior edge. Scutellum transversely carinate. Elytrae with each apex rounded and denticulate. Disc with white pubescence very short but well visible, regularly disposed. Laterotergа whit longer white pruinose pubescence. Abdomen dark bronze, with pubescence like elytra. Same colour in the legs: all claws like *A. disorientatus* n. sp. Metatarsus shorter than metatibia; first metatarsomere as long as the sum of the following two (1=2+3).

ETYMOLOGY. After the peculiar structure of the pronotum striae.

REMARKS. For the pronotum sculpture *A. rarestriatus* n. sp. is unique in the Brazilian agrilofauna. The specimen was collected on herbaceous small bush, still unidentified, that is probably the host plant.

Agrilus* (*Agrilus*) *taediosus n. sp.

EXAMINED MATERIAL. Holotype male (Figs. 7, 8): Brazil, Minas Gerais, PERD, 17.XI.2010 G. Curletti and L. Migliore leg. (MZUSP).

DESCRIPTION OF HOLOTYPUS. Length 6.5 mm. Dorsal colour dark bronze. Vertex as wide as the half of the anterior edge of pronotum. Eyes small, little visible from the back. Frons green-bronze, glabrous, widely furrowed, without transverse carina before the clypeus. Antennae bronze, brief, serrate from IV antennomere. Pronotum gibbous, depressed at the sides, wider anteriorly, with curved lateral edges and sinuate before the posterior angles that are acute. A wide superficial, longitudinal furrow in middle. Sculpture composed by numerous transversal striae alternate to small points. Premarginal carina entire, superficial, little visible. Marginal carinae joined at the base. Prosternal gular lobe cut in middle of anterior edge. Scutellum transversely carinate. Elytrae with each apex rounded and denticulate. Elytra stumpy, glabrous, with apices rounded and microdenticulate. White pubescence on the laterotergа only, with glabrous abdomen. All claws mucronate. Metatarsus shorter than metatibia. First metatarsomere as long as the sum of the following two (1=2+3). Aedeagus small and thin with median lobe acute (Fig. 8).

ETYMOLOGY. From the Latin taedĭum = boredom, for the want of remarkable characters.

REMARKS. On the whole of cited characters, *A. taediosus* n. sp. is close to *A. needhami* Obenberger, 1933b described from São Paulo (type in NMPC). The two species are principally distinguishable for having the very different shape of aedeagus.

Agrilus* (*Agrilus*) *vanini Curletti et Migliore, in press

EXAMINED MATERIAL. 1 female: Brazil, Minas Gerais, PERD, (19°45'48"S - 42°37'54"W), 20.XI.2010, G. Curletti and L. Migliore leg. (type in MZUSP).

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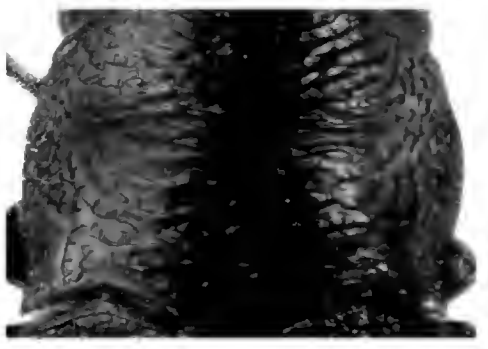

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Figure 1. *Agrilus* (*Agrilus*) *pirilampo* n. sp., holotype. Figure 2. *A.* (*A.*) *disorientatus* n. sp., holotype. Figure 3. *A.* (*A.*) *coal* n. sp., holotype. Figure 4. Idem, aedeagus in dorsal view, 1.2 mm. Figure 5. *A.* (*A.*) *rarestriatus* n. sp., holotype. Figure 6. Idem, pronotum. Figure 7. *A.* (*A.*) *taediosus* n. sp. holotype. Figure 8. Idem, aedeagus in dorsal view, 1.5 mm. Scale bar = 1 mm.

List of species found in PEIT

***Agrilus* (*Agrilus*)** sp.

EXAMINED MATERIAL. 1 female specimen: Brazil, Minas Gerais, PEIT, 11.XI.2007, G. Curletti and L. Migliore leg.

REMARKS. This specimen close to *A. gileti* Obenberger, 1933, belongs probably to a new species, but the morphological characters are no sufficient for the description.

Agrilus* (*Agrilus*) *clazon Obenberger, 1933

EXAMINED MATERIAL. 1 female specimen: Brazil, Minas Gerais, PEIT, 11.XI.2007, G. Curletti and L. Migliore leg.

REMARKS. Species described from São Paulo (Obenberger, 1933b: 80); type in NMPC. The specimen from Itacolomi is more bronze, probably for the recent capture.

Agrilus* (*Agrilus*) *badius Kerremans, 1897

EXAMINED MATERIAL. 1 male specimen: Brazil, Minas Gerais, PEIT, 11.XI.2007, G. Curletti and L. Migliore leg.

REMARKS. Species described from Minas Gerais (Kerremans, 1897: 79, Caraça); type in BMNH.

Agrilus* (*Agrilus*) *octavius Obenberger, 1935

EXAMINED MATERIAL. 1 female specimen, Brazil, Minas Gerais, PEIT, 15-30.III.2012, G. Curletti and L. Migliore leg.

REMARKS. Species described from São Paulo (Obenberger, 1935: 124); type in NMPC.

ACKNOWLEDGMENTS

We wish to thanks the staff members for the help in the field, especially Geraldo dos Santos Adriano. The IEF, the State Institute of Forestry and the administration of Rio Doce and Itacolomi State Park, for providing permits and logistical facilities for the work. We thank FAPEMIG and PELD/CNPq for financial support. SPR is a researcher funded by CNPq.

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The genus *Lichenophanes* Lesne, 1899 in Italy (Coleoptera Bostrichidae) and short considerations on the saproxylophagous beetle-fauna of Nebrodi Mountains (Sicily)

Calogero Muscarella[1], Ignazio Sparacio[2], Andrea Liberto[3] & Gianluca Nardi[4*]

[1]Cooperativa Silene, Via D'Ondes Reggio, 8A Scala G - 90127 Palermo, Italy; e-mail: calogero@silenecoop.org
[2]Via E. Notarbartolo, 54 int. 13 - 90145 Palermo, Italy; e-mail: isparacio@inwind.it
[3]Via Camillo Pilotto, 85 F/15 - 00139 Roma, Italy; e-mail: andrea.liberto@ansa.it
[4]MiPAAF, Corpo Forestale dello Stato, Centro Nazionale per lo Studio e la Conservazione della Biodiversità Forestale "Bosco Fontana" di Verona, Sede di Bosco Fontana, Strada Mantova 29 - 46045 Marmirolo (MN), Italy; e-mail: l_nardi@hotmail.com
[*]Corresponding author

ABSTRACT The Italian distribution and ecology of *Lichenophanes numida* Lesne, 1899 and *L. varius* (Illiger, 1801) are summarized; both species are recorded for the first time from Sicily, and *L. varius* also from Veneto and Molise Regions. *L. varius* is a protected species, at different levels, in most of European countries in which it occurs, so its main threatening factors are discussed. Finally, the importance of the dead wood for the conservation of saproxylic beetle-fauna of Sicilian forests, is underlined.

KEY WORDS distribution; saproxylic fauna; global warming.

Received 21.09.2013; accepted 11.11.2013; printed 30.12.2013

INTRODUCTION

The genus *Lichenophanes* Lesne, 1899 (Coleoptera Bostrichidae Bostrichinae) occurs with 41 species in Europe, Asia, Africa and Americas, especially in more mesic areas (Ivie, 2002; Borowski & Węgrzynowicz, 2007).

As stated by Lesne (1899) in the original description of this genus, its etymology refers to the mimetic lichen-like appearance of the colouration of many of its species. *Lichenophanes* is distinguished from other genera of Bostrichinae (cf. Lesne, 1899, 1901; Ivie, 2002; Bahillo de la Puebla et al., 2007) by the shape of the apophysis of the first sternite dilated ventrally, and by the presence, on each side of the articles of the antennal club, of a pairs of sensory rounded dimples (Lesne, 1899, figs. 57-59; De Marzo & Porcelli 1989, fig. 5b) with well-defined margins and covered by a dense golden pubescence (Fig. 1).

From a biological point of view, this genus includes secondary saproxylophagous beetles that, so, during the larval stages feed on wood yet partially degraded by other organisms.

In the Palaearctic Regions are present only three species (Borowski & Węgrzynowicz, 2007), two of them occur in Europe: *L. numida* Lesne, 1899 and *L. varius* (Illiger, 1801), both live also in Italy (Audisio et al., 1995; Nardi, 2004; Borowski, 2007; Borowski & Węgrzynowicz, 2007). New records of these species give an opportunity to revise their distribution in Italy and to summarize (Table 1; Figs. 2-7) the morphological features for their identification.

Lichenophanes varius	*Lichenophanes numida*
Colour brown	Colour dark brown
Length 5.5-13 mm	Length 9-14 mm
Clypeus without reddish, dense and long hairs	Clypeus with reddish, dense and long hairs
Pronotum slightly longer than wide (Figs. 2, 3) (Lesne, 1899: figs. 66-67)	Pronotum slightly wider than long (Fig. 4) (Lesne, 1899: fig. 68)
Apex of elytra (visible ventrally) not enlarged (Fig. 6) with crenulate margin	Apex of elytra (visible ventrally) enlarged (Fig. 7) with smooth margin
Intercoxae process of the abdomen rounded or truncate at the apex (Fig. 5)	Intercoxae process of the abdomen pointed at the apex
Ventral surface of the abdomen with dense and regular punctures	Ventral surface of the abdomen with sparse punctures on the midline, denser on the sides
Apical declivity of the elytra generally with numerous pubescent areas (Fig. 10)	Apical declivity of the elytra generally with only two pubescent areas in the upper part
Lobes of the parameres of the aedeagus wider than long with parallel sides to the basal half and the apical half abruptly truncated and occupied by a sensory and pubescent area (Bahillo de La Puebla et al., 2007: fig. 9c)	Lobes of the parameres of the aedeagus as long as wide, regularly decreasing in width from the base to the apex, with outer margin regularly rounded (Bahilo de La Puebla, 2007: figs. 9a-b)

Table 1. Morphological characters that differentiate the two species: *Lichenophanes varius* and *L. numida* (cf. Lesne, 1899, 1901; Porta, 1929; Bahillo de la Puebla et al., 2007).

MATERIALS AND METHODS

In this paper, all the available Italian data are critically revised and listed together with new records. For each record, the following information, when available, is provided: region, province, commune, locality, biotope, metres a.s.l., geographic coordinates, date, collector, additional information on the finding, number of specimen/s (es.), collection, possible published data source (bibliographic reference or website, in parenthesis); the symbol "(!)" refers to examined records. The labels of the examined specimens are generally written in Italian; hereunder, the regions and the collecting methods were translated in English; the same is valid for literature records. The mainland Italian regions are listed from north to south, and from west to east, all toponyms are listed alphabetically. When deemed useful for the discussion of both species, material examined from other countries ("Other material examined") is also provided. The material was identified according to Lesne (1899, 1901) and Bahillo de la Puebla (2007). Comments and interpretations are given in square brackets.

ACRONYMS. Specimen depositories: CFA = F. Angelini, Francavilla Fontana (Brindisi), Italy (F. Angelini, pers. com., 2013); CDS = D. Sechi, Cagliari, Italy; CLE = P. Leo, Cagliari, Italy; CLI = A. Liberto, Rome, Italy; CMO = L. Mola, Castel Mella (Brescia), Italy; CMU = C. Muscarella, Palermo, Italy; CNA = G. Nardi, Cisterna di Latina (Latina), Italy; CNBFVR = Centro Nazionale per lo Studio e la Conservazione della Biodiversità Forestale "Bosco Fontana" di Verona, Sede di Bosco Fontana, Marmirolo (Mantua), Italy; CPA = G. Pace, Rome, Italy (G. Pace, pers. com., 2013); CSP = I. Sparacio, Palermo, Italy; CVO = V. Vomero, Rome, Italy (V. Vomero, pers. com., 1995); MCGB = G. Binaghi c/o Museo Civico di Storia Naturale "Giacomo Doria", Genoa, Italy; MCGD = A. Dodero c/o Museo Civico di Storia Naturale "Giacomo Doria", Genoa, Italy (R. Poggi, in litteris, 1996);

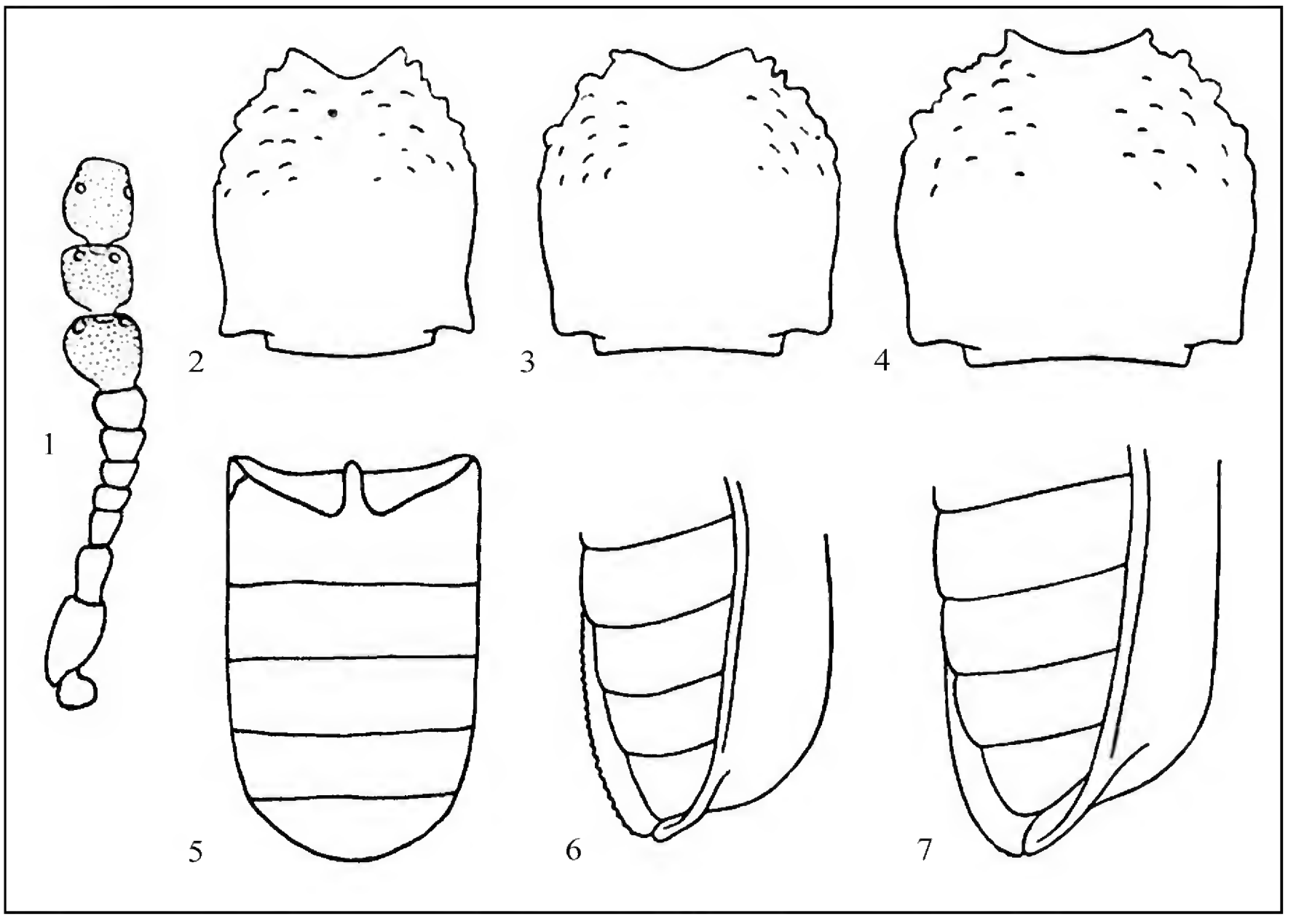

Figure 1. Antenna of the genus *Lichenophanes*. Figures 2-7. Morphological characters of *Lichenophanes varius* and *L. numida,* see Table 1 (cf. Lesne, 1899, 1901; Bahillo de la Puebla et al., 2007).

MCGM = C. Mancini c/o Museo Civico di Storia Naturale "Giacomo Doria", Genoa, Italy; MCSV = Museo Civico di Storia Naturale, Verona, Italy; MCSVB = M. Burlini c/o Museo Civico di Storia Naturale, Verona, Italy; MCSVS = A. Sette c/o Museo Civico di Storia Naturale, Verona, Italy; MCZRE = C. Emery c/o Museo Civico di Zoologia, Rome, Italy; MCZRG = G. Ganev c/o Museo Civico di Zoologia, Rome, Italy; MCZRL = P. Luigioni c/o Museo Civico di Zoologia, Rome, Italy; MNHN = Muséum National d'Histoire Naturelle, Paris, France; MSNF = Museo di Storia Naturale dell' Università degli Studi di Firenze, Sezione di Zoologia "La Specola", Florence, Italy (F. Cianferoni, pers. com., 2013).

Main collectors: AL = A. Liberto; AM = A. Molinu; AS = A. Sette; AV= A. Verdugo; CE = C. Esposito; CM = C. Muscarella; DB = D. Birtele; DS = D. Sechi; DW = D. Whitmore; EC = E. Colonnelli; FA = F. Angelini; FI = F. Izzillo; GA = G. Altadonna; GM = G. Magnani; GN = G. Nardi; GP = G. Pace; GS = G. Sama; IG = I. Ganev; IS = I. Sparacio; LM = L. Mola; MBr = M. Bracalini; MBu = [M.] Burlini; MG = M. Gigli; ML = M. Lopresti; PC = P. Cerretti; PL = P. Leo; RD = R. De Togni.

Other abbreviations and recurrent terms used in Records: Bosco = Wood; ca = circa = about; coll. = collection; dint. di = dintorni di = environs of; env. = environs; es. = specimen/s; ex = emerged from wood of; FEI = "Forum Entomologi Italiani" (http://www.entomologiitaliani.net) (accessed 13 August 2013); Lago = Lake; loc. = locality; M. = Monte = Mount; prov. = province; presso = near; sdb = same data but; Via = Road; wdc = without date of collection; wfd = without further data; ! = material examined.

RESULTS

Revised quotations and new records of the species in Italy with details are listed below.

Lichenophanes numida Lesne, 1899

Lichenophanes numida Lesne, 1899: Lesne, 1901: 92; Audisio et al., 1995: 7; Urbano Granero, 2002: 30; Nardi 2004; Bahillo de la Puebla et al., 2007: 163; Borowski & Węgrzynowicz, 2007: 97; López-Colón & Bahillo, 2011: 3; Baena & Zuzarte, 2013: 33.

Lichenophanes numida Lesne, [18]99: Winkler, 1927: 796.

Lichenophanes numida Lesne: Luigioni, 1929: 640; Porta, 1929: 415.

Lichenophanes numida Lesne, 1898 [sic!]: Vrydagh, 1960: 10.

Lichenophanes numidica [sic!] Lesne, 1899: Angelini, 1998: 20.

Lichenophanes numida (Lesne, 1899) [sic!]: Fernández-Carillo et al., 2001: 42; Murria Beltrán, 2002: 198.

ITALIAN RECORDS (Fig. 8). Basilicata: Matera prov.: Lago di San Giuliano, loc. Ponte Cagnolino, VIII.1992, FA, light trap (Angelini, 1998); sdb, 27–31.VII.1993, 1 ex (CFA). Sardinia: no exact locality and date (Winkler, 1927; Luigioni, 1929; Porta, 1929; Vrydagh, 1960; Audisio et al., 1995; Fernández-Carillo et al., 2001; López-Colón et al., 2001; Murria Beltrán, 2002; Urbano Granero, 2002; Nardi, 2004; Bahillo de la Puebla et al., 2007; Borowski & Węgrzynowicz, 2007; López-Colón & Bahillo, 2011; Baena & Zuzarte, 2013); Cagliari prov.: "Gonnos, en juin (Baudi [leg.] in Coll. Oberthür)" (Lesne, 1901); "Gonnos, VI.[18]91, *A. varia*", 1 es. (MCGD); Gesturi, Giara VIII.2004, ex *Quercus suber*, DS, 3 es. (CDS); idem, VIII.2005, 1 es. (CDS); Sinnai, M. Sette Fratelli, VIII.2005, ex *Quercus suber*, DS, 3 es. (CDS); Villaputzu, Rio Ollastu, m. 80, 17.VI.2007, collecting at light, DS, 1 es. (CDS); San Nicolò Gerrei 19.VI.2013, collecting at light, DS, 1 es. (CDS); Nuoro prov.: Orune, wfd, 1 es. (MCGD); ibidem, wfd, 2 es. (MCGM) (!); ibidem, wdc, coll. Demarchi, 2 es. (MCGB) (!); Oristano prov.: Magomadas, Nigolosu, VII.1994, PL, 1 es. (CLE) (!); Sassari prov.: Buddusò, loc. Sos Canales, 14.VI.1997, AM, 2 es. (CLI) (!); Sassari, Rio Bunnari, 8.VI.1997, DS, collecting at light, 1 es. (CDS) (!). Sicily: Palermo prov.: Bosco della Ficuzza, Torretta Torre, 940 m, Plot Conecofor SIC1, UTM 33 S 357671 4194110, 5.V.2004, under the bark of a *Quercus* sp. tree, GN, 3 es. remains (CNBFVR) (!); [Bosco della] Ficuzza, Torretta Torre, 986 m, UTM 33 S 359993 4196856, 28.VI.2005, DB, PC, ML & DW, collecting at light, 1 es. (CNA) (!); [Monreale], Lago Scanzano, 8.VII.2008, IS, direct collection, 1 es. (CSP) (!).

OTHER MATERIAL EXAMINED. Algeria: Tizi Ouzou, Parc Nat. [= National] d'Akfadou, 800-1000 m, 17-18.VI.1982, GS, 4 es. (MCSV); Ft. [= Fôret] d'Akfadou, 1000 m, 4–7.VI.1980, GS & GM, 2 es. (MCSV). Spagna: Càdiz, Los Barrios, Arroyo Valdeinfierno, P.N. [= National Park] Los Alcornocales, 155 m, 10.VI.2008 , AV, 4 es. (CMU).

CHOROTYPE. W-Mediterranean: Morocco, Algeria, Tunisia, Portugal, Spain and Italy (Borowski, 2007; Borowski & Węgrzynowicz, 2007). Borowski (2007) recorded this species also from "AFR" [= Afrotropical Region], very probably on the basis of unpublished data, since no other literature record from this Region (see also Borowski & Węgrzynowicz, 2007) is known.

ECOLOGY. The adults of this species, as those of *L. varius*, are nocturnal (Español, 1956), and are often collected at light (Lesne, 1905; Español, 1956, 1974, as *L. numida* Lesne, 1898 [sic!]; Angelini, 1998; Murria Beltrán, 2002; Urbano Granero, 2002; Llinares & Navarro, 2003; !); they remain hidden in their tunnels, under bark or in the cracks of trunks during the day (Español, 1956). The adults are collected chiefly from May to August (Bahillo de la Puebla et al., 2007). The main host plant is *Quercus suber* L. (cf. Bahillo de la Puebla et al., 2007), but this beetle develops also on *Q. canariensis* Willd. (FEI, 2012), *Q. pyrenaica* Willd. (Baena & Zuzarte, 2013), *Eucalyptus* spp. (Lesne, 1901, 1905; Pic, 1905) and *Populus nigra* L. (López-Colón & Bahillo de la Puebla, 2011). On High Atlas (Morocco), this species reaches an altitude of 2000 m a.s.l. (Kocher, 1956).

REMARKS. *L. numida* is quite spread in the southern and central parts of the Iberian Peninsula (Bahillo de la Puebla et al., 2007), but according to Llinares & Navarro (2003) its presence in this area, as for other saproxylic beetles, is due to passive introductions with woods from Maghreb.

About the occurrence of this species in Sardinia, it must be underlined that the old above records from "Gonnos" refer probably to one of the following toponyms of the Cagliari province: Gonnoscodina, Gonnosfanadiga, Gonnosnò, Gonnostramatza. The species after the record of Lesne (1901), was cited

generically from Sardinia by several authors (Winkler, 1927; Luigioni, 1929; Porta, 1929; Vrydagh, 1960; Audisio et al., 1995; López-Colón, 2000; Fernández-Carillo et al., 2001; López-Colón et al., 2001; Murria Beltrán, 2002; Urbano Granero, 2002; Nardi, 2004; Bahillo de la Puebla et al., 2007; Borowski & Węgrzynowicz, 2007; López-Colón & Bahillo, 2011; Baena & Zuzarte, 2013) but the same Lesne (1938) has omitted (or has overlooked?) this record. The new records confirm definitively the occurrence of this species in Sardinia. While, the generic record for "S" (= Peninsular Italy) of Audisio et al. (1995) is an error (Liberto & Nardi, unpublished data), but the occurrence of the species in this area was later reported by Angelini (1998). The species is here firstly recorded from Sicily. The above first Sicilian specimens come from an old mixed oak-forest belonging to the *Quercetum gussonnei* vegetational association (cf. Mason et al., 2006), while the latest specimen comes from a dense planting of *Eucalyptus* trees situated among stands of the same above-mentioned oak-forest; so at least two of the host plants of this beetle occur in these Sicilian sites (cf. Gianguzzi & La Mantia, 2004). Various kinds of traps (window flight, Malaise, pitfall) were used in this forest (cf. Mason et al., 2006), but the species was not intercepted by these methods. The same situation was observed in various Sardinian sites (cf. Cerretti et al., 2009; Nardi et al., 2011). In Italy this species is rare and localized; before this paper, the sole recent record was from Basilicata Region (Angelini, 1998).

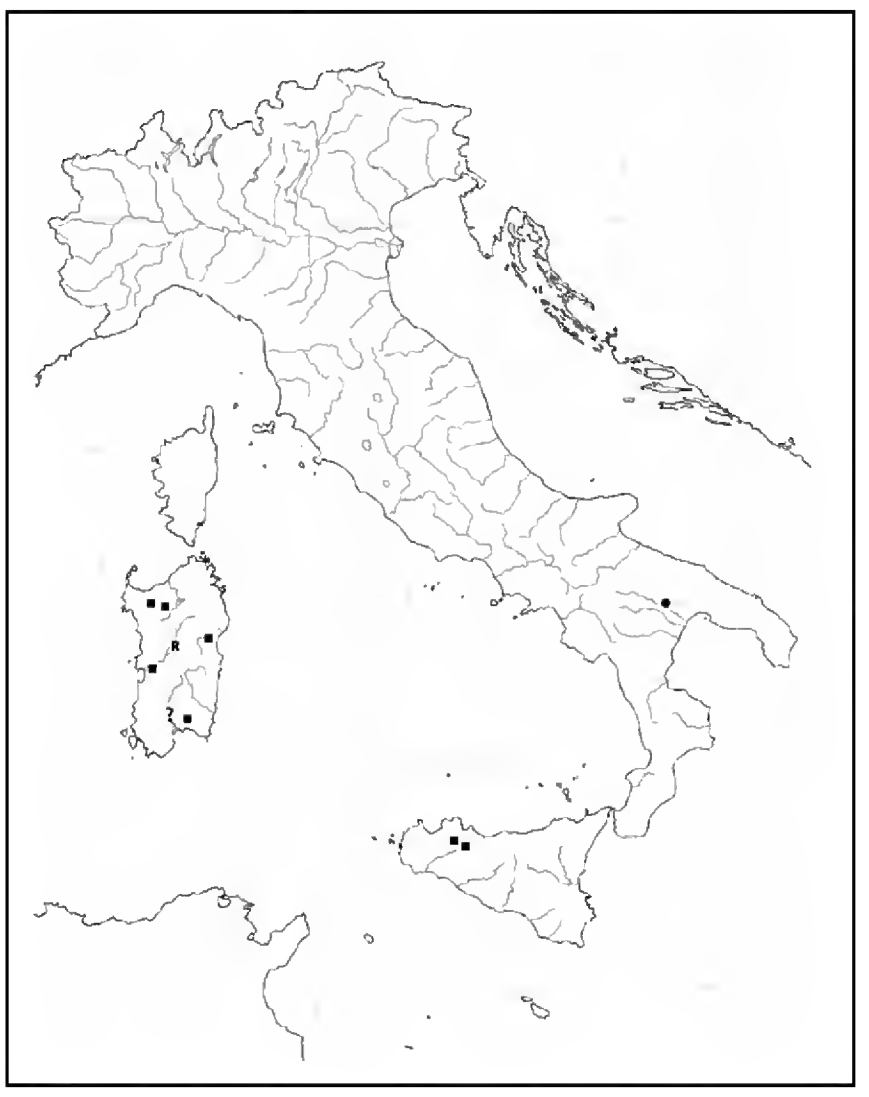

Figure 8. Distribution in Italy of *Lichenophanes numida*. Dot = references; square = new places; R = regional reports; ? = dubious locations.

Lichenophanes varius (Illiger, 1801)

Apate varia Illiger: Comolli, 1837: 37.
Apate varia Ill.: Villa & Villa, 1844: 62; Bertolini, 1875: 143.
Apate varia Illig.: Bargagli, 1873: 40.
Apate varians [sic!] Ill. (*Dufouri* Latr. [= *dufourii* (Latreille, 1805)]): Costa, 1884: 28.
Lichenophanes varius Illiger, 1801: Lesne, 1898: 470; Lesne, 1901: 470.
Lichenophanes varius Illig.: Bertolini, 1904: 76; Luigioni, 1920: 207; Porta, 1929: 415; Grandi, 1956: 417; Tassi, 1963: 26; De Marzo & Porcelli, 1989: 88; Gobbi, 2002: 46.
Lichenophanes varius Ill.: Luigioni, 1929: 640; Faggioli, 1955: 174; Frediani, 1961: 3.
Lichenophanes varius: Borchert, 1938: 78; Gobbi, 1984: 54, 58.
Lichenophanes varius (Illiger, 1801): Audisio et al., 1995: 7; Nardi, 1997: 177–178; Gobbi, 2000: 195, 221; Nardi, 2004; Nardi & Zaharadník, 2004: 127; FEI, 2011, 2012; Pezzi, 2013: 110.

ITALIAN RECORDS (Fig. 9). Lombardy: no exact locality and date (Bertolini, 1875, 1904; Luigioni, 1929; Porta, 1929; Borchert, 1938); "p" [= plain] (Villa & Villa, 1844); Brescia prov.: Capriano del Colle, Bosco delle Colombere, 20.VI.2012, LM, 1 es. (CMO) (FEI, 2012); Como prov.: "campagne di Rovello Porro" (Comolli, 1837); Mantua prov.: Marmirolo, Bosco della Fontana, Stand 12, [31.V–]14.VI.2000, FM, Qr1B3 [= trunk window trap on an untreated standing *Quercus robur* tree], 1 es. (CNBFVR) (!) (Nardi & Zaharadník, 2004). Veneto: Verona prov.: Illasi, Parco Perez-Pompei, 18.V–12.VII.2010, AS, trappola [= trap = wine trap (cf. Allemand & Aberlenc, 1991)], 1 es. and 1 es. remains (MCSVS) (!); ibidem, 20.V.2011, RD & AS, ex *Carpinus betulus*, 1 es. (MCSVS) (!); ibidem, 12.VI.2011, RD & AS, 1

es. (MCSVS) (!); ibidem, 21.VI.2011, RD & AS, ex *Carpinus betulus*, 1 es. (MCSVS) (!); sdb 2.VII.2011, 3 es. (MCSVS) (!); sdb 7.VIII.2011, 1 es. (MCSVS) (!); Musella, 5.VIII.1981, AS, ex *Quercus* sp., 5 es. (MCSVS) (!); sdb 5.IX.1982, ex Carpino [(*Carpinus betulus*)], 1 es. (MCSVS) (!); Negrar, [Fraz.] Montecchio, 500 m, 11.VII.2011, RD & AS, ex *Carpinus betulus*, 1 es. (MCSVS) (!); [Sommacampagna] (Verona), [Fraz.] Custoza, Val dei Mulini, 25.II.2010, AS, 2 es. remains (MCSVS) (!). Emilia-Romagna: Ravenna prov.: Mezzano, Zona di Protezione Speciale (ZPS) "Bacini ex zuccherificio di Mezzano", 2006–2013 (Pezzi, 2013). Tuscany: Grosseto prov.: Grosseto, 20.VII.2011, MBr, ex *Quercus pubescens*, 4 es. (FEI, 2011). Lazio: no exact locality and date (Luigioni, 1929; Porta, 1929; Borchert, 1938); Frosinone prov.: [Monti Lepini,] Supino, loc. Pian della Croce, 1100 m, 9.VII.2006, GP, under the bark of an unidentified tree (maybe a Beech (*Fagus sylvatica*), 27 es. (CPA); Latina prov.: Monti Lepini, Norma, Monte Arrestino vers. SW, 750 m ca, 25.VII.2002, GN & CE, about 16 hours, a death specimen carried by a *Camponotus* (*Camponotus*) *vagus* (Scopoli, 1763) (Hymenoptera, Formicidae) (M. Mei det., 2013) on a trunk of a fallen *Quercus pubescens* tree, under an old tree of the same species covered with Polyporaceae, 1 es. (CGN) (!); Parco Nazionale del Circeo [= Circeo National Park], Sabaudia, 1.VI.1996, GP, under the bark of a *Quercus* sp. tree, 2 es. (CLI) (!); Rome prov.: [Manziana,] Bosco di Manziana, 12.III.2012, under the bark of a death standing *Quercus* sp. tree, MG, 1 es. remains (FEI, 2012); Roma [= Rome], VI.1922, Delbue leg., on walls, 1 es. (MCZRL) (!) (Tassi, 1963; Nardi, 1997); dint. di Roma [= Rome], presso Via Appia Antica, 2.VII.1963, F. Tassi leg., about 20 hours while fluttering around the canopy of a large oak tree, 1 es. (Tassi, 1963); Roma, Nuovo Salario, 1995, introduced with woods (CVO) (Nardi, 1997); Sasso Furbara, 250 m, 2.VI.1996, FI, ex *Quercus suber*, 1 es. (CLI) (!); sdb 22.V.1996, 1 es. (CLI) (!); Viterbo prov.: Bassano [di Sutri = Bassano Romano], VII, under the bark of a dead Beech [(*Fagus sylvatica*)], 1 es. (Luigioni, 1920); Bassano [di] Sutri, 18.VII.1909, Luigioni leg., 1 es. (MCZRL) (!); Tuscania, 13–24.IV.1972, ex *Quercus suber* (Gobbi, 1984: 54); dint. Tuscania, 5.V.1972, ex dry branks of *Quercus suber* (Gobbi, 1984: 58). Molise: Campobasso prov.: Campomarino, Fraz. Campomarino Lido, 17.VI.1992, AL, on *Populus* sp., 1 es. (CLI) (!). Campania: no exact locality and date (Luigioni, 1929; Porta, 1929); Naples prov.: no exact locality and date (Luigioni, 1929; Porta, 1929); Naples prov.: "Naples" (MNHN) (Lesne, 1898, 1901); "Nap" [= Neapel = Naples] (Borchert, 1938); Napoli [= Neaples], wfd [very probably collected during the XIX century], 1 es. (MSNF); "Nap." [= Napoletano = Naples area] (Bertolini, 1875); "n" [= ditto] (Bertolini 1904); [Naples,] Capodimonte, 27.VI.1867, 2 es. (MCZRE) (!); sdb 29.VI.1867, 1 es. (MCZRE) (!); dint. di Napoli [= Naples], Capodimonte, VI.1911, Anguis. [= Anguissola] leg., 1 es. (MCZRL) (!). Apulia: Foggia prov.: Gargano, Foresta Umbra (Faggioli, 1956); ibidem, [4.VII–4.VIII.1955], direct collection on dry woods (Grandi, 1956); Villaggio Amendola, 21.V.1999, P. Crovato leg., on *Ulmus* sp., 1 es. (CLI). Basilicata: Matera prov.: Policoro, 25.V.1986, 1 female (De Marzo & Porcelli, 1989); Potenza prov.: Foresta [demaniale] Gallipoli–Cognato, 500 m, 14.VI.1994, G. Gobbi leg., taken from a little cell in a death brank of an *Acer monspessulanum* tree, 2 es. (Gobbi, 2002); Foresta demaniale Gallipoli-Cognato, 500 m, 15.VI.1996, AL, under the bark of a fallen *Quercus cerris* tree, 1 es. (CLI) (!). Sicily: Messina prov.: [Monti Nebrodi,] Biviere di M. Sori, VII.1938, MBu, 1 es. (MCSVB) (!); [Monti Nebrodi,] Monte Soro, Piano Vescovo, 1400 m, 1.VII.1989, IS, 1 es. (CSP) (!); [Monti Nebrodi,] Messina, Monte Trefinate, 20.VII.2013, GA & CM, [on a stump of a *Quercus cerris* tree], 1 es. (CMU) (!); Monti Nebrodi, tra [= between] Caronia e [= and] Capizzi, 1300 m, 37°56'01"N/14°30'67"E, 6.VII.2005, AL, on a *Quercus cerris* tree, 1 es. (CLI) (!). Sardinia: no exact locality and date (Bertolini, 1875, 1904; Porta, 1929; Audisio et al., 1995; Nardi, 2004); no exact locality and date, "Baudi, Ghiliani [leg.]" (Bargagli, 1873); Nuoro prov.: "un individuo sotto le cortecce delle Elci sul Monte Chiesa di Aritzo: luglio" [= a specimen under the barks of Holms [(*Quercus ilex*)] on Mount Chiesa of Aritzo: July] (Costa, 1884).

OTHER MATERIAL EXAMINED. [Bulgaria:] Svileuprad, 10.VII.1981, IG, 1 es. (MCZRG) (!). Czech Republic: Moravia, Břeclav, 2.VI.2007, M. Brabech leg., ex [unspecified tree], 1 es. (CNA) (!); sdb 2.VII.2008, 1 es. (CNA) (!). France: Corse du sud, env. Porto Vecchio, Rau Scopa Piana, 100 m, 7.VI.1999, EC, 2 es. (CLI) (!). Greece: Thessaly

(Trikala), Oros Antihassià, Vlahava env., 600 m, 29.VI.1999, AL, on *Quercus* sp., 1 es. (CLI) (!). [Romania:] Banat, Mehadia, wfd, coll. Burlini, 2 es. (MCSV) (!).

CHOROTYPE. Turano-Europeo-Mediterranean (cf. Nardi & Zaharadník, 2004; Borowski, 2007; Borowski & Węgrzynowicz, 2007).

ECOLOGY. The larvae are saproxylophagous and develop in the wood (branks and rotting trunks) of many broadleaved tree genera (e.g. *Alnus*, *Carpinus*, *Castanea*, *Fagus*, *Populus*, *Quercus* and *Tilia*) (cf. Lesne, 1901; Sahlberg, 1913; Iablokoff, 1945; Español, 1955; Horion, 1961; Damoiseau, 1966; Koch, 1989, as *Lichenophanus* [sic!] *varius*; Zaharadník, 1996; Nardi & Zaharadník, 2004; Ricarte et al., 2009) and roots of *Glycyrrhiza glabra* L. (Frediani, 1961); in Italy this species was found in *Acer monspessulanum* L., *Carpinus betulus* L., *Quercus* sp., *Q. pubescens* Willd., and *Q. suber* (Gobbi, 1984; FEI, 2011; Gobbi, 2002; !); moreover, adults were collected on the following trees: *Quercus* sp., *Q. cerris* L., *Q. ilex* L., *Q. robur* L., *Fagus sylvatica* L., and *Populus* sp. (Costa, 1884; Tassi, 1963; Nardi & Zaharadník, 2004; !).

The females seem to prefer for oviposition the trunk and smaller branches of large decaying logs, but with wood still compact, positioned on the sunny clearings of forests exposed to the East (Klingelhöffer, 1843; Perris, 1850 as *Apate dufourii*).

L. varius, similarly to other Bostrichidae, is able also at the adult stage of digging tunnels in the wood. These galleries have a circular entrance that penetrates into the wood horizontally for about 1–2 cm and then fold down with a straight stretch of about 2–3 cm. After the oviposition, the female reaches the entrance of the cavity where shortly after dies occluding the entry; the small larvae, after hatching, go towards the bottom, filling the gallery of sawdust, to build a small niche where to end the development (Klingelhöffer, 1843; Reitter, 1911). The larval stage lasts for more than five years (Recalde Iruzun & San Martín Moreno, 2012) and during this long period, the larvae may be preyed upon by birds such as woodpeckers and owls, other beetles such as Cleridae and, occasionally, even mammals such as dormice (*Glis glis* Linnaeus, 1766) (Floβmann, 2010). The pupal stage begins in late April and lasts about two weeks. The flickering occurs in early summer and the specimens remain active until August (Klingelhöffer, 1843; Lesne, 1901; Español, 1955).

Figure 9. Distribution in Italy of *Lichenophanes varius*. Dot = references; square = new places; asterisk = general reports; R = regional reports; ? = dubious locations.

The adult is typically crepuscolar and nocturn and is often attracted by artificial lights (Dajoz, 1961; Flechtner, 2000; Bahillo de la Puebla et al., 2007); according to Iablokoff (1945) it is particularly active in humid and rainy nights. *L. varius* during the day remains hidden under the bark, in the cracks of trunks or in its tunnels (Lesne, 1901; Iablokoff, 1943; Español, 1955; Horion, 1961), from where it is easy to get it out by blowing out the entrance with tobacco smoke (Perris, 1850).

According to some authors (cf. Iablokoffl, 1943, 1945; Español, 1955), *L. varius* might attack only wood invaded by the mycelia of *Biscogniauxia nummularia* (Bull.) Kuntze (1891) (Pyrenomycetes, Xylariaceae). This peculiar ecology, is probably, as observed for other saproxylophagous beetles (cf. Rejzek & Vlásak, 2000), one of the causes of the rarity of this species. The above Sicilian records seem to confirm this requirement since a large decay of the beechs caused by *Biscogniauxia nummularia* is known from one (Monte Soro) of the above mentioned collection sites (Torta et al., 2009), while the beetle from Monte Trefinaite was collected on a

stump of an oak (*Quercus* sp.) (Fig. 10) tree infested by the black ascocarpi of another species of the same genus: *B. mediterranea* (De Not.) Kuntze (1891) (A. La Rosa, pers. com., 2013). This fungus lives on oaks (*Quercus* spp.) while *B. nummularia* lives on beech (cf. Franceschini et al., 2009; Torta et al., 2009). *B. mediterranea* is recorded also from Bosco della Ficuzza (cf. Torta et al., 2009), where *L. numida* was collected (!). In recent years there has been a resurgence of attacks from these phytopathogenic fungi in Mediterranean forest stands. This is in response to climate change that essentially led to an increase in average temperatures and an altered pattern of annual rainfalls, which caused water stress to trees, limiting their tolerance to adverse factors (Franceschini et al., 2009). This resurgence probably can favour the populations of *Lichenophanes* spp.

REMARKS. The alleged rarity of *L. varius* in much of its range, including Italy (Tassi, 1963; Horion, 1969; Flechtner, 1999; Gobbi, 2000; Zaharadník & Nardi, 2004; Moulin, 2007; Lakatos & Molnár, 2009; Recalde Irurzun & San Martín Moreno, 2012), and its fragmented distribution is due not only to lack of research, but above all to the peculiar ecological requirements.

In fact, several authors (Cymorek, 1969; Geiser, 1994, 1998; Flechtner, 1999, 2000; Schillhammer, 2003) consider *L. varius* as "primary forest species", a species associated with primary forests that since the last European glaciation have not undergone environmental disturbances. Horion (1969) considers *L. varius* as a pre-glacial forest relict ("präglaziales urwaldrelikt"), that as a result of climate change remained confined to relict forest islands ("urwaldinseln") thus forming disjunct populations spread over a fragmented distribution area. To confirm this distribution model Horion (1969) claims to have identified the area of discontinuity, located along the valley of the Rhine River, between the French and North-German populations of *L. varius* and other beetles; the existence of this area confirms the existence of two glacial forest islands that have worked to refuge areas.

However, as noted by Nagel (1971), in central Europe this species is mainly distributed in areas that during the ice ages were devoid of forest islands, or in countries (e.g. Romania, Hungary and former Yugoslavia), which, although forested, were still covered by permafrost for most of the year, a condition that would inhibit the survival of *L. varius*.

Ponel (2007), however, argues that the fragmented distribution of *L. varius* is attributable to the human impact that from the Neolithic has gradually reduced the extent of primary forest grind into portions, relegating in these forestry islands the relict saproxylophagous species with high ecological requirements and determining elsewhere the extinction.

For all these reasons, *L. varius* is included in the Red Lists, both regional and national, in several European countries (Mason et al., 2013), in addition, it is considered rare in environmental conditions not compromised (Bulgarini et al., 2004) and its habitat of choice is considered in strong regression throughout Europe (Franc, 2004; Fischer et al., 2012).

L. varius is referred to as CR (Critically Endangered) in Poland (Głowaciński, 1992; Pawłowski et al., 2002) and in Germany (Geiser, 1998); "stark gefährdet" (highly endangered) in the lander of Baden-Wuerttemberg and Brandenburg, "vom aussterben bedroht" (endangered) in the land of Bavaria (see Bussler, 2013; Büche & Möller, 2005), "Rare" in the Upper Silesia (Kubisz et al., 1998), "stark gefährdet" in Austria (Geiser, 1994), "VU" (Vulnerable) in Slovakia (Holecová & Franc, 2001). It is not among the species mentioned by a proposal for an Italian Red List of invertebrates (Cerfolli et al., 2002), probably due to lack of available data. It is also classified as "NT" (Near Threatened) in the European Red List of Saproxylic Beetles developed by Nieto & Alexander (2010) on behalf of the IUCN (International Union for Conservation of Nature, 2013). Finally, *L. varius* was included by Brustel (2001) in a list of saproxylophagous beetles that are bioindicators of high-quality mature French woodlands. It is not surprising, therefore, that this species in Sicily has been found just on Nebrodi Mountains, that are the Sicilian mountain range that includes forest environments of greater naturalness (cf. Sabella & Sparacio, 2004).

The old Italian regional records were listed also by most of subsequent authors (see above), nevertheless Luigioni (1929) has not listed the species from Sardinia; the sole detailed records from this island (Bargagli, 1873; Costa, 1884) are prior to the description of *L. numida*. In this framework, it is possible that the two species have been confused, nevertheless *L. varius* occurs also in the nearby Corsica Island (Lesne, 1901; Bertolini, 1904; Luigioni, 1929; Porta, 1929; Sainte-Claire Deville, 1937; Borchert, 1938; Vrydagh, 1960; Horion,

Figure 10. *Lichenophanes varius* from Monte Trefinaite (Nebrodi Mountains, Sicily). Photo by C. Muscarella.

1961; !), which has also a similar biogeographical history (cf. De Jong, 1998), so only the study of the old Sardinian specimens (Bargagli, 1873; Costa, 1884) can confirm their identifications, but unfortunately their re-examination has so far been impossible. The above-listed new records from Veneto, Molise and Sicily, suggest that *L. varius* probably occurs in most of Italian regions. The new records show an unexpected diffusion of the species in the Verona province (Veneto), but in this province it was not intercepted by various kinds of traps (window flight, Malaise, pitfall) in the relatively undisturbed broadleaved woods of Mount Baldo (Spada, 2008; Nardi & Spada, 2008). In this province the species develops also on *Carpinus betulus* (!) that in Italy is a new host plant, while it was already listed by Damoiseau (1966) and Ricarte et al. (2009). At Bosco della Fontana (Lombardy, Mantua prov.), *L. varius* is very rare; this nature reserve (236.11 ha) includes one of the last remaining oak-hornbeam forest (*Querco-Carpinetum boreoitalicum*) in the Po plain. This reserve is a forest-habitat island, completely surronded by cultivated fields (cfr. Mason et al., 2002; Mason, 2004). In this locality a sole specimen was trapped during 2000 (Nardi & Zaharadník, 2004), although this forest, since 1988, was object of monitoring of the entomofauna (Mason et al., 2002; Cerretti et al., 2004a; D'Amen et al., 2013a; Cornacchia & Nardi, unpublished data), also at canopy-level (Cerretti et al., 2004b; Stireman et al., 2011; Birtele & Hardersen, 2012). In Lombardy, this species was not trapped (Nardi, unpublished data) also in forest sites situated along the Ticino Valley Regional Park (cf. Della Rocca et al., 2013), in spite of being recorded from the bordering Swiss Ticino Region (Luigioni, 1929; Borchert, 1938; Fontana, 1947). The above site from Molise Region is in an area that in the past was covered by large woodland formations, and it is near two remaining forests. The former forest is Bosco Fantine (Campomarino, Campobasso prov.) and is 2–3 km in a beeline; it is an hygrophil wood survived to a reclamation ("Bonifica Ramitelli") made during the first half of the twentieth century (Taffetani, 2011), the second forest is a few km south of Bosco Fantine, a little beyod the regional border Molise-Apulia, in the commune of Marina di Chieuti (Foggia prov.), and is a well preserved but unprotecteded small hygrophilic wood. The record from Villaggio Amendola (Apulia, Foggia prov.) comes from a row of elms and is very surpising, since the environment in this locality is very degraded: it is constituted by cultivated fields or by fallow fields with *Ferula* sp. (Apiaceae) along the State Road Garganica near a militar airport, moreover in the neighbouring area no forest is present. At the time, there was a row of elms not very old, all cut during the previous year. On these elms, before their cutting, were present also some Buprestidae (Coleoptera) typical of this tree: e.g. *Anthaxia* (*Anthaxia*) *senicula* (Schrank, 1789), = *A.* (*A.*) *deaurata* (Gmelin, 1790, and *A.* (*A.*) *manca* (Linnaeus, 1767) (Liberto, unpublished data). This locality is in the historic Appenine region of Capitanata (southern Molise and northern Apulia); in all this historic region there is a grid of these rows of elms with function of windbreak, nowadays gradually replaced with *Eucalyptus* sp. The dispersal flight capacity of this species is probably low (Liberto & Nardi, unpublished data), so probably the occurence in this site, may reflect a past habitat situation when the forest density was probably higher than that measured actually (cf. Pratesi & Tassi, 1979; Ranius, 2006; Taffetani, 2011).

Finally, it must be underlined that the type specimen of this specis is probably lost (Vrydagh, 1962).

SHORT CONSIDERATIONS ON THE SAPROXYLOPHAGOUS BEETLE-FAUNA OF SICILY

The discovery of *L. varius* in various Italian regions and its ecological value, as documented above,

further underline the importance of conservation of forest environments which often act as refuge-area for many saproxylophagous species; they, represent a fauna consortium highly specialized in the processes of degradation of wood and creation of ecological niches of vital importance for the development of numerous other organisms which, according to some estimates, are up to about 30% of the overall biodiversity of a forest (Pignatti et al., 2009).

Moreover, in recent years, the "dead wood" has become a key indicator to assess the well-being of forest environments and the implementation of their management (Mason et al., 2003; MCPFE, 2003; European Environment Agency, 2007); the role of the "dead wood" in the global ecology of a forest, in terms of biodiversity, has been highlighted and shown in numerous works (Wermelinger & Duels, 2002; Mason et al., 2003; Schlaghamersky, 2003; Tagliapietra, 2003; Speight & Good, 2003; Hahn & Christensen, 2004; Humphrey et al., 2004; Ranius & Fahrig, 2006; Travaglini et al., 2007; Bishop et al., 2009; Pignatti et al., 2009; La Mantia et al., 2010; D' Amen et al., 2013b, 2013c) .

In particular, on Nebrodi Mountains (Sicily), where *L. varius* was recently collected, different saproxylophagous beetles that are included in the Habitat Directive (cf. Trizzino et al., 2013) can be found as well: *Rosalia alpina* Linnaeus, 1758, *Cerambyx cerdo* Linnaeus, 1758 (Cerambycidae) and *Osmoderma cristinae* Sparacio, 1994 (Cetoniidae). Moreover, in this area are present many taxa endemic of Sicily, in rarefaction and with an extremely limited range: *Ropalopus siculus* (Stierlin, 1864), *Clytus clavicornis* Reiche, 1860, *Grammoptera viridipennis* Pic, 1893 (Cerambycidae), *Gnorimus decempunctatus* Helfer, 1833 (Cetoniidae), and *Lucanus tetraodon sicilianus* Thunberg, 1806 (Lucanidae) (Sparacio, unpublished data). The Nebrodi Mountains host at least 70 species (Sabella & Sparacio, 2004; Sparacio, unpublished data) included in the "European Red List of Saproxylic Beetles" (Nieto & Alexander, 2010).

The paper of Nieto & Alexander (2010), although worthy of further updates, shows that in Sicily there are at least 112 of the 436 mentioned species (Muscarella & Sparacio, unpublished data). Then it occurs that Sicily (0.24 % of European territory) hosts approximately 25% of the saproxylophagous beetles considered threatened or endangered in Europe.

This faunal community according to the "2nd National Report on the implementation of the Habitats Directive and the conservation status of habitats and species in Italy" is particularly threatened (La Posta et al., 2008). For this reason the EU directives on the protection of the saproxylic fauna have been implemented by the Italian State which has enacted specific laws, both regional and national, and proposed guidelines for the management of dead wood and fauna associated with it (Campanaro et al., 2011; Trizzino et al., 2013).

The main factor of disturbance of such an important wildlife is the short-sighted management of forests carried out by some administrations that do not consider the dead wood as fundamental to the ecological balance of the forest but rather as a threat to health, a vector of pests and insects "harmful " or, at best, as a simple source of firewood. As a result, the indiscriminate falling of dead stumps not yet fallen, and removing decayed and senescent trees have a negative impact on the populations of saproxylophagous beetles with inevitable repercussions on the entire food chain in forest ecosystems causing biodiversity loss (see Biscaccianti & Lorenzetti, 2012).

ACKNOWLEDGMENTS

Thanks are due to Giovanni Altadonna (Messina), Fernando Angelini (Francavilla Fontana, Brindisi), Daniele Baiocchi (Rome), Daniele Birtele (Centro Nazionale per lo Studio e la Conservazione della Biodiversità Forestale "Bosco Fontana" di Verona, Verona), Fabio Cianferoni (Museo di Storia Naturale dell'Università degli Studi di Firenze, Sezione di Zoologia "La Specola", Florence, Italy), Enzo Colonnelli (Rome), Paolo Cornacchia (Porto Mantovano, Mantua), Paolo Crovato (Naples), Carmine Esposito (Velletri, Rome), Enzo Gatti (Belluno), Maurizio Gigli (Rome), Fabio Gorian (Centro Nazionale per lo Studio e la Conservazione della Biodiversità Forestale "Bosco Fontana" di Verona, Verona), Francesco Izzillo (Naples), Alfonso La Rosa (Palermo), Piero Leo (Cagliari), Agostino Letardi (ENEA, S. Maria di Galeria, Rome), Massimo Lopresti (Centro Nazionale per lo Studio e la

Conservazione della Biodiversità Forestale "Bosco Fontana" di Verona, Verona), Franco Mason (Centro Nazionale per lo Studio e la Conservazione della Biodiversità Forestale "Bosco Fontana" di Verona), Maurizio Mei (Museo di Zoologia, Sapienza Università di Roma, Rome, Italy), Alessandro Molinu (Sassari), Giuseppe Pace (Rome), Emanuele Piattella (Museo di Zoologia, Sapienza Università di Roma, Rome, Italy), Roberto Poggi (Museo Civico di Storia Naturale "Giacomo Doria", Genoa), Maria Concetta Sala (Palermo), Daniele Sechi (Cagliari), Laura Spada (Centro Nazionale per lo Studio e la Conservazione della Biodiversità Forestale "Bosco Fontana" di Verona, Marmirolo, Mantua), Antonio Verdugo (Càdiz), Augusto Vigna Taglianti (Museo di Zoologia, Sapienza Università di Roma, Rome, Italy), Vincenzo Vomero (Rome), Daniel Whithmore (Natural History Museum, London), and Alberto Zilli (Museo Civico di Zoologia, Rome), for help in the field or in the lab, and/or for enabling us to study the collections in their care.

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Biodiversity Journal, 2013, 4 (4): 467-470

First record of *Pipistrellus pygmaeus* (Leach, 1825) (Mammalia Chiroptera) in Sicily (Southern Italy)

Gaetano Fichera[1], Mauro Mucedda[2*], Paolo Catalano[1] & Ermanno Pidinchedda[2]

[1]Centro Speleologico Etneo, Via Valdisavoia, 3 - 95123 Catania, Italy
[2]Centro Pipistrelli Sardegna, Via G. Leopardi, 1 - 07100 Sassari, Italy; e-mail: m.mucedda@tiscali.it
*Corresponding author

ABSTRACT We report the capture through mist-nets of two adult females *Pipistrellus pygmaeus* (Leach, 1825) (Mammalia Chiroptera), along the course of Simeto river, in Adrano (Catania, Sicily, Italy). Their presence has been reported for the first time in Sicily, increasing the number of bat species present in the region to twenty three.

KEY WORDS Chiroptera; *Pipistrellus pygmaeus*; Sicily; Simeto river.

Received 09.10.2013; accepted 22.11.2013; printed 30.12.2013

INTRODUCTION

In Sicily we know only two species of *Pipistrellus* Kaup, 1829 genus (Mammalia Chiroptera): *P. pipistrellus* (Schreber, 1774) and *P. kuhlii* (Kuhl, 1817), both widely distributed all over the Italian territory.

Recently, the *P. pygmaeus* (Leach, 1825) was genetically separated from *P. pipistrellus* (Barratt et al., 1997), and they are considered two cryptic species (Russo & Jones, 2000), therefore its distribution in Italy, particularly, is little known and incomplete. Up to now the presence of *P. pygmaeus* was reported in Valle d'Aosta (Debernardi & Patriarca, 2008), Lombardy (Martinoli & Spada, 2008), Tuscany (Agnelli et al., 2005), Umbria (Spilinga et al., 2013), Lazio and Campania (Russo & Jones, 2000), Abruzzo (Russo et al., 2011) and Sardinia (Veith et al., 2011).

Thus, until now Sicily was one of the Italian regions where the presence of *P. pygmaeus* had not been verified. In this publication we report the presence of *P. pygmeus* in Sicily, that was captured twice with mist-nets along the Simeto river.

MATERIALS AND METHODS

The area of Sicily where the research was conducted is situated at 216 m a.s.l., along the Simeto river, the second most long Sicilian river, under the Acquedotto Biscari bridge (Adrano, Catania) (Fig. 1). This location is characterized by clay outcrops and a tamarisk vegetation along the river. Nearby there are citrus crops, vegetables and uncultivated areas.

The captures were made using two 6-meter long mist nets (19 mm mesh and 5 pockets each) one on top of the other for a total height of 4 meters. They were positioned on the river, a few inches above the water surface supported by telescopic poles. The nets were positioned half an hour before sunset and removed 3 hours after it. The biometric measurements of animals were performed with a calliper (0.1 mm accuracy) and with a pesola (0.5 g accuracy). The recordings of bats sounds were made with a Pettersson D 240 Bat-detector, in Time expansion mode, assisted by a Zoom H2 recorder. The computer processing were carried out with the Pettersson Batsound software.

All specimens were promptly released at the end of operations. All activities were carried out with the authorization of the Sicilian Regional Assessorate for Agricultural and Food Resources (1742-01/06/2012) and of the Ministry for the Environment and Territorial and Sea Protection (0009358-07/06/2012).

Figure 1. The pointer indicates the location of capture of *Pipistrellus pygmaeus* in Sicily.

Figure 2. The specimen of *Pipistrellus pygmaeus* captured on July 10 2013. Note the light-colored fur.

RESULTS

During the research conducted in the areas surrounding Mount Etna on the 10th of July and the 8th of September 2013, two capture sessions were carried out using mist nets along the River Simeto, and two *P. pygmaeus* specimens were caught. They were both adult females, one of them was a lactating, whose biometric data are reported in Table 1.

Date	Sex	Forearm length	Weigth
July 10 2013	Female lactating	29.0 mm	5.0 g
September 8 2013	Female	30.9 mm	4.9 g

Table 1. Measures of *Pipistrellus pygmaeus*.

The animals were identified on the basis of the following morphological characteristics: the presence of a ridge between the nostrils, the cells between the veinings of the wings typical of the species, as indicated by Dietz & Helversen (2004). The color of the fur is of a lighter brown compared to the *P. pipistrellus*, almost blond as already observed for specimens of Sardinia (personal observation) and as shown in the images of Dietz et al. (2007) (Fig. 2). The animals were released immediately after examination. The validity of the species was also confirmed by the recording of the sounds emitted by the two bats released from the hand in open space. Only the final part of the recorded sequences were analysed, to avoid influence by the hand release. Three calls from each bat were measured from power spectra, given the following values of Frequency of Maximum Energy (FMaxE): 56.5 ± 0.2 kHz for the first bat and 56.6 ± 0.7 kHz for the second bat.

Sounds of other specimens of *P. pygmaeus* with typical feeding buzz were also recorded, showing foraging activity in this locality (Fig. 3).

DISCUSSION AND CONCLUSIONS

In Sicily, Agnelli et al. (2008) report a list of 20 species of bats, some of which still have to be

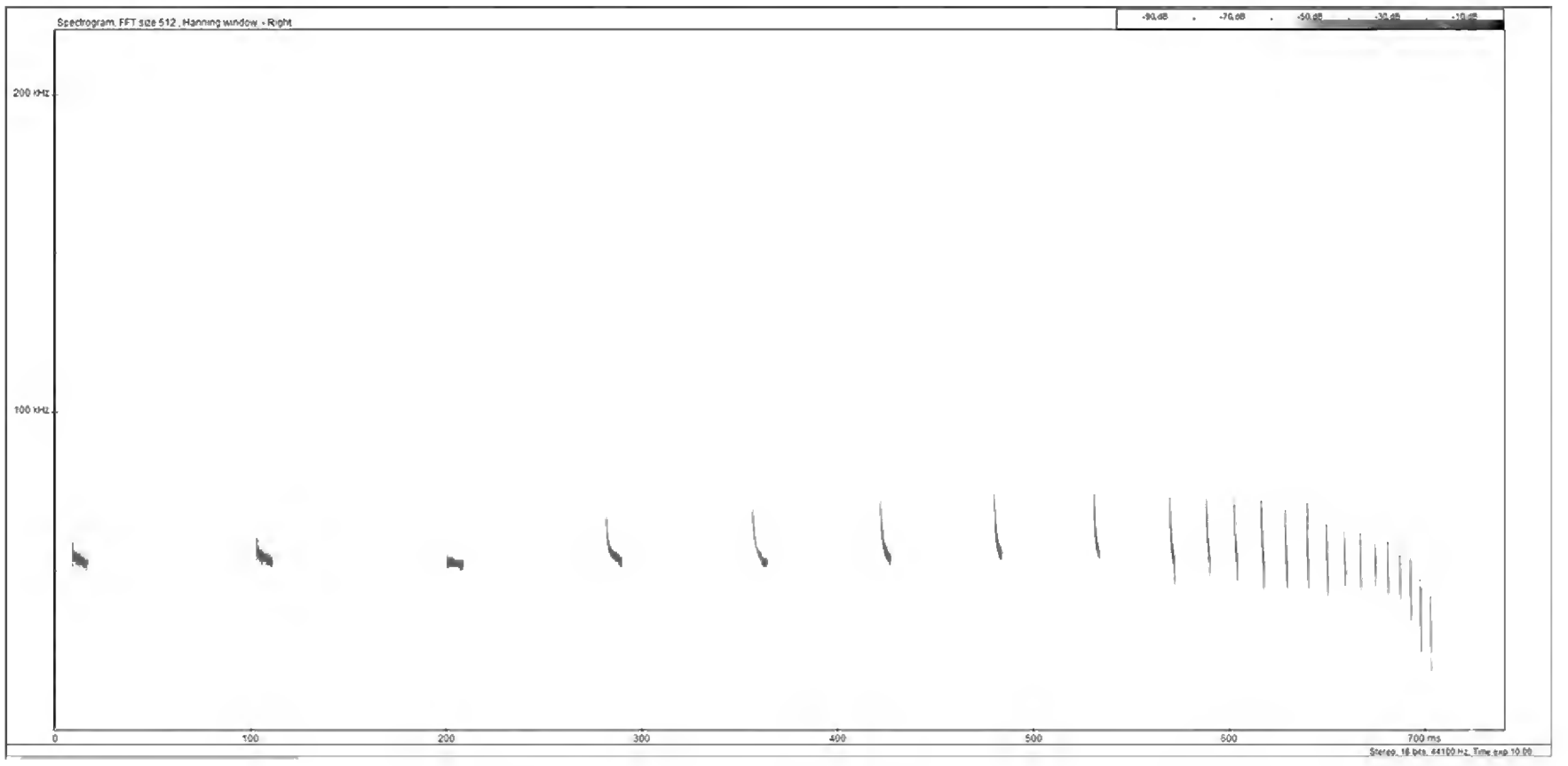

Figure 3. Spectrogram of a capture sequence of a *Pipistrellus pygmaeus* with final feeding buzz.

confirmed. More recently *Hypsugo* cfr. *darwinii* (Tomes, 1859) (Veith et al., 2011) and *Myotis bechsteinii* (Kuhl, 1817) (Di Salvo et al., 2012) were added and the presence of *Barbastella barbastellus* (Schreber, 1774) was also confirmed (Mucedda et al., 2012).

Di Salvo et al. (2009) only hypothesized the presence of *P. pygmaeus* in Sicily, by bioacoustic recordings that didn't allow to distinguish the species from *Miniopterus schreibersii* with certainty.

The capture of *P. pygmaeus* allows us to add a new species to the bat fauna of Sicily and brings the number of confirmed species of bats living in the island to 23: *Rhinolophus ferrumequinum* (Schreber, 1774), *R. hipposideros* (Bechstein, 1800), *R. mehelyi* Matschie, 1901, *R. euryale* Blasius, 1853, *Myotis bechsteinii* (Kuhl, 1817), *M. blythii* (Tomes, 1857), *M. capaccinii* (Bonaparte, 1837), *M. daubentonii* (Kuhl, 1817), *M. emarginatus* (Geoffroy, 1806), *M. myotis* (Borkhausen, 1797), *M. mystacinus* (Kuhl, 1817), *M. nattereri* (Kuhl, 1817), *Pipistrellus pipistrellus* (Schreber, 1774), *P. kuhlii* (Kuhl, 1817), *P. pygmaeus* (Leach, 1825), *Hypsugo savii* (Bonaparte, 1837), *H.* cfr. *darwinii* (Tomes, 1859), *Eptesicus serotinus* (Schreber, 1774), *Barbastella barbastellus* (Schreber, 1774), *Nyctalus lasiopterus* (Kuhl, 1817), *Plecotus austriacus* (Fischer, 1829), *Miniopterus schreibersii* (Kuhl, 1817), *Tadarida teniotis* (Rafinesque, 1814).

The finding also allows us to ensure its reproduction on the island and to expand the range of the species in Italy, of which it is the southern limit. Future research should aim at identifying roosts, to define the distribution of *P. pygmaeus* in Sicily and establish the conservation measures that have to be taken.

ACKNOWLEDGEMENTS

We thank Mariacristina Borrello for the help during the field work, Marianna Catalano and Emily Halliday for the translation.

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Biodiversity Journal, 2013, 4 (4): 471-482

A review of the impacts of invasive aquatic weeds on the biodiversity of some tropical water bodies with special reference to Lake Victoria (Kenya)

Peninah Aloo[1*], William Ojwang[2], Reuben Omondi[2], James Murithi Njiru[3] & Dalmas Oyugi[4]

[1]Department of Aquaculture and Fisheries Management, School of Natural Resources and Environmental Studies, Karatina University, P.O. Box 1957, Karatina, Kenya
[2]Kenya Marine and Fisheries Research Institute, P.O Box 1881, Kisumu, Kenya
[3]Department of Fisheries and Aquatic Sciences, Moi University, P.O Box 3900, Eldoret, Kenya
[4]Kenya Wildlife Service Training Institute, Kenyatta Avenue, P.O. Box 842, Naivasha, Kenia
[*]Corresponding author: e-mail: aloopenina@yahoo.com

ABSTRACT

Aquatic weeds may be defined as troublesome or unsightly plants growing in abundance in aquatic situations where they are not wanted. These plants are either adapted to continuous supplies of water or are at least tolerant to waterlogged soil conditions for substantial periods of time. The wide range of adaptation to varying amounts of water, and the impossibility of sharply distinguishing between aquatic and terrestrial environments, makes it difficult to precisely define an aquatic plant. The menace of water weeds is reaching alarming proportions in many parts of the world, especially in tropical water bodies where they have led to serious ecological and economic losses. Lake Victoria, Kenya, which is the largest freshwater body in the tropics, has undergone serious ecological changes including over-exploitation of its fishery resources, degradation of the catchment area, introduction of exotic fish species and invasion by the water hyacinth, *Eichhornia crassipes* (Mart.) Solms (Pontederiaceae), among others. The presence of the weed in the lake has led to many problems including blockage of water pumps, reduced fishing activities and increase in water borne diseases such as schistosomiasis. Positively, aquatic weeds constitute a free crop of great potential value; they are a highly productive crop that requires no tillage, fertilizer, seed, or cultivation. Moreover, these plants have the potential for exploitation as animal feed, human food, source of food to some aquatic organisms, soil additives, fuel production, wastewater treatment, source of raw materials and habitat to many organisms. This paper reviews the effects of aquatic weeds in aquatic systems with examples from some selected waterbodies and special reference to Lake Victoria.

KEY WORDS Invasive; Lake Victoria; weeds; tropical; waterbodies.

Received 14.10.2013; accepted 22.11.2013; printed 30.12.2013

INTRODUCTION

Aquatic weeds are higher plants that grow in water or in wet soils but some weeds may endure periods of desiccation. They usually occur along the shores of water bodies like dams, lakes and along rivers and river mouths. The distribution, permanency and quality of water available for their occupation govern their distribution and ecology. The most variable environmental factors of basic ecological importance for aquatic plants are the length of the period during which water is present; whether

the water is still or moving; the availability of plant nutrients; and the quality and quantity of light penetration into the water. Factors that influence the establishment and distribution of aquatic plants include: depth, topography, types of substrate, exposure to currents and/or wind and water turbidity. The distribution of macrophytes is often related to their method of attachment (Sculthorpe, 1976).

Aquatic plants, like most water organisms, are more widely distributed throughout the world than terrestrial plants. This is because factors or conditions required by aquatic plants are uniform in general than those to which land plants must adapt to. The aesthetically pleasing appearance and unique growth form of floating aquatic weeds have been responsible for their spread to various tropical and sub-tropical countries by humans during the 1800s and 1900s. In Kenya, aquatic weeds were used to grace aquaria and ornamental ponds from where they escaped into natural or artificial water bodies causing serious problems (Njuguna, 1992).

Macrophytes are among the most productive plant communities in the world (Sculthorpe, 1976) and are known to provide nutrition for humans and herbivorous animals. In general, water plants have both positive and negative importance to man, either directly or indirectly (Mitchell, 1974).

Study area

Lake Victoria (Fig. 1) is the largest tropical lake in the world. The lake is shared by Kenya (6% by area), Uganda (43%) and Tanzania (51%). It has a mean depth of 40 m, maximum depth of 84 m, shoreline of 3450 km, a water retention time of 140 years and a catchment area of 193 000 km^2, which extends into Rwanda and Burundi. It is situated 1134 m above sea level and has a surface area of 68,800 squared kilometers. The lake is roughly in square shape; its greatest length and width being about 400 and 320 km, respectively. Much of the lake is less than 40 m deep and the deepest part, 60-90 m, is in the northeast. The bottom is mainly covered by a thick layer of organic mud, but with patches of hard substrate, sand, shingle or rock (Scholtz et al., 1990). The coastline is intended with bays and gulfs. The Kagera and Nzoia rivers are the principal influents while the only outflow occurs to the River Nile via Lake Kyoga.

The lake receives nearly 80% of its water inputs from rainfall and a similar amount is lost via evaporation (Bootsma & Hecky, 1993) (Table 1).

Parameter	Characteristic
Lake area (km^2)	68,800
Maximum Depth (m)	(92)
Mean Depth (m)	40
Volume (km^3)	2,760
Catchment (km^2)	194,000
Outflow (O)(km^3/y)	20
Inflow (I)(km^3/y)	20
Precipitation (P)(km^3/y)	100
Evaporation (km^3/y)	100
Flushing Time (V/O)(years)	140
Residence time (V/(P+I)(years)	23

Table 1: Catchment and basin parameters of Lake Victoria. Source: Bootsma & Hecky, 1993; IDEAL 1990; Welcomme, 1972; Sigel & Coulter, 1996.

Lake Victoria is an important source of affordable protein food in the form of fish. It provides employment, income, and export earnings to the riparian communities. It is a source of water, mainly taken without treatment, and is also used for transport. As well as their food value, the fish species of the lake are of important evolutionary significance and have been extensively studied.

Lake Victoria Environmental Management Programme (LVEMP) (2001) reported that the quality of Lake Victoria waters has been deteriorating over the last 30 years due to increased inflow of nutrients into the lake. Population increase within the catchment area also raises the need for more food hence, there is widespread use of fertilizers to boost food production, adding to the agricultural load in the lake. Concentrations of phosphorus have increased substantially within deep waters while nitrogen levels have increased closer to the shores.

Figure 1. Map of Lake Victoria.

As a consequence of the increase in nutrients levels, vast algal blooms have become a common feature of Lake Victoria, with blue green algae dominating, causing de-oxygenation of the water, increased sickness for populations using the lake water and high water treatment costs together with loss of deep water fish species. Fish inhabiting shallow waters are also at risk from periodic upwelling of hypoxic waters. In addition, reports also indicate increased invasion of the lake by aquatic weeds including the abnoxious water weed, *Eichhornia crassipes* (Mart.) Solms (Pontederiaceae).

Types and characteristics of aquatic weeds

Aquatic macrophytes can be sub-divided into four groups on the basis of their water requirements, life forms and habitats. The categories include: submerged, emergent, floating leafed and free-floating macrophytes.

Submerged macrophytes are plants that are usually rooted in the substrate but are completely under the water surface. These plants cannot be established at a depth more than 10 m and are adversely affected by large fluctuation in the water level. Submerged plants have thin finely dissected leaves adapted for rapid exchange of nutrients with water. Examples include *Potamogeton pectinatus* L. (Potamogetonaceae), *Najas horrid* A. Braun ex Magnus (Hydrocharitaceae) and *Vallisneria spiralis* L. (Alismataceae). The growth rate of submerged plants has been recorded to range from 10 mg dry matter per day for *Ceratophylum demersum* L. (Ceratophyllaceae) to over 80 mg in *Hydrilla verticillata* (L.f. Royle) (Hydrocharitaceae) (Denny, 1972).

Emergent macrophytes include plants which are rooted with their principal photosynthetic surfaces above the water. They are markedly exclusive since they always occur in dense monospecific stands reminiscent of monocultures. Boyd (1969) suggested that this comes about because of their success in taking up and storing nutrients, which are later made available to young growing organs by translocation. Emergent plants such as *Typha* sp. (Typhaceae) and *Cyperus papyrus* L. (Cyperaceae) are generally rigid and are not dependant on water for support. They have both high growth rate and high biomass (Symoens et al., 1981). The emmergents such as *Typha* can only occur in shallow water or damp soils along the shoreline and are unlikely to survive large changes in lake level (Mitchell, 1974).

Floating leafed macrophytes are plants that are rooted but have floating leaves. Examples of such macrophytes are *Nymphaea lotus* L. (Nymphaeaceae) and *Trapanatans* L. (Trapaceae). These are usually restricted in the shallower areas of water bodies.

Free-floating macrophytes are aquatic plants that float on the water surface.Typical examples of free floating macrophytes include *Salvinia molesta* D. Mitch. (Salviniaceae) and *E. crassipes*. These plants are independent of depth and substratum requirements as well as largely unaffected by changes in lake levels; hence they are the greatest threat to any water body (Adeniji, 1979). A review of literature makes it clear that in the tropics, the greatest threat is posed by this group of macrophytes.

DISCUSSION

Problems of aquatic weeds

Aquatic plants are considered nuisance when excessive growth interferes with desired water uses

in a number of ways (Adeniji, 1979). In line with increased industrialisation, travel and communication, agricultural productivity, increased human population and changes in consumption, problems associated with aquatic weeds have increased in the last century (Davis & Hirji, 2003).

The menace of some aquatic plants may reach alarming rates especially in the tropical regions where warm water fosters plant growth. The problem is aggravated by the increasing enrichment of water bodies by poor land use practices and other effluents from the human and industrial wastes. Less than 20 of the 700 species of macrophytes are considered weeds (Triest, 1993). Although originally perceived as a practical problem for fishing and navigation, recent research indicates that aquatic weeds are now also considered a threat to biological diversity affecting fish fauna, plant diversity and other freshwater life and food chains (Garry et al., 1997). Excessive population of macrophytes, especially floating and emergent weeds, results in exclusion of light from the lower layers of water. This can cause reduction of primary production and may also affect the various physical and chemical characteristics of water.

They can also lead to blockage of hydroelectric installations and water intakes and irrigation outlets. Submerged and free floating plants have also been reported to interfere with fishing and navigation activities. The invasion by aquatic weeds of any environment has always led to increase in diseases such as malaria and bilharzia, whose vectors use the weeds as breeding grounds as in Lake Victoria (Johnson et al., 1990; Twongo, 1996). The weeds also provide hiding grounds for dangerous organ-isms such as snakes.

It is evident that aquatic weeds are a total nuisance from the point of view of the human use of the water where they occur. It is important to evaluate the effects of the weeds on the entire ecosystem for example, on the invertebrates, benthic fauna, fish and large animals.

Effects of aquatic weeds on aquatic organisms

Mitchell (1974) stated that the appearance of macrophytes in any aquatic ecosystem leads to an increase in the density of other plants and animal species. Therefore, two major effects of these weeds on the ecosystem are habitat diversification and food source for the organisms.

a) Habitat diversification

Macrophytes physically change aquatic ecosystems in several ways which are important in habitat diversification. They slow down the movement of sediments in fast stretches of rivers (Butcher, 1933); consequently, the number of species increases in previously unproductive regions. The mesh formed by finely divided leaves of some submerged species (*Potamogeton* sp.), and the networks of filaments formed by some algae provide excellent refuge for juvenile fish (Mitchell, 1974). The structurally complex habitats formed by macrophytes coupled with periodic low oxygen levels is also known to protect several fish species from both excessive human exploitation and predation (Chapman et al., 1996; 2002). Several insect larvae and fish species such as the tilapiines use submerged macrophytes materials in the construction of nests. The older rhizomes of reed swamp emergents such as papyrus or any soft plant material present in shallow water provide a burrowing substrate for insects such as mayflies. These invertebrate fauna form a crucial link in the foodweb of natural and man-made tropical lakes (Petr, 1970).

Investigations by Bowmaker (1968, 1973) and Mitchell (1976) in Lake Kariba demonstrated that *Salvinia* mats play an important role as a habitat for young fish and their prey and, that mobile mats swept over the lake by wind assist in the distribution of fish fry. Reports from Lake Naivasha in Kenya indicated that the abundance of some invertebrates such as the water boatman *Micronecta scutellaris* (Stål, 1858), Hemiptera Corixidae, was closely related to *S. molesta* mats (Aloo, 1988). Perhaps the most important contribution of macrophytes to the ecology of Nyumbaya Mungu reservoir in Tanzania was their close association with the fish and the aufwuchs communities. In this reservoir, the major shoals of commercial tilapiine cichlids fishes such as *Sarotherodon pangani* (Lowe, 1955) and *S. jipe* (Lowe, 1955) (= genus *Oreochromis*) were reported to be closely associated with aquatic plants such as the *Cyperus articulates* L. (Mitchell,1974).

Emergent plants such as *C. papyrus* also provide special conditions needed by swamp inhabitants including the swamp worm Almaemini (Clark et al., 1987). This worm is adapted to life under anaerobic conditions and can even live for several days without oxygen. In Lake Volta, Petr (1968) demonstrated the importance of the invertebrates associated with weed beds and submerged plant surfaces while in Lake Kariba, Bowmaker (1968) noted their abundance among the floating mats of *Salvinia*. McLachan (1969) reported that the appearance of submerged macrophytes such as *Potamogeton* and emergents such as *Ludwigia* (Onagraceae) in Lake Kariba resulted in marked changes in the benthic fauna. Total mud species numbers increased from 28 to 46 in the bottom close to the base of these plants. In Lake Victoria, the introduction of *E. crassipes* led to an increase in the population of leeches, dragon fly nymphs and several mollusc species which were reported to occur under hyacinth mats (Twongo, 1996).

Furthermore, the macrophytes coverage, particularly the swampy areas are known to subject fish populations in particular to extreme physicochemical regimes that in the long-term acts as natural selection forces responsible for speciation. The fish assemblage in Lake Victoria which was previously composed of the haplochromine cichlids was thought to have evolved through this speciation mechanism. According to postulation by Greenwood (1974) and Kaufman (1992), these unique habitats together with small water bodies around Lake Victoria acted literally as boiler plates for speciation and the multiplication of cichlids.

b) Food source

Several studies using stable isotopes have reaffirmed plants, particularly aquatic plants (both C3 and C4 plants) as the main source of energy in most water bodies (Ojwang et al., 2004; 2007). Other studies using traditional gut contents analysis have shown that herbivorous tilapiine cichlids fishes such as *Tilapia rendalli* (Boulenger, 1897) and *T. zillii* (Gervais, 1948) feed on aquatic plants as their main diet. Though there are some indications of preference for submerged plants (*Elodea*, *Ceratophyllum* and *Najas*), floating plants (duckweeds, *Wolffia* spp., Araceae) and emergent plants (*Typha*) are also eaten (Sculthorpe, 1976; Blackburn et al., 1971).The development of submerged vegetation in the lower Volta was reported to have profound effects on the whole ecosystem. Fish found food and shelter in the beds of hydrophytes. Populations of *Tilapia* spp. and *Neritina* sp. (Gastropoda Neritidae), a gastropod which feeds on *Vallisneria* (Hydrocharitaceae) increased remarkably, a phenomenon which was attributed to increase in productivity in the ecosystem by both *Potamogeton* and *Vallisneria* plant species (Hall & Pople, 1968).

Other fish species such as *Disticho dusschenga* Peters, 1852, *D. mossambicus* Peters, 1852 (Distichodontidae) and *T. rendalli* also fed on *Potamogeton* and *Vallisneria*. *T. rendalli* was reported to be the only fish specialized in grazing on macrophytic plants in Nyumbaya Mungu, although the scavengers such as *Clarias mossambicus* (Peters, 1852) (Clariidae) and *Synodontis punctulata* (Günther, 1889) (Mochokidae) occasionally ingested plant fragments (Bailey et al., 1978). In the Kenyan Lake Naivasha, Oluoch (1983) reported an abundance of macrophytes in the stomach of the crayfish *Procambarus clarkii* Girard, 1852 (Crustacea Cambaridae).

It is not only fish species that depend on macrophytes as source of energy. In Lake Cabora Bassa, Bond & Roberts (1978) observed hippos, baboons, monkeys, warthog and kudus feeding on *E. crassipes* particularly during the dry season. Waterfowls such as the Egyptian geese fed to a limited extent on stranded plants (Davies et al., 1975). Lake Naivasha supports 31,000 ducks which forage on a wide range of aquatic plants (6 spp.) and 43,000 coots *Fulica cristata* Gmelin, 1789 (Aves Rallidae) that depend largely on the submerged plant *Naja spectinata* (Parl.) Magn., Bivalvia Najadaceae (Watson & Parker, 1970; Clark et al., 1987).

The lake also supports a large population of *Myocaster coypus* (Molina, 1782), Rodentia Myocastoridae, which is reported to enjoy the emergent vegetation around the lake shore. Recent studies indicate that the decline in aquatic macrophytes in Lake Naivasha has led to the low numbers of the crayfish, *P. clarkii* (Harper, 2010).

c) Other benefits of aquatic plants

A few species of aquatic plants are directly important to man for food and for materials used in building/constructions. The Indian rice, water chestnut and delta potatoes are sources of food. Some weeds (Nile cabbage, water spinach) are used as vegetable among many African communities. In some parts of the world, the bulrush is used for building boats, floor mats and wall partitions. The papyrus, *C. papyrus*, has been utilized for weaving baskets, making mats and thatching huts especially in rural communities (Prescott, 1969).

Limnologically, aquatic plants and shoreline vegetation play important roles including beach building, the filling in of lake margins with the accompanying aging and eutrophication and prevention of shore erosion. A few aquatic plants bring about the deposition of lime, thus, after a long period of time, produce useful marl deposits. Besides these, there are many interactions between aquatic plants, water chemistry and the nature of bottom deposits (Prescott, 1969).

Macrophytes strands can act as a filter for excessive nutrients, which would otherwise lead to eutrophication of adjacent water bodies. Although the absorption may not in itself ensure the removal as the plants might re-release them on decomposition, the wet low oxygen soils favour denitrification by bacteria leading to loss of nutrients. The plants also remove heavy metals, biocides and other toxins from the water temporarily into their tissues. In theory, this could harm organisms higher up the food chain, however, the plants have various biological, chemical, biochemical and physical processes which immobilize, transform and fix the contaminants (Malthy, 1986).

Recent changes in the distribution and diversity of macrophytes in Lake Victoria

Lake Victoria has undergone drastic ecological changes since the introduction of alien fish species in the 50s and 60s. Prior to these introductions, the lake's fisheries were dominated by haplochromines which were alleged to have hindered the establishment of macrophytes in the inshore areas by constantly disturbing the substrate (Witte et al., 1992). The large populations of haplochromines were later decimated by the piscivorous Nile perch, *Lates niloticus* Linnaeus, 1758 (Latidae).

Aquatic plants along the lake's shoreline were dominated by papyrus, *C. papyrus*. Floating islands which were common during the rainy seasons consisted of populations of the emergent macrophytes which were sloughed by currents and winds. The other plants on floating islands were few mainly comprising climbers such as *Ipomoea aquatic* Forssk., Convolvulaceae. Before the invasion of the lake by water hyacinth, succession of aquatic plants were not as drastic, a phenomenon earlier reported by Russell (1942) and Penfound & Earle (1948).

Macrophytes in Lake Victoria mostly occur in the vicinity of river mouths and sheltered bays. River mouths favour the establishment of macrophytes because of sedimentation from rivers while the incoming nutrients stimulate the growth of various plant species. More than 30 families and 60 species of macrophytes have been recorded from Lake Victoria. These are dominated by Cyperaceae, of which many species have not been identified.

E. crassipes (Fig. 2) was first recorded on the Ugandan side of Lake Victoria in 1988 (Twongo, 1991). The weed reached Lake Victoria from River Kagera which originates in Burundi through Rwanda and Tanzania and enters the lake in Uganda. While the introduction of *E. crassipes* may have been accidental, the weed was originally transported from its native home in South America to be used as an-ornamental plant. By 1992 the weed was firmly established in most suitable littoral environments along the entire shoreline of Uganda (Twongo, 1996). Water hyacinth had already been reported in Tanzania (AAPS, 1990) as well as in the sheltered bays in Kenya.

The weed was confirmed to be present on the Kenyan side of Lake Victoria in 1991, although unconfirmed reports of its presence at the River Yala swamp had been received as early as 1990 (Mailu, 1999). The spread of the weed across Lake Victoria was greatly aided by strong winds which swept large masses of the weed from the bays along the north-western shores across the lake, to the northern and possibly north-eastern shores.

Currently, *E. crassipes* is widespread on the Kenyan waters of Lake Victoria occurring abundantly in Winam Gulf, Karungu Bay, Muhuru

Bay, Luanda, Usenge, Asembo Bay, Osieko Beach and along Yala Swamp. Small mats of the weed were reported to occur at Sio Port, Mbita Point and Nzoia River (Aloo, 2003). The weed is estimated to occupy a total of 5,000 hectares on the Kenyan side of Lake Victoria. The geo-climatic requirements of water hyacinth favour its growth and reproduction in the lake. Factors that lead to its increased growth and production include nutrients especially nitrogen and phosphorus. Lake Victoria is nutritionally enriched by drainage from agricultural, discharge from factories, urban waste and inadequately treated sewage effluents. The population of water hyacinth has, therefore, spread rapidly under the nutritionally favourable conditions and ambient temperatures in Lake Victoria.

Figure 2. Water hyacinth, *Eichhornia crassipes*.

Macrophytes succession in Lake Victoria after water hyacinth invasion

On the establishment of water hyacinth in Lake Victoria, the floating mat provided substrate for the establishment of other plants including terrestrial plant species. Succession of the aquatic plants has also been accelerated due to the shading effect on other plants and increase of organic matter upon the death and eventual sinking of the plant biomass. *Pistia stratiotes* L. (Araceae), *Azolla pinnata* R. Br. and *A. nilotica* Decne. ex Mett. (Azollaceae) were the most common floating macrophytes in Lake Victoria before the invasion of water hyacinth. The grass, *Vossia cuspidata* (Roxb.) Griff. (Poaceae) formed a thin layer behind *P. stratiotes* followed by *C. papyrus*, *Aeschynomene elaphroxylon* Taub. (Fabaceae), *Phragmites australis* (Cav.) Trin. ex Steud. (Poaceae) and *Typha domingensis* Pers. (Typhaceae). On establishment in mid-1990s, the large populations of water hyacinth both smothered and pushed, landwards, *P. stratiotes* and *Azolla* spp. This compact mass, the resulting debris and proximity to land led to the increase of *V. cuspidata* and *Echinochloa pyramidalis* P. Beauv. (Poaceae) communities by acting as a substrate.

Other emergents which were reported to be closely associated with water hyacinth mats were *Hibiscus diversifolius* Jacq. (Malvaceae) and *T. domigensis*. These emergents in turn shaded and competed for nutrients resulting in the death of the latter. After the invasion of water hyacinth, floating islands consisted mainly of the hyacinth and *V. cuspidata*. Aquatic communities that were decimated by water hyacinth included the floating leafed *N. lotus* and *T. natans* and the submerged plants, *C. demersum* and *N. horrida*.

Effects of Water Hyacinth in Lake Victoria

The problems created and damage caused by *E. crassipes* are greater than those due to any other floating aquatic weed in Lake Victoria. It is no wonder that the weed has been described as truly the world's worst aquatic weed (Harley, 1990). The weed forms dense, impenetrable mats, which impede or prevent boat traffic in natural water courses, artificial or natural lakes, irrigation and flood mitigation canals. Detailed assessment of the impact of water hyacinth infestation on a given ecosystem and its resources might justify the huge economic tag that is required to control the vast expanses of the weed around the shores of Lake Victoria (Twongo, 1996). The rapid spread of *E. crassipes* in Lake Victoria led to serious economic, social, health and environmental impacts in the riparian states.

The weed has affected the fisheries, water supply and transport, environmental health and power generation, interfering with the lives of over 30 million people that depend on the lake (Aloo, 2003). Fish production in the lake has declined since the weed has blocked many fish landing beaches; it has infested sheltered bays

which are breeding grounds of fish while in open waters the mats of the weed has swept away and entangled fleets of nets. The mats also pose obstruction to fisheries exploitation which has led to higher operation costs hence increase in fish prices. Many landing beaches have been abandoned and income-generation from the sale of fish has been negatively affected.

Water hyacinth has caused clogging of water pipes, leading to frequent water shortages in lakeshore urban centres. The infestation has occasionally resulted in disruptions, delays and rising operation costs in the transport sector yet water transport is the cheapest means of transport for the lakeside communities. The weed has grossly interfered with cross border trade between the three East African states. Decomposition of the weed requires large amounts of oxygen which leads to a drop in levels of oxygen in areas infested by the weed, reducing survival of aquatic organisms especially fish. The decomposed material also leads to pollution of the water making it unfit for any use. The weed has also been reported to impact negatively on the health of lakeside communities, since it provides optimal habitat for mosquitoes and snails which are vectors for malaria and bilharzia respectively (Twongo, 1996).

While some studies have been carried out in Kenya to investigate the association of water hyacinth with various vector borne diseases, large number of snails are usually found among water hyacinth mats in Lake Victoria. Dazo et al. (1966) reported a positive association between bilharzia vectors *Bulinus truncatus* Audouin, 1837 (Gastropoda Planorbidae) and *Biomphalaria alexandrina* Ehrenberg, 1831 (Gastropoda Planorbidae) and various aquatic macrophytes including water hyacinth in Egypt. There is an urgent need to monitor the impact of water hyacinth infestation on incidence of water associated vector-borne diseases. The weed also provides a hiding place for dangerous organisms such as snakes. Water hyacinth is now a widespread weed occurring in dams, rivers and home aquaria all over Kenya. The weed has formed a green carpet on the Nairobi dam, situated in Motoine River Valley South of Kibera slums in Nairobi, covering the entire water surface. Today, the dam has completely dried out thus affecting the recreational activities that existed in the dam before invasion by water hyacinth (Aloo, pers. obs.). Currently, the weed has been reported to be a threat to the Athi River, which is Kenya's second largest river. In Masinga dam, a few patches of the weed have been observed floating on the water.

Positive attributes of water hyacinth in Lake Victoria

Aquatic weeds have some positive effects in the water bodies where they occur. In Lake Victoria, reports have indicated that there has been a resurgence of the endemic fish species especially some Cichlidae of the genus *Haplochromis*, *Clarias gariepinus* (Burchell, 1822) (Clariidae), *Protopterus aethiopicus* Heckel, 1851 (Protopteridae) and Elephant-snout fish *Mormyrus kannume* Forsskål, 1775 (Mormyridae) as a result of the invasion of the lake by the weed (Bugenyi & Van de Knaap, 1998; Njiru et al., 2000; Ogari, 2000).This is because mats of the weed provide hiding habitat for many fish species (Ogari, 2000). The swampy areas, particularly the remaining wetlands along the shores of Lake Victoria, are recognized as refugia to some of the native fish populations (Denny, 2000). Most of the fish species inhabiting the swampy areas are tolerant of extreme environmental conditions (Chapman et al., 2002). For example, *P. aethiopicus* and *C. gariepinus* are physiologically hardy and have structures that enable them access to free atmospheric oxygen.

The structural complexities of the swampy habitats coupled with periodic low oxygen levels protect a number of indigenous fish species from both excessive human exploitation and predation from Nile perch. Species richness has been observed to be specifically higher in the swampy areas along the shores of the lake than in the interior areas (Chapman et al., 1996; 2002; Balirwa et al., 2003). These are areas that physiologically limit the foraging abilities of Nile perch, which frequent waters of higher oxygen content. On the other hand, the unique ability of macrophytes to improve water clarity favours both mate recognition amongst the haplochromine cichlids and at the same time promoting the coexistence of the species with the Nile perch, since the predatory techniques of Nile perch are best suited to waters of intermediate turbidity.

E. crassipes has been inhabited by many aquatic insects which are an important diet to the juveniles of many fish species. In some parts of the lake, there has been increase in the abundance of aquatic birds which depend on water hyacinth as their food and resting stations in the course of their foraging activities. Water hyacinth has also been utilized for various purposes such as fodder, raw materials and for water purification purposes (Twongo, 1996). The weed's role as water purifier is of great importance in Lake Victoria where many lake side municipalities' wastewater treatment plants are presently broken or are ill maintained, thus the amount of raw sewage flowing directly into Lake Victoria is enormous. This enhances the proliferation of the water hyacinth and other aquatic weeds.

Re-appearance of water hyacinth in Lake Victoria

Currently, water hyacinth has abundantly reappeared in the lake (pers. obs.). Biological control method through the introduction of the natural enemies of the plant, *Neochetina eichhorniae* Warner, 1970 and *N. bruchi* Hustace, 1926 (Coleoptera Curculionidae) was widely used in the early years of invasion. This method was believed to have reduced the total area covered by hyacinth from 6000 ha in April 1998 to 400 ha in 2001 (Wawire & Ochiel, 2001).

Today, there have been serious resurgences of the weed especially around Homa Bay and Kisumu areas. Unpublished reports also indicate that there is an ecological association between water hyacinth and the hippo grass which is also found abundantly in the lake. Thus the case of succession of the weeds in Lake Victoria is a subject of interest to ecologists and require further studies.

CONCLUSIONS

The impacts of aquatic weeds are diverse and their significance in ecosystems, especially in large water bodies cannot be ignored. The weeds need to be managed prudently to allow sustainable exploitation and exploration of mitigation measures, to minimize potential negative impacts often associated with their massive proliferation. The spread of aquatic weeds in the tropics is a matter of great concern and concerted mitigation efforts are required to allow for continued use of enormous aquatic resource potentials in the tropics. This is critical as the majority of livelihoods in the tropics depend on the water bodies and their resources. In Lake Victoria, plants succession due to introduction of invasive species, *E. crassipes* has led to several ecological changes in the lake with far-reaching socio-economic consequences (Aloo, 2003).

Although aquatic weeds have caused serious problems in many waterbodies, their positive effects cannot be ignored especially on the biodiversity of such systems. The weeds not only provide shelter to many aquatic organisms but they are also a source of food to some fish species and other vertebrates and provide raw materials for use in several livelihood activities (Dean, 1969; Bond & Roberts, 1978; Mitchell, 1974; Oluoch, 1983). In Lake Victoria, for example, the appearance of *Eichhornia* has led to an increase in the catches of *C. gariepinus*, *Haplochromis* spp., *P. aethiopicus*, *M. kannume* and many haplochromine species (Njiru et al., 2000). Many of these fish species were a favourite dish to local communities in the pre-Nile perch Lake Victoria. Given the magnitude of aquatic weeds infestation in Lake Victoria, this paper recommends the following:

- a survey of the extent and nature of the aquatic weeds infestation should be undertaken to establish the magnitude of the problem in Kenya's aquatic systems including small water bodies;

- multidisciplinary research should be carried out on aquatic weeds to understand their effects on the aquatic systems and their potential benefits to both humans and other organisms;

- there is need to investigate the relationship between water hyacinth and the hippo grass in Lake Victoria;

- control strategies should take into account the potential effects of the method on the flora and fauna found in the water body.

ACKNOWLEDGEMENTS

The authors wish to acknowledge Karatina University, Kenya Marine and Fisheries Research In-

stitute, Moi University and Kenya Wildlife Service Training Institute.

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Biodiversity Journal, 2013, 4 (4): 483-500

New faunistic data on *Trochoidea* (*Trochoidea*) *caroni* (Deshayes, 1832) (Gastropoda Pulmonata Hygromiidae)

Nicola Maio[1*], Agnese Petraccioli[1], Paolo Crovato[2], Nabil Amor[3] & Gaetano Odierna[1]

[1]Dipartimento di Biologia, Complesso Universitario di Monte S. Angelo, Università degli Studi di Napoli Federico II, Edificio 7, Via Cinthia, 21 - 80126 Naples, Italy
[2]Via S. Liborio 1, - 80134 Naples, Italy
[3]Unité de Recherche: Génétique, Biodiversité et Valorisation des Bioressources, UR/09-30. Institut Supérieur de Biotechnologie de Monastir, Monastir 5000, Tunisie
[*]Corresponding author: nicomaio@unina.it

ABSTRACT

Trochoidea (*Trochoidea*) *caroni* (Deshayes, 1832), with *T.* (*T.*) *elegans* (Gmelin, 1791) and *T.* (*T.*) *trochlea* (Pfeiffer, 1846), belong to a group of species ("*elegans* group"), which, although considered valid by most authors, show a not completely defined systematic position. In this work, we report four new records (Terracina and Spigno Saturnia for Latium, Sorrento for Campania and Castagneto Carducci for Tuscany) and confirm two historical records (Ischia Island for Campania and Manfredonia for Apulia) of *T. caroni* from Italy, and all published and new faunistic data about the presence of this species in the Sicilian Islands, Capri Island and Maltese Islands. Moreover, we report some historical data from the Western Mediterranean Sea: two bibliographical records from the Balearic Islands, not verified, and three records from North Africa (Tunis in Tunisia, Annaba in Algeria and an unmarked locality in Morocco). We also report the up to now historical faunistic data of *T. trochlea*, a not well known species with an undefined status, and of some populations of *T. elegans* with raised whorl. It is not yet possible to draw a certain conclusion on the particular biogeography of these taxa, but the new data presented in this work, enhance the current knowledge on the distribution of *T. caroni* which would be larger than previously known.

KEY WORDS

Trochoidea; land gastropods; Italy; Mediterranean; faunistics.

Received 19.09.2013; accepted 13.11.2013; printed 30.12.2013

INTRODUCTION

Trochoidea (*Trochoidea*) *caroni* (Deshayes, 1832) (Gastropoda Pulmonata Hygromiidae) is morphologically characterised by a trochiform, pyramidal, dextrorse shell with 8–10 well raised whorls having a sharp marginal keel, finely ribbed external surface and small umbilicus. The height-to-diameter ratio (h/d) of the spire ranges from 1.00 to 1.30, in some cases as low as 0.88: see Sacchi's "*elata*" form (Sacchi, 1955a).

Anatomically, *T.* (*T.*) *caroni* is characterised (Giusti et al., 1995) by penial papilla elliptical or reniform in transverse section with long C-shaped groove on one side; four pleats defining two lozenges, each surrounding the opening of an appendicula into the vagina; atrial appendix containing crest-like structure; long penial flagellum. *T.* (*T.*) *caroni* lives in garigue and grassy meadow environments, under stones and detritus, sometimes also on calcareous rocks or at their base. It is currently reported in Italy as a living species in Central Western Sicily and on

Capri (Alzona, 1971; Cossignani & Cossignani, 1995; Manganelli et al., 1995). The aim of the present paper is to provide new data on the presence of *T. caroni* in certain regions of Italy and to collect all data in the literature and available from museum collections on its present and past distribution.

T. caroni has close anatomical affinity ("*elegans* group") with *T.* (*T.*) *elegans* (Gmelin, 1791), *T.* (*T.*) *spratti* (Pfeiffer, 1846), a species endemic to the island of Malta, and *T.* (*T.*) *cumiae* (Calcara, 1847), endemic to the island of Lampedusa (Giusti et al., 1995). In particular, the systematic and biogeographical positions of *T. caroni*, *T. elegans* and *T. trochlea* (Pfeiffer, 1846), the latter a little-known North-African species, are still unclear.

T. trochlea was described as a new species by Pfeiffer (1846) but the original types are not known. According to the original description (Pfeiffer, 1846), this species is morphologically characterised by a conical shell with eight keeled, crenulated whorls, having diameter about the same as height, or slightly greater (h/d = 1.04 in Pfeiffer (1846), 1.05 in Bourguignat (1864) with a variety B *minor* reaching 1.14). In the continuation of Rossmässler's "Iconographie", Kobelt (1877) also reports similar measurements for *Helix trochlea* Pfeiffer ["Diam. et alt. 7-8 Mm", h/d= 1.14]. Bourguignat (1864) adds other distinctive characters with respect to *T. elegans*, such as more accentuated striations, small umbilicus, crenulated keel and more imbricated whorls that overlap each other. Its distribution is thought to include Algeria and Northern Tunisia (Pfeiffer, 1853; Morelet, 1853; Bourguignat, 1864, 1868; Kobelt, 1877; De Saint-Simon, 1882; Letourneux & Bourguignat, 1887; Monterosato, 1893; Sacchi, 1955a).

Morphologically, *T. elegans* is characterised by a conical shell with 6-7 whorls of variable height and diameter greater than height. It is distinguished from *T. caroni* by a different height-to-diameter ratio (h/d) of the spire, in the range 0.82–0.62 (Sacchi, 1954) or less ("*scitula*" form); external surface with fine regular growth ridges; umbilicus small. Its distribution is European-Western Mediterranean (Southern France, Spain, Greece, Tunisia, Algeria and perhaps Morocco; (Pallary, 1904)) with isolated populations in Belgium, Northern France, Sardinia and Corsica; introduced into Great Britain from the early 1800s (Férussac, 1821), into South Carolina (USA) from before 1875 (Mazyck, 1876) and perhaps the Balearic Islands (Gargominy, 2011). In Italy it is present in Liguria, Tuscany, Umbria (Misuri, 1907), Latium and doubtful in Sicily. It is a xerophilous species with wide ecological valence colonising coastal, ruderal and cultivated calcareous environments. The biometric character hitherto used therefore does not discriminate the three species with absolute certainty and various anatomical similarities also exist. Since there are currently no other diagnostic criteria, it was decided to list the data available in the literature and from museum collections, exactly as reported by the original authors or collectors, also for *T. trochlea* and *T. elegans*.

MATERIALS AND METHODS

In order to obtain an exhaustive picture of the distribution of *T. caroni* in Italy, field surveys were conducted and their results were compared with historical data obtained from other sources. This research was carried out in addition to the data-gathering in the literature and by studying malacological collections in different Italian and foreign museums and private collections. The field studies were conducted between September 2002 and September 2006 on Capri and in Sicily and in the period 2006-2009 in Latium. The species identification was based on Giusti et al. (1995); the taxonomical and nomenclatural arrangement follows Manganelli et al. (1995) and Bank (2011).

RESULTS

Trochoidea* (*Trochoidea*) *caroni (Deshayes, 1832)

ORIGINAL DESCRIPTION. Deshayes, 1832, species n. 142, pag. 262, locus typicus "Sicile": "*Hélice de Caron. Helix Caroni. Nob. H. testa conica, elongato-pyramidata, trochiformi, longitudinaliter striata, striis confertis, sublamellosis; anfractibus numerosis, basi carinatis; carina squamosa; apertura depressa, quadrangulari, simplici; labro tenui. Diamètre de la base 9 millim., longueur 11 millim". [h/d = 1.22]*".

Férussac (1821) reports the species for the first time as: "*Helix elata* Faure Biguet [J. P. Faure-Biguet] espèce n. 304, p. 46, "Hab. L'île de Caprée", without

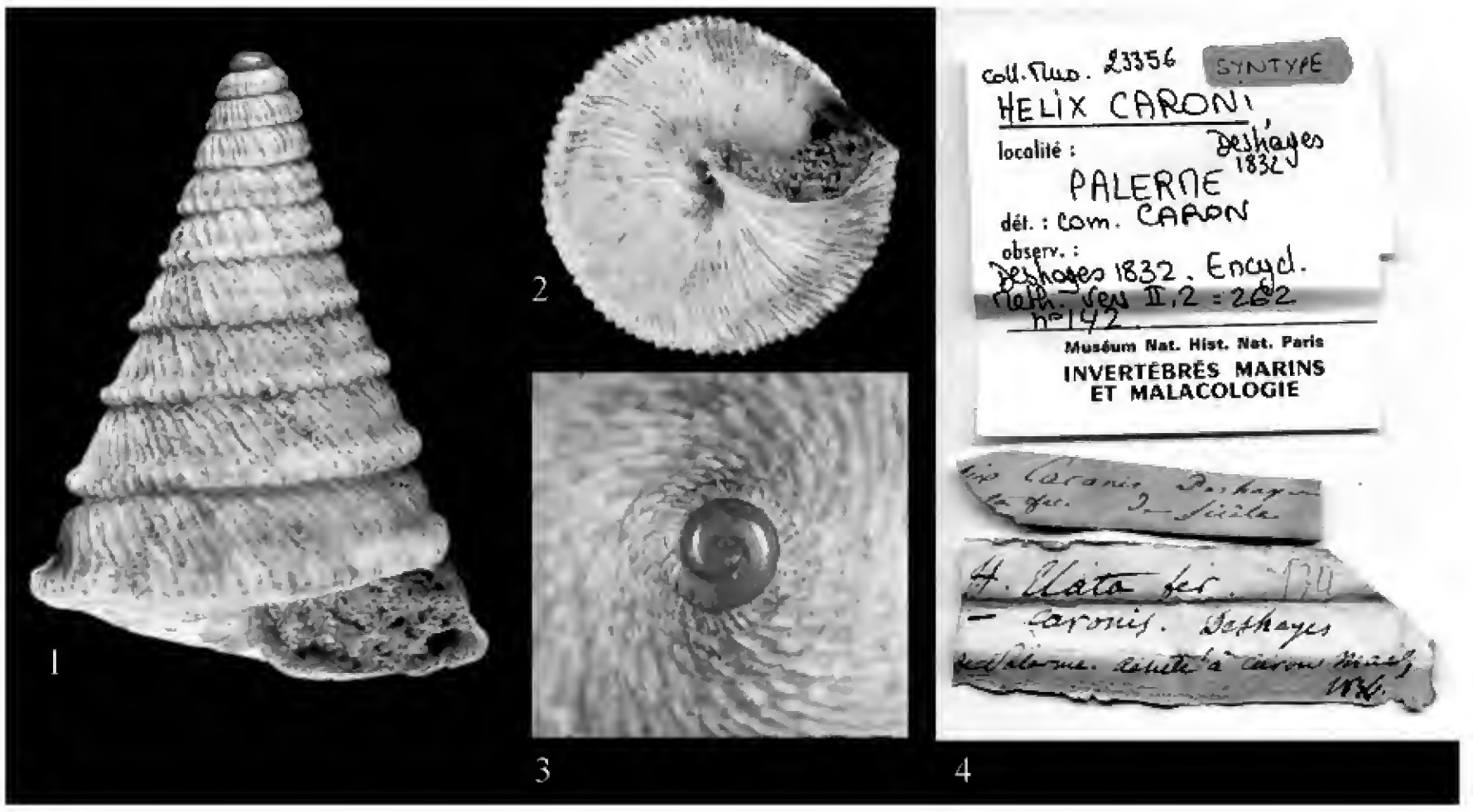


Figure 1. Syntype n° Moll 23356 from Palermo collected by "M. Caron" (collection Mollusques, Muséum National d'Histoire Naturelle, Paris), apertural view. Figure 2. Idem, umbilical view. Figure 3. Idem, apical view. Figure 4. Idem, original labels. Photos by P. Maestrati, Muséum National d'Histoire Naturelle, Paris.

any description. Thus the name is now considered a nomen nudum.

Deshayes (1832) [according to Sherborn (1924: p. 1110) the correct year of publication is 1832] published the first valid description of the species, assigning the name "*Helix Caroni*". The original type series is still kept in the National Museum of Natural History in Paris: a syntype from Palermo collected by "M. Caron", to whom the species is dedicated (syntype: "1 lot de 1 spécimen, Typothèque Leg. Caron, n° Moll 23356") and other 8 syntypes from "Sicilia" (syntypes: "1 lot de 8 spécimens, Typothèque, n° Moll 23357") (Maio, pers. obs.; Figs. 1–4).

Rossmässler (1837: pp. 23, 24, fig. 344), who gives Faure-Biguet's description of *Helix elata*, considers the species a synonym of *Helix caroni*.

EXAMINED MATERIAL. LATIUM. The first report of *T. caroni* in Latium is by Statuti (1882) who mentions finding a single shell on the beach between Porto di Badino and Torre Olevola, a few km from Terracina in Latina Province. The author sustains that the specimen reached the beach with flotsam from nearby rivers of the Pontine Plain. The studies conducted in this area produced 12 shells (three juveniles) from the Municipality of Spigno Saturnia (Latina) in spring and summer 2006 (Figs. 5–7). The specimens have an h/d ratio greater than 1.40. Their good state of conservation suggests that they come from a population still present in the area. However, this could not be confirmed as no live specimens were found (Petraccioli et al., 2011).

A live population of *T. caroni* was identified in 1986 (Hallgass, 2007; com. pers.; Figs. 8–10, 25) at San Silviano in the Ausoni Mountains, near Terracina (Latina), at an altitude of 200 m. Specimens have an h/d ratio between 1.10 and 1.30. The species is indicated generically in Latium by Welter-Schultes (2012).

CAMPANIA. The first historical report of *T. caroni* in Campania dates back to Férussac (1821) who reports data of Faure-Biguet for Capri. The species is referred to as "*Helix elata* Faure Biguet". Rossmässler (1837) also reports it from Capri as Faure-Biguet's *Helix elata*. Achille Costa (1840, sub *Corocolla* (sic!) *elata*) claims to have found it under stones on the road to S. Giacomo (Capri, Naples) and lists it among rare species. Philippi (1836, 1844, sub *Helix elata* Faure Biguet) confirms the presence of the species on Capri. Monterosato (1893) reports *Xerophila caroni* Desh. (=*turrita* Ph.) from "isola di Capri (Philippi)".

In his writings, Bellini (1899, 1900, 1901, 1910, 1915, 1920, 1922, 1924, 1926) reports it with various names: *Helix (Xerophila) turrita* Phil., *Helix (Tropidocochlis) turrita* Phil., *Tropidocochlis elatus* Faure Biguet, *Tropidocochlis turritus* Phil., *H.* (*Tropidocochlis*) *elata* Faure Biguet, *Tropidocochlis Caroni* Deshayes, *H.* (*Xerophila*) *elata* Fer. var. *caprensis* and claims it to be a rare species on Capri, though locally abundant in litter at Castiglione, Arco Naturale, Via Krupp and Pizzolungo. Bellini (1901) describes a hypsometric zone of Capri between Valletta (120 m) and Mt. S. Michele (245 m), which he calls "zona di *H. elata* e *H. surrentina*". He distinguishes an eastern subzone where *H. elata* predominates. Bellini (1899; 1900) also describes a variety *caprensis* (Bellini, 1899: pp. 4–5), "rara nella parte occidentale dell'isola, nelle zolle incolte al di sotto del Castello Barbarossa" [rare in the western part of the island, in uncultivated turf and below Castello Barbarossa]. Original specimens collected by Bellini are kept in the malacological collection of the Zoological Museum of Naples University Federico II and in the museum of the Centro Caprense "Ignazio Cerio" on Capri (Maio, pers. obs.). Sacchi (1953) reports its presence on Capri, on Mt. Tuoro and Mt. Solaro, in sparse garigues with rosemary, as: "endemita del gruppo *Helicella* (*Trochoidea*) *elegans* Gm., a spira elevata e a forma turricolata, che corrisponde alle forme descritte dal Bellini (1915) come *H. caroni* Desh. e *H. elata* Faure". Subsequently (Sacchi, 1955a, 1955b, 1956a), he states that "*Helicella* (*Trochoidea*) *caroni* Desh. and *H. elata* Faure" are indistinguishable on Capri.

Three specimens found in Via Tragara in August 1979 are kept in the S. Duraccio collection (ex coll. Pirozzi no. 69). During our study on Capri, we found *T. caroni* in 10 stations ranging in altitude from about 25 m to 200 m, but only in two of these stations did we find live specimens (Table 1, Figs. 11–13, 27). They were found at the base of the trunks or near superficial roots of mainly leguminous plants typical of Mediterranean maquis, growing on calcareous rock in the littoral zone (Petraccioli et al., 2005a, 2005b, 2006). The h/d ratio was about 1.05.

There is an interesting report of fossils of this species from Capri. Segre (1959) reports it as *Helix caronii* (sic!) Desh. (F. Settepassi det.) found in calcarenite of Villa Jovis (Monte di Lauro, Capri), a well-cemented, medium to coarse grained calcareous sandstone from the Lower Pleistocene (Barattolo et al., 1992; Petraccioli et al., 2007).

Sacchi (1953) states that it is possible to find "una piccola forma, (...) mostrante affinità con *Helicella elegans* e forme simili" at the base of coastal cliffs between Amalfi and Positano (Salerno).

Specimens	Sampling stations	Date	Habitats	Alt. m	UTM
Living	Trackfrom via Mesola to Fortino Mesola (Anacapri)	17.04.2004	Dry stone walls, mediterranean maquis	37-150	3289
Living	Fortino Mesola (Anacapri)	17.04.2004	Mediterranean maquis	37	3289
Shells	"Belvedere o Piazzetta delle Noci" (Capri)	15.04.2004	Pinewood, dry stone walls. In humus	194	3789
Shells	Scala Fenicia, quarto tratto, Capri	06.04.2003	On calcareous rock	67-100	3489
Shells	Via Krupp (Capri)	18.07.2003, 01.11.2003	On calcareous rock	25-125	3588
Shells	Via Arco Naturale (Capri)	18.07.2003	In litter	75	3788
Shells	Via Pizzolungo (Capri)	16.04.2004	In litter	50-100	3688
Shells	Via Cesina (Capri)	16.11.2003	Dry stone walls. In debris	150-200	3689
Shells	Giardini Augusto (Capri)	24.01.2004	Gardens. In debris	75-96	3688
Shells	Monte Tamborio (Capri)	07.11.2003	On calcareous rock. In debris	200	3689

Table 1. Faunistic data of *Trochoidea* (*Trochoidea*) *caroni* from Capri Island.

Finally, two shells of juvenile specimens of *T. caroni* were found in humus at Sorrento (Naples) (March 1984, G. Fasulo legit) (Figs. 14–16). The site unfortunately no longer exists, due to road-works that destroyed the original habitat. Their h/d ratio was about 0.95.

Delle Chiaje (1841) reports *Helix elegans* Drap. from Ischia Island. The plate was previously published by the author in the atlas "Memorie sulla Storia e Notomia degli Animali senza vertebre del Regno di Napoli" dating between 1822 and 1830 (Delle Chiaje, 1830) (Fig. 23). The figure clearly indicates that the species in question is actually *T. caroni*, which at the time had not yet been described. The synonymy is also confirmed by Benoit (1862, 1875) and Statuti (1882).

APULIA. A specimen of *T. caroni* found at Manfredonia (Foggia Province), collected by W. Kobelt in 1878, is kept in the L. Pfeiffer collection at the Senckenberg Forschungsinstitut und Naturmuseum in Frankfurt am Main, Germany (R. Janssen, pers. com.; see Table 3). Its h/d ratio is 7.0/6.6 = 1.06.

TUSCANY. A specimen found of *T. caroni* at Castagneto Carducci (Livorno Province) in 1983 is kept in the S. Duraccio collection (ex coll. Pirozzi no. 69F, G. D'Anna legit). Its h/d ratio is 8.5/7.0 = 1.21.

SICILY. The first historical report of *T. caroni* from Sicily dates back to Férussac (1821), who cites W.E. Leach's report of "*Helix elata* Faure Biguet". Subsequently, Deshayes (1832) described *Helix Caroni* on a specimen from Sicily (Figs. 1–4).

Philippi (1836: pp. 137–138, pl. 8, fig. 17) describes it in his first volume as a new species with the name of *Carocolla turrita* on specimens from Palermo (Fig. 24). He also reports *Carocolla elata* Faure-Biguet (pl. 8, fig. 16) from Palermo, Sciacca (Agrigento Province) and from Pachino (Siracusa Province). In his second volume (Philippi, 1844), he reports *Helix turrita* Ph. as a synonym of *H. caroni* Desh. from Palermo. Rossmässler (1837) also cites the same works.

Pirajno (1840, sub *Helix elata*), reports it "presso Scillato [Palermo] alla Portella di mare".

Describing the Trapani area, Power (1842, as *Caracolla elata*) reports *T. caroni* "sul monte S. Giuliano sotto erbe e pietre" and near the walls of the Castello di Erice (Sparacio, 2012). Aradas & Maggiore (1840) reported *T. caroni* as *H. elata* Fèr. (Elice alta) in their "Catalogo delle Conchiglie viventi e fossili", as being "frequente in Palermo e Sciacca, rarissima nei nostri dintorni. Trovasi pure alle Madonie presso Scillato alla portella di Mare", and as *H. turrita* Phil. (Elice torriciuolata) as being "comune in Palermo, e alle falde di Monte Pellegrino, abita in terreni aridi".

Calcara (1845) reported *T. caroni* sub *Helix elata* in the Palermo area, on the banks of the River Oreto and as *Helix caroni* from "Malaspina, alle Croci, falde di Monte Pellegrino, sponde dell'Oreto, a Sferracavallo e Carini".

Benoit (1862, p. 206, pl. 5, fig. 18) describes a local form of *Helix* cfr. *caroni* with a less accentuated conical form and rounded apex, as *Helix Sequentiana*. He found it in the Eastern Madonie Mountains and near Cefalù (Palermo). He also describes a variety *dilatata* of *H. elata* Faure-Biguet that he found near Palermo and on Mt. S. Giuliano (or Mt. Erice) near Trapani. He describes *H. caroni* Deshayes on Mt. Pellegrino, on the banks of the River Oreto, "alle Croci", at Carini, near Palermo, as well as at Calatafimi, near the Temple of Segesta, Trapani (Benoit, 1875, 1881). Some specimens of the Minà Palumbo collection bear Fiume Oreto and Palermo as collection sites (Liberto et al., 2010).

De Saint-Simon (1882) reports *Helix caroni* generically from Sicily. Westerlund (1889) reports it from Palermo as *Helix caroni*, from the Madonie Mountains as *Helix sequentiana*, and generically from Sicily as *Helix turrita*.

Monterosato (1893) reports *Xerophila caroni* Desh. (= *H. Caroni*, Ben. – Ill. Sist. 1857, t. V. f. 14) from Favignana and the Egadi islands (Benoit). He also states that the species of this group are: "a) *X. Caroni*, Desh. (=*turrita*, Ph.) - Prov. di Palermo, Nicosia, Siracusa; b) *H. exacta*, Monts. mss. =*H. Caroni*, Ben. - Ill. Sist. T. V, f. 15 (Calatafimi); c) *H. elata*, Faure-Biguet et var. *dilatata*, Ben. - Prov. di Trapani; d) =*H. Seguenziana*, Ben. *H. ?pyramis*, Ph. - Calatafimi, Sciacca ed altre località Siciliane". Monterosato (1894) later cites *H.* (*Xerocochlea*) *Caroni* Desh. "comune e caratteristica delle parti basse del Monte Pellegrino e dei suoi dintorni sino a S. Polo, in tutta la parte che lo circonda".

De Gregorio (1895, sub *Helix elata* Faure Biguet) reports *T. caroni* from "Fiume Anapo in Siracusa e (…) Carini"; in the same paper (1895, as *Helix elata* Var. *dilatata* Ben.) also from Monte San Giuliano.

Specimens	Localities (Municipality)	Province	Date	Collection	Collector
Shell	Monte Pellegrino	Palermo	1949	"V.Wiese" Haus der Natur, Cismar (Germany)	Brandt
17 es.	via Sampolo (Palermo)	Palermo	1910-60	"C. Alzona" MCSNM	Monterosato
3 es.	San Vito (Palermo)	Palermo	1910-60	"C. Alzona" MCSNM	Monterosato
4 es.	Monreale	Palermo	1910-60	"C. Alzona" MCSNM	Monterosato
6 es.	Salaparuta	Trapani	1910-60	"C. Alzona" MCSNM	
2 es.	Erice	Trapani	Ott. 1951	"C. Alzona" MCSNM	C. Sacchi
2 es.	Agrigento	Agrigento	1910-60	"C. Alzona" MCSNM	
11 es.	Porto Empedocle	Agrigento	Ott. 1951	"C. Alzona" MCSNM	C. Sacchi
5 es.	Siracusa	Siracusa	1910-60	"C. Alzona" MCSNM	
Shells	Sferracavallo (Palermo)	Palermo	15.09.1978	Coll. I. Sparacio	I. Sparacio
Living	Bosco della Ficuzza (Corleone) 600 m s.l.m.	Palermo	21.11.1979	Coll. I. Sparacio	I. Sparacio
Living	Capaci (Capaci)	Palermo	17.02.1980	Coll. I. Sparacio	I. Sparacio
Living	Foci Fiume Pollina (Pollina)	Palermo	24.05.1981	Coll. I. Sparacio	I. Sparacio
Living	Bolognetta	Palermo	19.06.1987	Coll. I. Sparacio	I. Sparacio
Living	Isola delle Femmine	Palermo	15.08.1990	Coll. I. Sparacio	I. Sparacio
Living	Golfo di Cofano, Castelluzzo (San Vito Lo Capo)	Trapani	14.10.1984	Coll. I. Sparacio	I. Sparacio
Living	Golfo di Cofano, fascia costiera (S. Vito Lo Capo)	Trapani	06.10.1987	Coll. M. Cuomo	M. Cuomo
Living	Monte Cofano, Castelluzzo (San Vito Lo Capo)	Trapani	04.1991	Coll. I. Sparacio	I. Sparacio
Living	Calatafimini (Calatafimi Segesta)	Trapani	05.12.1984	Coll. I. Sparacio	I. Sparacio
Shells	Favignana, Cala Rossa	Trapani	25.08.1990	Coll. I. Sparacio	I. Sparacio
Living	località Lido Cornino (Custonaci)	Trapani			Cossignani & Cossignani, 1995
Living	Monte Erice (Erice)	Trapani			Giusti et al., 1995
Living	Favignana (Is. Egadi)	Trapani		G. Manganelli	Giusti et al., 1995
Living	San Vito Lo Capo	Trapani	20.08.2006	Coll. I. Sparacio	I. Sparacio
Living	Favignana (Is. Egadi)	Trapani			Reitano, 2006b
Living	Zone aride costiere per Cala Rossa (Terrasini)	Palermo	2006		Reitano, 2006a
Living	Monti delle Madonie	Palermo	2006		Reitano, 2006b
Living	Dintorni di Grotta Conza, Sferracavallo	Palermo	2012		Reitano et al., 2012
Shells	North side of the city	Agrigento	10.09.2008	Coll. W. Renda	W. Renda
Living	Erice	Trapani	26.08.2008	Coll. W. Renda	W. Renda
Living	Isola delle Femmine	Palermo	16.10.2008	Coll. W. Renda	W. Renda
Living	Capaci		24.09.2010		I. Sparacio

Table 2. Faunistic data of *Trochoidea* (*Trochoidea*) *caroni* from Sicily.

Many specimens (more than 20) of *T. caroni* from Sicily are kept in the malacological collection of the Zoological Museum of Naples. These specimens, reported with various names such as: *Helix caroni*, *H.* (*Turricula*) *turrita*, *H.* (*T.*) *caroni*, *Helix* (*T.*) *exacta*, date to the second half of the nineteenth century and were acquired under the direction of Achille Costa; most come from localities in Palermo Province or from near the city (exact toponyms are not indicated); some were donated by the eminent Sicilian malacologist Tommaso De Maria Allery di Monterosato (Maio, pers. obs.).

Bellini (1915) reports the species as *Tropidocochlìs Caroni* Deshayes "nei dintorni di Palermo, Nicosia [Enna] e Siracusa".

In October 1953, Sacchi (1955b, 1956a, 1956b) reported it as *Helicella (Trochoidea) caroni-elata* from Sicily, island of Mozia (Isola dello Stagnone, Marsala, Trapani) and Capo Gallo (Palermo), and in November 1953 as *Helicella* (*Trochoidea*) *caroni* on silicicolous substrates at Mistretta (Messina Province) and on Isola delle Femmine (Palermo), stating that the latter form differed from the former "per la conchiglia molto alta e turricolata". Sacchi (1955b, 1956b) also reports finding fossil specimens of *H. elata* on Levanzo, Favignana and Marettimo (Egadi Islands, Trapani) in pink sandstone.

Some specimens from Porto Empedocle (Agrigento) are kept in the Löbbecke Museum in Düsseldorf (Maio, pers. obs.). They were collected by J. Boscheinen in 1974 and determined as *Trochoidea elata* (Férussac, 1819) by T. Meijer in 1975. Specimens of this species are reported from different sites in Trapani Province, Palermo and Agrigento between 1949 and 2010 (Tab. 2). Fiorentino et al. (2004) reports it from the Egadi Islands.

Finally, the present authors found various colonies of *T. caroni* at Cala Rossa (Terrasini, Palermo) (Figs. 17–19, 26, 28) in November 2004, at Giacalone (Palermo) in October 1995 and at S. Vito Lo Capo and Macari (Trapani Province) in June 2006. The h/d ratio ranged from 1.14 to more than 1.20.

MALTA. The species was first documented as a fossil from the Quaternary of Malta by Trechmann (1938, sub *Xeroclivia* sp.). Four specimens from Marfa Point in the North of the island, determined by Trechmann, are kept in the Department of Paleontology of the British Natural History Museum of London (Sacchi, 1955b). Giusti et al. (1995) found many juvenile fossil specimens and shell fragments similar to Sicilian populations of *T. caroni* in deposits at Cirkewwa dating to the Lower and Upper Quaternary (Hunt, 1997; Kolouch, 2003). Their h/d ratio ranged from 1.24 to more than 1.29 (Giusti et al., 1995).

Recent specimens of *T. caroni* were reported from the Maltese Islands in the nineteenth century: Gulia (1874) and Feilden (1879) reported specimens that Giusti et al. (1995) assume to have been stranded transported by the sea. A specimen from Malta, found in the first half of the nineteenth century, is kept in the Philipp P. Carpenter collection of the Field Museum of Natural History in Chicago (Maio, pers. obs.). Originally labelled *Iberus trochlea* Pfr., it was later determined by K. H. Beckmann as *T. caroni*. Four specimens (two recent without date and two Quaternary) from Malta, determined as *Trochoidea* cfr. *caroni*, are kept in the Paul Sammut collection in Rabat, donated to Heritage Malta, the cultural agency of the Government of Malta (Various authors, 2007).

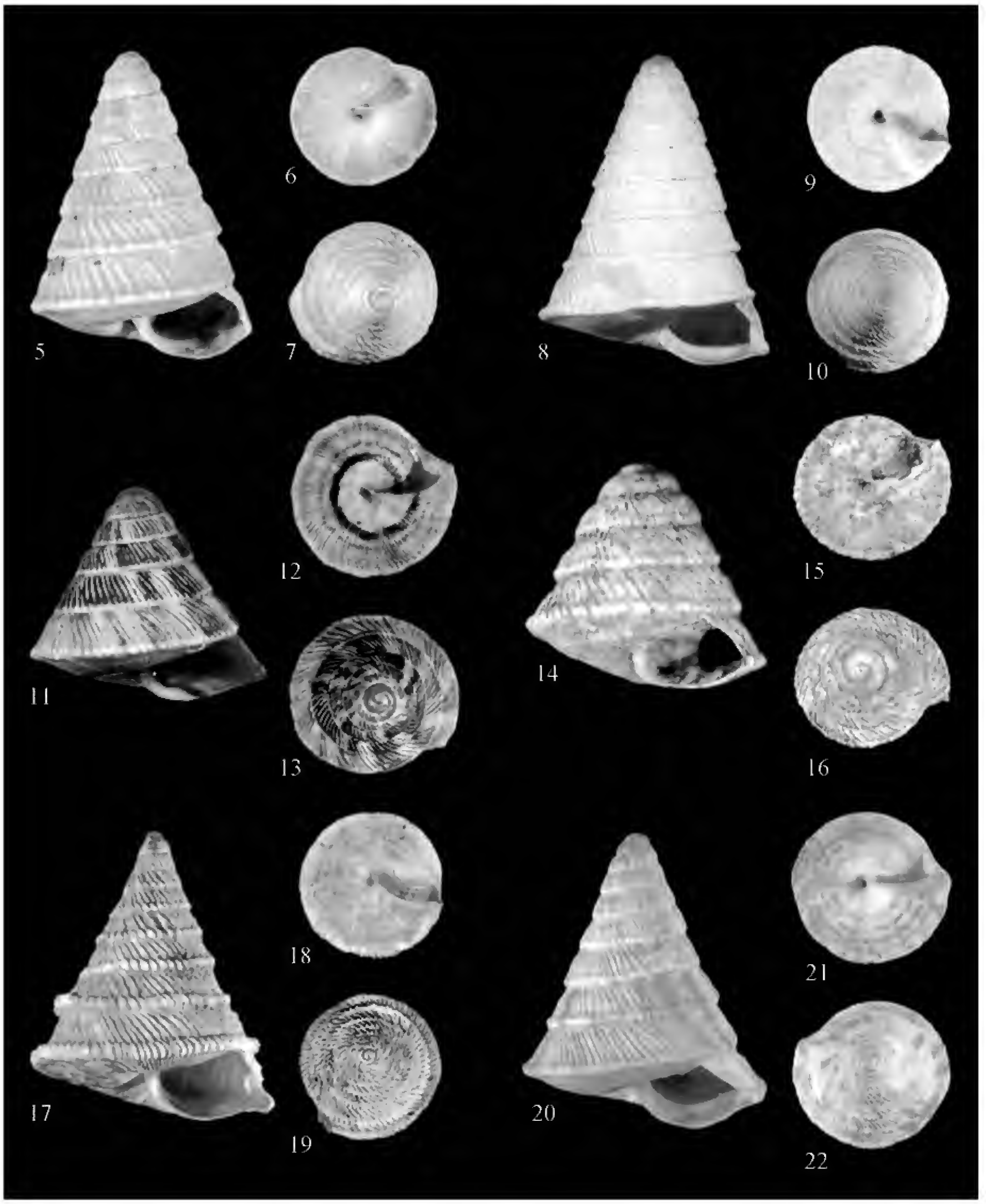
NORTH AFRICA. Monterosato (1893) reports *Xerophila caroni* Desh. (=*turrita* Ph.) from "Tunisi (auct. [Monterosato?])" and *H. elata*, Faure-Biguet et var. *dilatata*, Ben. from "Bona (Kob.)".

Bellini (1915) reports the species as *Tropidocochlìs Caroni* Deshayes from Tunis.

Four specimens from Annaba (= Bona, Algeria) attributed to *T. caroni* are kept in the Löbbecke Museum in Düsseldorf (Germany). They were collected by Carl Emil Lischke in 1868 and determined by him as *Trochoidea elata* (Férussac, 1819) (Figs. 20–22). Their h/d ratio ranges from 0.97 to 1.12. Two specimens of the species from Morocco, dating to the first half of the twentieth century, are kept in the Walter F. Webb collection of the Field Museum of Natural History in Chicago (USA). Originally labelled "*Helicella sequentiana* (Benoit)", they were determined as *T. caroni* by K. H. Beckmann.

All these specimens were examined directly by one of the authors (Maio, pers. obs.) and despite the shell variations also present in North African populations of this group (see Bourguignat, 1864: vol. 1, T. 32, f. 4-22), seem to belong to *T. caroni*.

BALEARIC ISLANDS (SPAIN). Bullen (1910) reports fossils of "*Trochula elata* (Faure-Biguet)" in two different Holocene deposits on the island of Majorca (Balearic Islands), namely at Porto Pi and Alcudia. Sacchi (1954, 1955a) mentions an old report of *Helicella* (*Trochoidea*) *elata* from Majorca, considered doubtful by Jaekel (1952).



Figs. 5–22. Shells of *T. caroni.* Figs. 5–7. Spigno Saturnia, height 8.8 mm, diameter 6.1 mm: apertural view (Fig. 5), umbilical view (Fig. 6), apical view (Fig. 7). Figs. 8–10. Terracina, height 9.6 mm, diameter 7.1 mm: apertural view (Fig. 8), umbilical view (Fig. 9), apical view (Fig. 10). Figs. 11–13. Capri, height 6.7 mm, diameter 6.6 mm: apertural view (Fig. 11), umbilical view (Fig. 12), apical view (Fig. 13). Figs. 14–16. Sorrento, juvenile shell, height 3.3 mm, diameter 3.5 mm: apertural view (Fig. 14), apical view (Fig. 15), umbilical view (Fig. 16). Figs. 17–19. Terrasini, height 11.1 mm, diameter 9.6 mm: apertural view (Fig. 17), umbilical view (Fig. 18), apical view (Fig. 19). Figs. 20–22. Annaba (Algeria) Löbbecke Museum, Düsseldorf, Germany, height 9.6 mm, diameter 8.6 mm: apertural view (Fig. 20), umbilical view (Fig. 21), apical view (Fig. 22). diameter 8.6 mm: apertural view (Fig. 20), umbilical view (Fig. 21), apical view (Fig. 22).

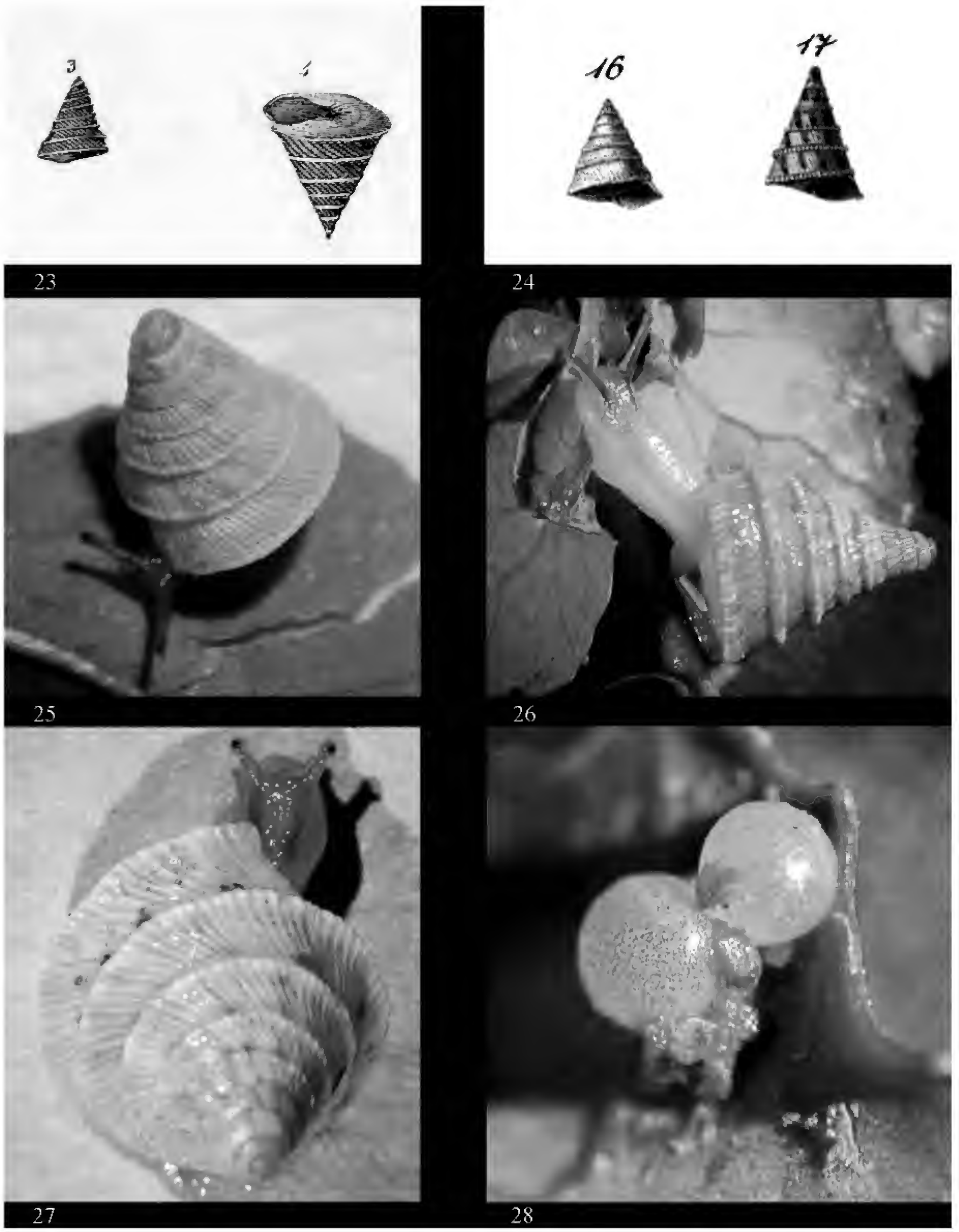


Fig. 23. *Carocolla elata* Faure-Biguet and *C. turrita* Philippi, 1836 illustrated in Philippi (1836), pl. 8, fig. 16 and 17, respectively. Fig. 24. *Helix elegans* from Ischia illustrated in Delle Chiaje (1841), pl. 72, figs. 3, 4. Fig. 25. Live specimen of T*rochoidea caroni* from Terracina, height 7.8 mm, diameter 7.0 mm. Fig. 26. Live specimen of *T. caroni* from Terrasini, height 12.5 mm, diameter 10.4 mm. Fig. 27. Live specimen of *T. caroni* from Capri, height 6.8 mm, diameter 6.6 mm. Fig. 28. *T. caroni* from Terrasini, detail of two eggs (diameter 1.5 e 1.7 mm).

Trochoidea* (*Trochoidea*) *trochlea (Pfeiffer, 1846)

Original description. Pfeiffer, 1846, species no. 302, p. 69, locus typicus: "Patria ?": "*Helix trochlea Pfr. - T. perforata, conico-turrita, trochlearis, costulato-striata, albida, interdum fusco-maculata vel basi fusco-fasciata; anfr. 8 acute crenulato-carinati, late exserti, utriuque planulati, ultimus basi subtilius et confertius striatus, convexiusculus, antice non descendens; apertura securiformis; perist. acutum, margine basali arcuato, intus leviter labiato, columellari subdilatato, ad perforationem subreflexo. Diam. 7 2/3, alt. 8 mm [h/d=1.04] - Patria? (Coll. Cuming.)*".

Examined material. The first faunistic reports of *T. trochlea* date back to Morelet (1853, sub *Helix trochlea* Pfr.) from the promontory of Ippona, Capo di Guardia near Bona [present town of Annaba, author's note], Algeria, and to Bourguignat (1864) who reports four varieties of *Helicella trochlea* Pfeiffer (var. *minor*, *depressa*, *fusco-maculata* and *hypozona*) from Bugia [present town of Béjaïa, author's note], Algiers and at Capo di Guardia, near Annaba (Algeria). Bourguignat (1868) also reports it from Tunisia at Kamart (Tunis), in the ruins of Carthage and on the eastern slope of Djebel Ahmar (Tunisia). Specimens with this determination from Annaba are kept in the Löbbecke Museum in Düsseldorf (1868, legit Lischke) and have h/d ratios in the range 0.68-1.04 (mean: 0.86) (Maio, pers. obs.; Figs. 29–31). Kobelt (1877) writes: "This very attractive species represents [=substitutes?] the group of the "*Hel. Caroni*" in Algeria, where it is found in the Provinces of Algiers and Constantine in various points" (Fig. 32). De Saint-Simon (1882) reports specimens of *Helix trochlea* collected at Capo di Guardia, near Bona, of which he examined the radula. Letourneux & Bourguignat (1887) also report it from Tunisia, as well as from Bona, Bugia and Algiers (Algeria). Monterosato (1893) reports *H. trochlea* Pfeiff. from "Algeria a Bona e nel deserto del Sahara (Mouss.)" and *H. speciosa*, Monts. as "nuova forma vicina alla trochlea ma pur distinta" from Salaparuta (Trapani Province) in Sicily (Prof. A. Palumbo).

Wenz (1923) reports this species as a "Pliocen. S. - Diluv." fossil at "Cap de Garde bei Bone" and Joleaud (1936) also reports it as a fossil from Capo di Guardia in the "panchina quaternario antica del posto". Sacchi (1955a) reports finding specimens of *Helicella* (*Trochoidea*) *trochlea* Drap. in Eastern Algeria at Capo Carbon, near Bugia and at Capo di Guardia.

In the L. Pfeiffer collection of the Senckenberg Forschungsinstitut und Naturmuseum in Frankfurt am Main (Germany), there is a specimen reported as "*Helix trochlea* Pf., coll. O. Reinhardt ex Parreyss" from "Sicilia" (h/d=0.81) and nine specimens reported as "*Trochula trochlea* Pf., coll. C. Bout ex H. Rolle" from "Sierra Nevada, Hispania" (h/d=0.72). In the same collection there are other specimens with labels indicating provenance from sites in Algeria and Tunisia (R. Janssen, pers. com.; see Table 3).

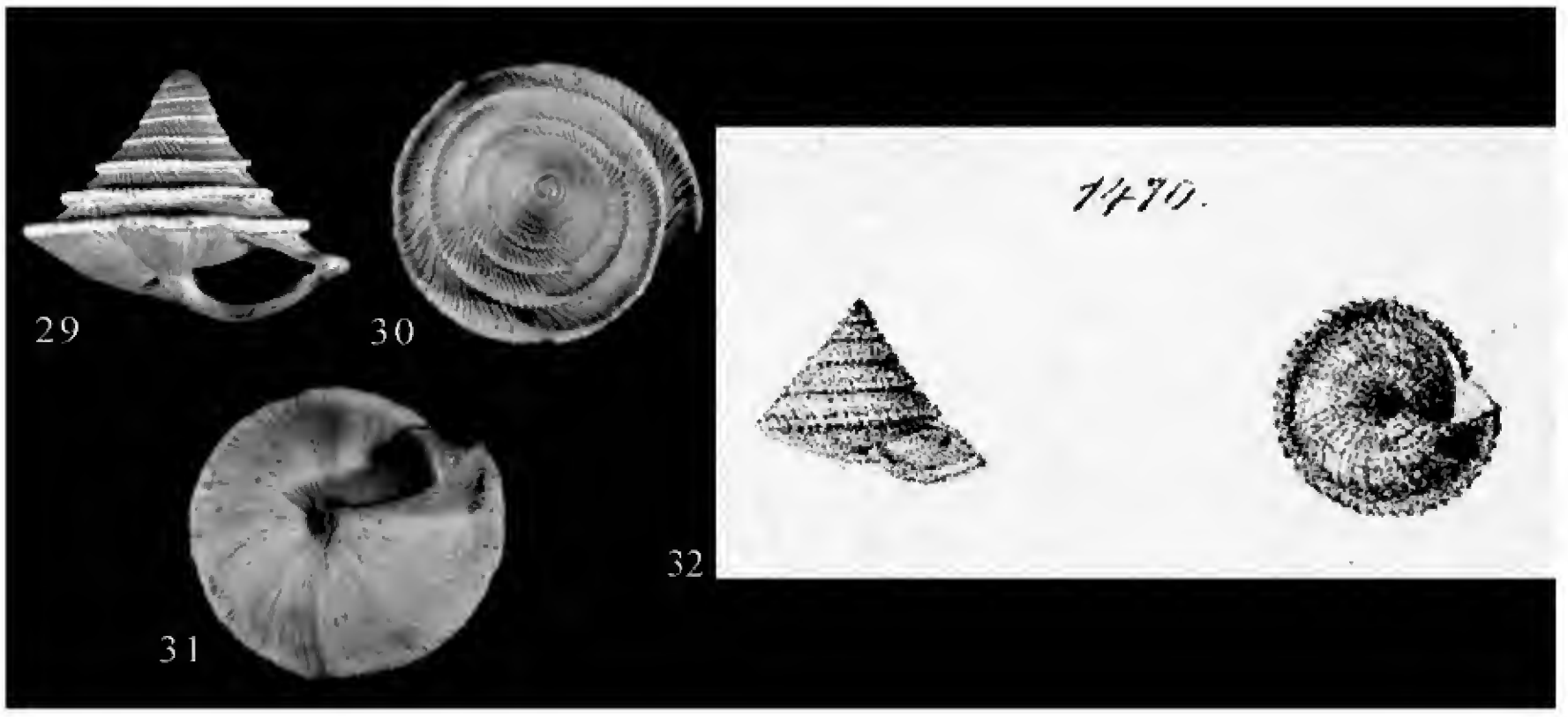
Trochoidea (Trochoidea) elegans (Gmelin, 1791)

Original description. Gmelin, 1791, species no. 229, p. 3642, locus typicus "Barbaria et australi Europa": "*Helix elegans. H. testa pyramidali alba umbilicata: anfractibus sex acutis planiusculis marginatis. Habitat terrestris in Barbaria et australi Europa.* [Barbaria or Berberia: the Mediterranean coastal area of Barbary and the Barbary States: Tunisia, Algeria and Morocco, author's note]".

Examined material. During the present study, some populations with particularly elevated spire were found in the literature. Morphologically very similar to *T. caroni*, they were of uncertain taxonomic attribution. The reports are included to complete the information on this particular group of land snails.

Sacchi (1955a) reports finding specimens of *Helicella elegans* with elevated spire and morphological characteristics very similar to *H. elata* on Ibiza. In the same paper he reports "molto turricolate" forms of *H. elegans* from Tunis and specimens of *Helicella* (*Trochoidea*) *elegans* stated to belong to "forme assai alte di spira" from Southern France. Sacchi (1954, 1955a) does not exclude the hypothesis of the presence of turriculate forms in the Balearic Islands, though he considers them the result of geographical isolation of populations of *H. elegans* (reported, moreover, by Bofill I Poch & D'Aguillar-Amat (1924) as *Helix* (*Trochula*) *elegans).*

Two historical reports of *T. elegans* by Rossmässler (1837, Tafel XXVI, Fig. 345, sub *H. elegans* Gm.) and by Aradas & Maggiore (1840: specie LXVI, Elice elegante *H. elegans* Gm) from Sicily



Figures 29-31. Shell of *Trochoidea trochlea* from Annaba (Algeria), Löbbecke Museum, Düsseldorf, Germany, height 8.1 mm, diameter 10.2 mm: apertural view (Fig. 29), umbilical view (Fig. 30), apical view (Fig. 31). Figure 32. Figure n. 1470 of *Helix trochlea* from plate 146 in Kobelt (1877).

are also noteworthy. In particular, the latter authors write: "Rara: gli esemplari che possediamo ci son pervenuti da Palermo ad eccezione di un solo ritrovato nella plaia di Catania. Diam. lin. [Linea siciliana (o linia) = 1.79234583 mm] 5 ½ [= 9.86 mm], altezza lin. 2 ½ [=4.48 mm] (h/d: 0.46). Coll. (A.G.) [= Abate Emiliano Guttadauro?]". Philippi (1836) also reports it with the name *Carocolla elegans* Lamk. from Palermo and Pantelleria Island. The same citation is repeated by Monterosato (1893) with the comment "Non è stato più ritrovata, né credo si trovi".

DISCUSSION

On the basis of the data collected, the current distribution of *T. caroni*, limited to Capri and Sicily (Manganelli et al., 1995), proves to be much wider (Fig. 33). In peninsular Italy, new sites of collection are in fact reported: one at Terracina with live specimens, one at Spigno Saturnia with many fresh empty shells, one in Sorrento with two empty shells of juveniles, one at Castagneto Carducci with a shell of an adult specimen, one at Manfredonia with a shell in a museum collection, dating to 1878, and a bibliographic specimen from Ischia, dating to 1822–1830. It is also important to mention the reports by Statuti (1882: Porto Badino and Torre Olevola near Terracina) and the fossil reports from Capri by Segre (1959) attributed by him to the Lower Pleistocene, when Capri was joined to the Sorrentina peninsula (Barattolo et al., 1992; Capasso Barbato & Gliozzi, 1995). This report therefore demonstrates the ancient presence of the species on the island of Capri.

Of similar interest is the finding of fossil specimens on Malta, which may demonstrate colonisation from Sicily during the Quaternary (Giusti et al., 1995; Hunt, 1997; Kolouch, 2003). *T. caroni* may have been present on the island until last century at least, as historical reports from the mid and late nineteenth century suggest (Gulia, 1874; Feilden, 1879).

Reports from North Africa are also interesting but require further confirmation, since local forms of *T. trochlea* or other taxa cannot be excluded.

Reports from the Balearic Islands cannot be verified since the original specimens cited in the papers could not be traced.

In the light of this new data, it is possible to say that the distribution of *T. caroni* is certainly wider than hitherto known, although it is not yet possible to draw conclusions on the origin and spread of this population. Likewise for *T. trochlea* and *T. elegans* with elevated spires, it is impossible to determine the correct systematic, phylogenetic and biogeographic position of the taxa and their effective rela-

tionships with *T. caroni*. The morpho-biometric criterion used to date does not enable clear discrimination between the various populations. *T. trochlea* should have an h/d between 1.14 and 0.70 or lower, *T. caroni* between 1.30 or higher and 0.88 and *T. elegans* between 0.82 and 0.62 or lower. Thus the h/d ratios of the three forms overlap and the same is true of their distributions.

Studies of anatomical characters do not solve the problem. Interestingly, in their times, von Ihering (1892) and Hesse (1934) already observed that the anatomy of specimens of *T. caroni* from Capri was indistinguishable from that of Sicilian specimens. Moreover, Caziot (1908) and Sacchi (1956a) considered that the anatomy of *H. elegans* from Tunisia was identical to that of Sicilian *H. caroni-elata*. Giusti et al. (1995) observed an evident similarity of genital systems between *T. caroni* from Sicily and *T. elegans* from Tuscany and Algeria, sustaining that anatomically, all species of the "*elegans* group" (*T. elegans*, *T. caroni*, *T. spratti* and *T. cumiae*) were indistinguishable.

Sacchi (1955a; 1956b) considers *Helix caroni-elata* and *H. trochlea* valid species, distinct from *H. elegans* by virtue of "their particular geographic distribution" and the "remarkable morphological characterisation" of their shells, even if he views all these species as a single species complex ("ciclo di forme"). Giusti et al. (1995), too, suggest that these species probably all belong to a hypothetical "superspecies" or "species group", the validity of which has yet to be confirmed.

According to Liggia (2013), *T. trochlea* Pfeiffer 1846 is synonymous with *T. elegans* (Gmelin 1791), but the site does not provide sources or other references for this conclusion.

Conservation status

In the Red List of the International Union for the Conservation of Nature (IUCN), version 2013.1. (Falkner et al., 2011), the status of *T. caroni* is classified as "LC" (Least Concern) or "lowest risk, not endangered or low risk". In the Red List of the 27 countries of the European Union it is classified as "LC" and is considered a "European endemic species" (Cuttelod et al., 2011). *T. elegans* is also classified as "LC" by the IUCN (Gargominy, 2011) and in the European Red List it is considered a "European endemic species" (Cuttelod et al., 2011). In view of the extreme localisation of currently known populations of these species, we think they are near threatened and worthy of protection at regional and national level.

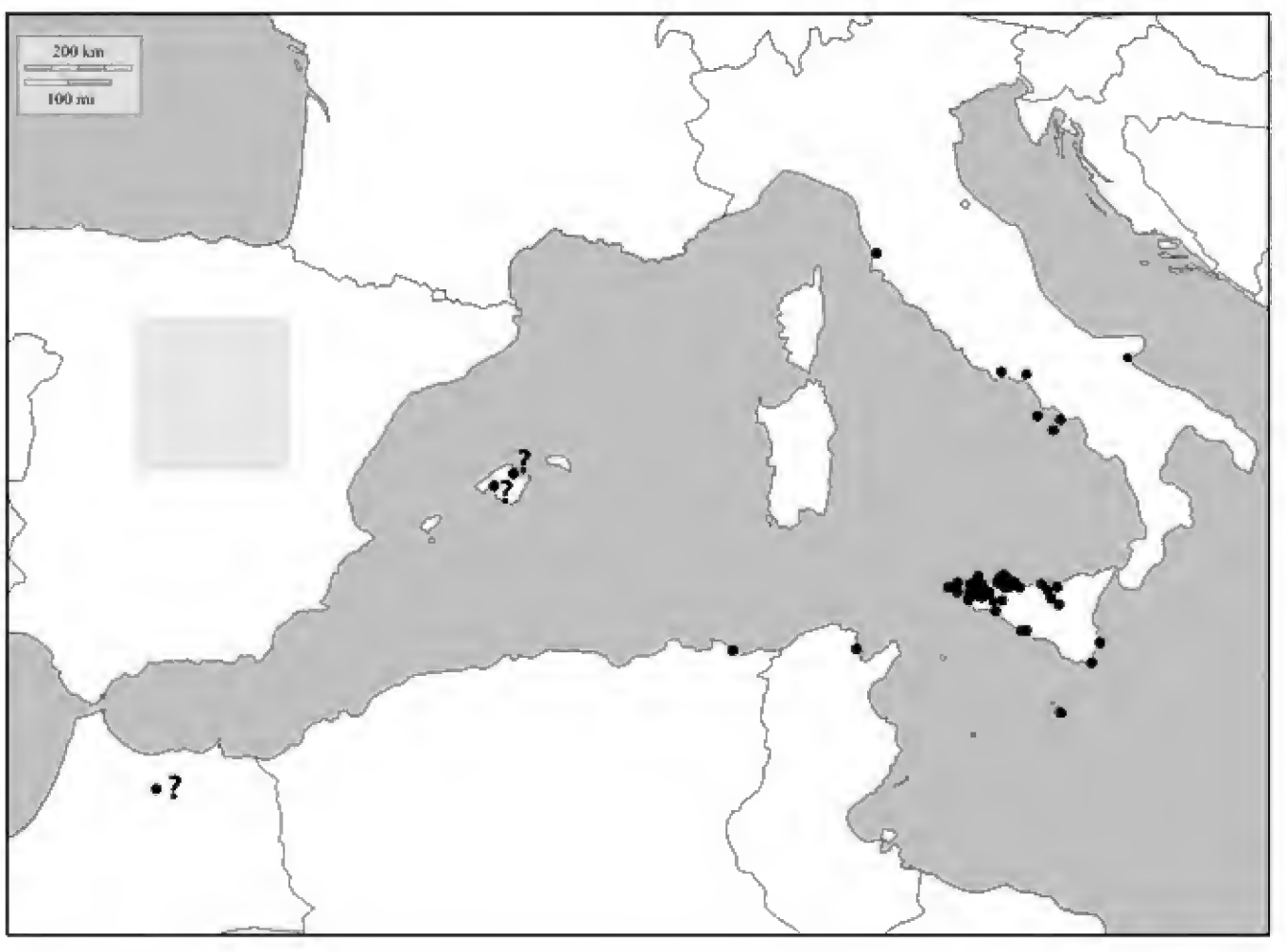


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Figure 33. Sites of finding of *Trochoidea caroni* in the Western Mediterranean.

Species	Localities	Collection	Collector, date, name reported
T. elegans	Spagna: Sierra Nevada	Slg. C. Bout ex H. Rolle	As *T. trochlea*
T. trochlea	Algeria	Slg. W. Kobelt	
T. trochlea	Algeria: Maskara	Slg. W. Kobelt	
T. trochlea	Algeria: Oran	Slg. Rossmässler	ex Terver 1944
T. trochlea	"Sicilia"	Slg. O. Reinhardt	ex Parreyss
T. trochlea	Algeria: Cape de Garde, Constantine	Slg. Jetschin	ex G. Schneider 1881
T. trochlea	Algeria: Bona	Slg. Jetschin	ex O. Stoll 1899 ex R. Mousson
T. trochlea	Algeria: Bône [Cap de Garde]	Slg. Jetschin	ex Kobelt 1887
T. trochlea	Algeria: Bône	Slg. Jetschin	ex M. Braun 1887
T. trochlea	Tunisia: "Umgebung von Tunis"	Slg. O. Reinhardt	ex ? 5.1891
T. trochlea	Algeria: Bône, Cap de Garde	Slg. W. Kobelt	
T. trochlea	Tunisia: "SW Biserta bei la PècherieamSee von Biserta"	Slg. H. Kaltenbach 15.3.1956	
T. trochlea	Tunisia: "Paßhöhe s. Biserta von Tunisaus"	Slg. H. Kaltenbach 14.3.1956	
T. caroni	Is. Capri	Slg. C. R. Boettger 1906	As *T. elata*
T. caroni	Is. Capri	Slg. K. L. Pfeiffer 1928	As *T. elata*
T. caroni	Is. Capri	Slg. J. Blum 3.1891	As *T. elata*
T. caroni	Is. Capri	Slg. W. Kobelt 1878	As *T. elata*
T. caroni	Is. Capri: Mte. Solaro	Slg. K. L. Pfeiffer 1928	As *T. elata*
T. caroni	Is. Capri		ex Fitz-Gerald 1878 as *T. elata*
T. elata	Napoli	Slg. C. Bosch ex H. Rolle	As *T. elata*
T. caroni	S-Italia: Manfredonia	Slg. W. Kobelt 1878	As *T. elata*
T. caroni	Is. Capri	Slg. S. H. Jaeckel	As *T. elata*
T. caroni	Is. Capri	Slg. H. Kaltenbach ex O. Schmidt	As *T. elata*
T. caroni	Is. Capri	Slg. Jetschin	ex Rousseau 1901 as *T. elata*
T. caroni	Is. Capri: M.te Solaro	Slg. Schlickum 19.8.1956	As *T. elata*
T. caroni	Is. Capri	Slg. W. Kobelt	ex Heynemann as *T. elata*
T. caroni	Is. Capri	Slg. Jetschin	ex Kobelt 1880 as *T. elata*
T. caroni	Is. Capri	Slg. Ehrmann	4.1894 as *T. elata*
T. caroni	Is. Capri	Slg. L. Henrich	As *T. elata*
T. caroni	Is. Capri	Slg. H. Kaltenbach ex O. Schmidt	ex A. Köhler 1906 as *T. elata*
T. caroni	Sicilia	Slg. Rossmässler	ex Philippi as *T. elata*
T. caroni	Sicilia	Slg. O. Reinhardt	ex Parreyss as *T. elata*
T. caroni	Sicilia	Slg. O. v. Moellendorff	As *T. elata*
T. caroni	Sicilia	Slg. Rossmässler	ex Hueb du Pavillon as *T. elata*
T. caroni	Sicilia: Trapani	Slg. S. H. Jaeckel	As *T. elata*
T. caroni	Sicilia: San Vito	Slg. K. L. Pfeiffer 1930	As *T. elata*

Table 3. Faunistic data of *Trochoidea* sp. della "Collezione L. Pfeifer" of the Senckenberg Forschungsinstitut und Naturmuseum (R. Janssen, pers. com.) of Frankfurt am Main, Germany.

Species	Localities	Collection	Collector, date, name reported
T. caroni	Sicilia	Slg. Jetschin	ex Linnaea 1885 as *T. elata*
T. caroni	Sicilia		ex Parreyss as *T. elata*
T. caroni	Sicilia: Trapani	Slg. K.L.Pfeiffer ex K. Henschel 1890	As *T. elata*
T. caroni	Sicilia: Palermo	Slg. C. Bosch ex H. Rolle	As *T. elata dilatata*
T. caroni	Sicilia: M.te San Giuliano	Slg. K. L. Pfeiffer 1930	As *T. elata*
T. caroni	Sicilia: Trapani-Marsala	Slg. K. L. Pfeiffer 1930	As *T. elata*
T. caroni	Sicilia: Trapani	Slg. Jetschin	ex Caruana Gatto as *T. elata*
T. caroni	Sicilia: Trapani	Slg. Jetschin	ex Kobelt 1880 as *T. elata*
T. caroni	Sicilia: Sferracavallo near Palermo	Slg. W. Kobelt 1878	As *T. elata*
T. caroni	Sicilia	Slg. W. Kobelt	ex Benoit as *T. elata*
T. caroni	Sicilia	Slg. Rossmässler	ex Ziegler as *T. elata*
T. caroni	Sicilia: Calatafimi	Slg. W. Kobelt	ex Monterosato as *T. elata*
T. caroni	Sicilia: Trapani	Slg. W. Kobelt 1878	As *T. elata*
T. elata	Sicilia: Palermo	Slg. Rossmässler	ex Philippi as *T. elata caroni*
T. elata	Sicilia	Slg. W. Kobelt	ex Westerlund as *T. elata caroni*
T. elata	Sicilia	Slg. O. Reinhardt	ex Parreyss as *T. elata caroni*
T. elata	[Sicilia]	Slg. Knotte	As *T. elata caroni*
T. elata	Sicilia	Slg. O. Boettger	ex C. Koch as *T. elata caroni*
T. elata	Sicilia	Slg. K. Harhagen	As *T. elata caroni*
T. elata	Sicilia	Slg. O. v. Moellendorff	As *T. elata caroni*
T. elata	Sicilia	Slg. A. Gyssea	As *T. elata caroni*
T. elata	Sicilia	Slg. W. Kobelt	ex Benoit as *T. elata caroni*
T. elata	Sicilia: Mte. Pellegrino near Palermo		ex ? 4.1889 as *T. elata caroni*
T. elata	Sicilia	Slg. S. H. Jaeckel	ex Scholtz as *T. elata caroni*
T. elata	Sicilia: Palermo	Slg. G. Nägele ex Monterosato 1897	As *T. elata caroni*
T. elata	Sicilia: Palermo	Slg. G. Nägele	As *T. elata caroni*
T. elata	Sicilia: Palermo		ex ? As *T. elata caroni*
T. elata	Sicilia: Palermo		ex Linnaea 1883 as *T. elata caroni*
T. elata	Sicilia: Sferracavallo near Palermo	Slg. S. H. Jaeckel 4.1935	As *T. elata caroni*
T. elata	Sicilia: Palermo	Slg. Jetschin	ex Wohlberedt 1903 as *T. elata caroni*
T. elata	Sicilia: Palermo	Slg. Th. Krüper	As *T. elata caroni*
T. elata	Sicilia: Palermo	Slg. H. Kaltenbach	ex A. Köhler as *T. elata caroni*
T. elata	Sicilia	Slg. Jetschin	ex Zellweger as *T. elata caroni*
T. elata	Sicilia: near Palermo	Slg. Jetschin	ex Kobelt 1880 as *T. elata caroni*

Table 3. Faunistic data of *Trochoidea* sp. della "Collezione L. Pfeiffer" of the Senckenberg Forschungsinstitut und Naturmuseum (R. Janssen, pers. com.) of Frankfurt am Main, Germany.

Species	Localities	Collection	Collector, date, name reported
T. elata	Sicilia: Palermo	Slg. W. Kobelt	ex Monterosato as *T. elata caroni*
T. elata	Sicilia: Palermo, San Polo	Slg. Jetschin	ex A. Bofill 1900 as *T. elata caroni*
T. elata	Sicilia: Sferracavallo near Palermo	Slg. H. Kaltenbach ex A. Köhler 1913	As *T. elata caroni*
T. elata	Sicilia: Palermo	Slg. C. Bosch ex H. Rolle	As *T. elata caroni*
T. elata	Sicilia: Palermo	Slg. W. Kobelt	As *T. elata caroni*
T. elata	Sicilia		ex ? as *T. elata caroni*
T. elata	Sicilia: Sferro Cavallo	Slg. C. Bosch ex H. Rolle	As *T. elata caroni*

Table 3. Faunistic data of *Trochoidea* sp. della "Collezione L. Pfeiffer" of the Senckenberg Forschungsinstitut und Naturmuseum (R. Janssen, pers. com.) of Frankfurt am Main, Germany.

ACKNOWLEDGMENTS

We thank: Joseph Boscheinen (Malakozoologie Curator, Stadt Düsseldorf Aquazoo, Löbbecke-Museum, Germany) for loan of specimens of *T. caroni* e *T. trochlea* preserved in the Löbbecke Museum; Ronald Janssen (Sektionsleiter Malakologie, Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt am Main, Germany) for informations and photos of the specimens of "L. Pfeiffer collection". Folco Giusti (University of Siena, Italy), Giuseppe Manganelli (University of Siena, Italy), Simone Cianfanelli (University of Florence, Italy) and Rafael La Perna (University of Bari) for precious advices given; Rüdiger Bieler (Curator and Director, Invertebrates Department of Zoology, Field Museum of Natural History di Chicago, USA), Jochen Gerber (Collections Manager, Invertebrates Department of Zoology, Field Museum of Natural History, Chicago, USA), Virginie Héros and Philippe Maestrati (rispectively Chargée de conservation, collection Mollusques, Département Systématique et Evolution, and Photographer, Muséum National d'Histoire Naturelle, Paris, France), Monica Leonardi (Museo Civico di Storia Naturale, Milano, Italy), Giacomo Doria and Maria Tavano (Museo Civico di Storia Naturale "Giacomo Doria", Genova, Italy), Aldo Giacomo Segre (Rome, Italy), Fabio Parenti (Rome, Italy), Ignazio Sparacio (Palermo, Italy), Walter Renda (Amantea, Italy), Agatino Reitano (S. G. Galermo, Catania, Italy), Fabio Liberto (Cefalù, Italy), Giuseppe Fasulo (Napoli, Italy), Sergio Duraccio (Naples, Italy) and Mario Cuomo (Naples, Italy) per le informazioni inedite fornite; the Centro Caprense "I. Cerio", Capri (Naples, Italy) and, particolarly, the President Claudio Giordano for collaboration. A particular thank goes to Alessandro Hallgass (Rome, Italy) for specimens from Terracina.

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Biodiversity Journal, 2013, 4 (4): 501-506

Glycaspis brimblecombei Moore, 1964 (Hemiptera Psyllidae) invasion and new records in the Mediterranean area

Kheddar Reguia[1] & Francisco Javier Peris-Felipo[2*]

[1]Department of Agricultural sciences, Faculty agro-veterinary, Universityof Saad. Dahlab BP 270,09000 Blida, Algeria
[2]Laboratory of Entomology and Pest Control. Institute Cavanilles of Biodiversity and Evolutionary Biology. University of Valencia.c/. Catedrático José Beltrán, 2 - 46980 Paterna, Valencia, Spain
[*]Corresponding author: Francisco.peris@uv.es

ABSTRACT *Glycaspis brimblecombei* Moore, 1964 (Hemiptera Psyllidae) is a sap-sucking insect known for being a severe pest in several *Eucalyptus* spp. This paper provides new information about the first record of *G. brimblecombei* in Algeria and Greece, and new information about its biology, analyzing the evolution and reasons of its expansion. It is also the first record of the parasitic wasp *Psyllaephagus bliteus* Riek in Algeria, frequently used as biological control of this psyllid. Samplings were carried out in European and North African Mediterranean countries from 2011 to 2013.

KEY WORDS *Glycaspis brimblecombei*; Psyllidae; *Psyllae phagusbliteus*; Mediterranean areas; invasion.

Received 22.10.2013; accepted 29.11.2013; printed 30.12.2013

INTRODUCTION

The red gum lerp psyllid, *Glycaspis brimblecombei* Moore, 1964 (Hemiptera Psyllidae), is a sap-sucking insect of Australian origin (Moore, 1964), which currently shows a widespread distribution outside its native range due to frequent introductions. It was detected in California, U.S.A. in 1998 (Brennan et al., 1999), in Mexico in 2000 (Castillo, 2003), in the Hawaiian Islands in 2001 (Nagamine & Heu, 2001), in Chile in 2002 (Sandoval & Rothmann, 2003), in Brazil (Santana et al., 2003) and Mauritius (Sookar et al., 2003) in 2003, in Madagascar in 2004 (Hollis, 2004), in Argentina in 2005 (Bouvet et al., 2005), in Ecuador in 2007 (Onore & Gara, 2007), in Venezuela (Rosales et al., 2008), Peru (Burckhardt et al., 2008) and Iberian Peninsula (Hurtado & Reina, 2008; Valente & Hoodkinson, 2009; Prieto-Lillo et al., 2009) in 2008, in Morocco in 2009 (Maatouf & Lumaret, 2012), in Italy in 2010 (Laudonia & Garonna, 2010) and recently in France (Cocquempot et al., 2012).

This psyllid is considered a serious pest that causes severe defoliation and some tree mortality on several *Eucalyptus* spp., being included in the EPPO list of quarantine species since 2002. It mainly feeds on *Eucalyptus camaldulensis* Dehnh., although it can also be found on other species including *E. rudis* Endl., *E. globulus* Labill., *E. diversicolor* F. Muell., *E. sideroxylon* A. Cunn. ex Woolls, *E. nicholii* Maiden et Blakely, *E. lehmannii* (Schauer) Benth., in California and *E. blakelyi* Maiden, *E. nitens* H. Deane et Maiden, *E. tereticornis* Sm., *E. dealbata* A. Cunn. ex Schauer, *E. bridgesiana* R. T. Baker, *E. brassiana* S.T. Blake, *E. mannifera* Mudie, in Australia (Moore, 1970; Brennan et al., 1999; 2001). However, in the Mediterranean area is primarily associated with red eucalyptus (*E. camaldulensis*), frequently used in urban and rural forestry programmes (Peris-Felipo et al., 2010).

G. brimblecombei can be distinguished from other species due to the length of its cephalic projections, located below the eyes and known as genal processes (Laudonia & Garonna, 2010). Adults show sexual dimorphism mainly on the body size, with females slightly larger than males (size varying between 2.5 and 3.1 mm). The body is light green, sometimes with yellow spots. During oviposition, females lay yellow ovoid eggs, individually or in groups and without any protection. Nymphs are yellowish orange with grey wing rudiments. Nymphs secrete honeydew, which builds a white cover for protection until the adult stage is reached. This cover, also called a shield, is conic in shape and is built by several layers linked to each other. The nymph and the protective shield, which reaches a maximum size of 3.0 × 2.0 mm (Ide et al., 2006), grow at the same rate.Oviposition takes place on leaves and, in the case of adverse weather; the eggs enter into a quiescence period until conditions become favourable. After hatching, nymphs rapidly develop into pupal instars, producing the protective shield and readying the insect for final development into adulthood (Laudonia & Garonna, 2010). Once the adult stage is reached, reproductive activity swiftly takes place, fertilized females oviposit and nymphs hatch a few days later, starting another cycle. *G. brimblecombei* may undergo a multivoltine cycle but variations of the life cycle have been observed in different geographical contexts. For instance, in Australia and California there are two to four generations per year whilst in Chile the life cycle is postponed for about one month during the spring-summer period (Hidalgo, 2005). In fact, biological control programs have been applied in Australia and California using the parasitoid *Psyllaephagus bliteus* Riek, as it is known for its efficiency in parasiting several psyllid species, including *G. brimblecombei* (Riek, 1962).

The present paper provides biological and distribution data of *G. brimblecombei* around the Mediterranean countries and information about its progressive expansion from the first record.

MATERIALS AND METHODS

Samples were carried out from 2011 to 2013 around the Mediterranean area excluding the eastern countries. In order to determine the degree of expansion of *Glycaspis* several *Eucalyptus* spp. (*E. camaldulensis*, *E. globulus*, *E. bosistoana* F. Muell. and *E. gomphocephala* A. Cunn. ex DC.) were checked. *Eucalyptus*-trees showing positive presence were sampled, and leaves and insects collected. The samples were either hand-picked or collected with entomological nets. Leaves were taken to the laboratory for observation under light stereomicroscope. Samplings around different areas of Valencia province (Spain) and North-West of Algiers (Algeria) were also taken to determine the presence of the parasitoid wasp *Psyllaephagus blitteus*.

RESULTS

The new records of *G. brimblecombei* increase our knowledge of its distribution in countries where it has not been discovered until this research such as Algeria and Greece.

Samples confirm that this psyllid is well established in South of Europe and North of Africa, having expanded very fast since the first time that was cited in Europe in 2008 (Spain) (Hurtado & Reina, 2008). During four years *G. brimblecombei* has spread throughout Eastern and Southern Spain (Peris-Felipo et al., 2010), Central and South of Italy (Laudonia & Garonna, 2010; Peris-Felipo et al., 2010) and France (Cocquempot et al., 2012), being now reported also in North-West of Algiers (Algeria) and the Peloponnese region (Greece) (Fig. 1).

There were differences between areas relating to the species of *Eucalyptus* infested by *Glycapsis*: *E. camaldulensis* was the only species affected in Europe while *E. gomphocephala* and to a lesser extent *E. globules*, were also infested in Algeria. There were no psyllids reported in *E. bosistoana*. In addition, in Algeria during 2012, samples to know the global population and activity of *G. brimblecombei* were done. In order to represent on the same graph the abundance, temperature (T) and precipitation (P), the Walter ratio (P = 3T) was used. The study shows that the population of *Glycaspis* was significantly higher from late May to early August in all regions, coinciding with low precipitations (less than 50 mm) and temperate temperatures (15 to 25ºC) (Fig. 2).

Despite reported damage caused by the species on *Eucalyptus* around the world, our observations have not revealed any negative effects so far,

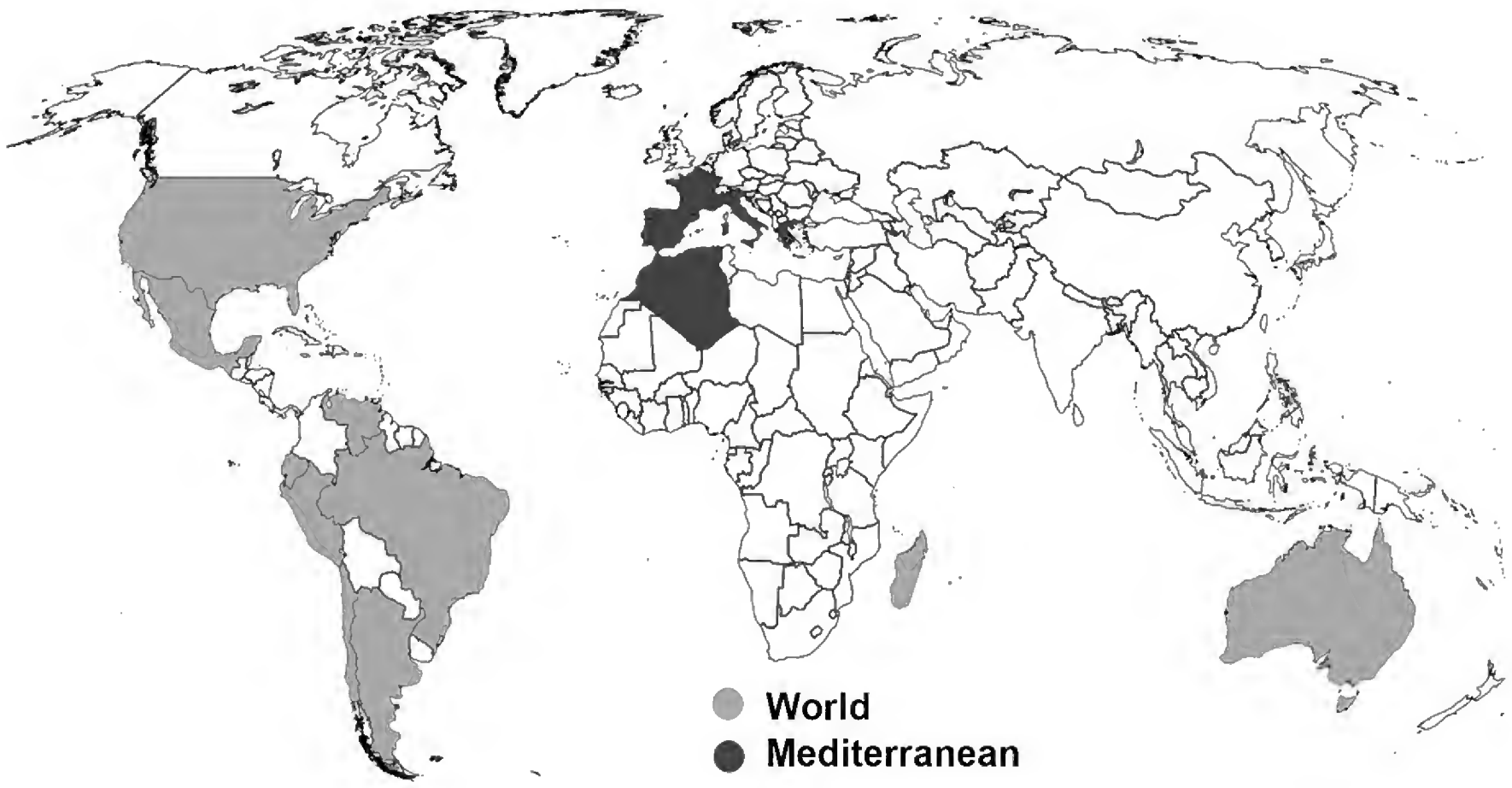


Figure 1. Distribution of *Glycaspis brimblecombei*.

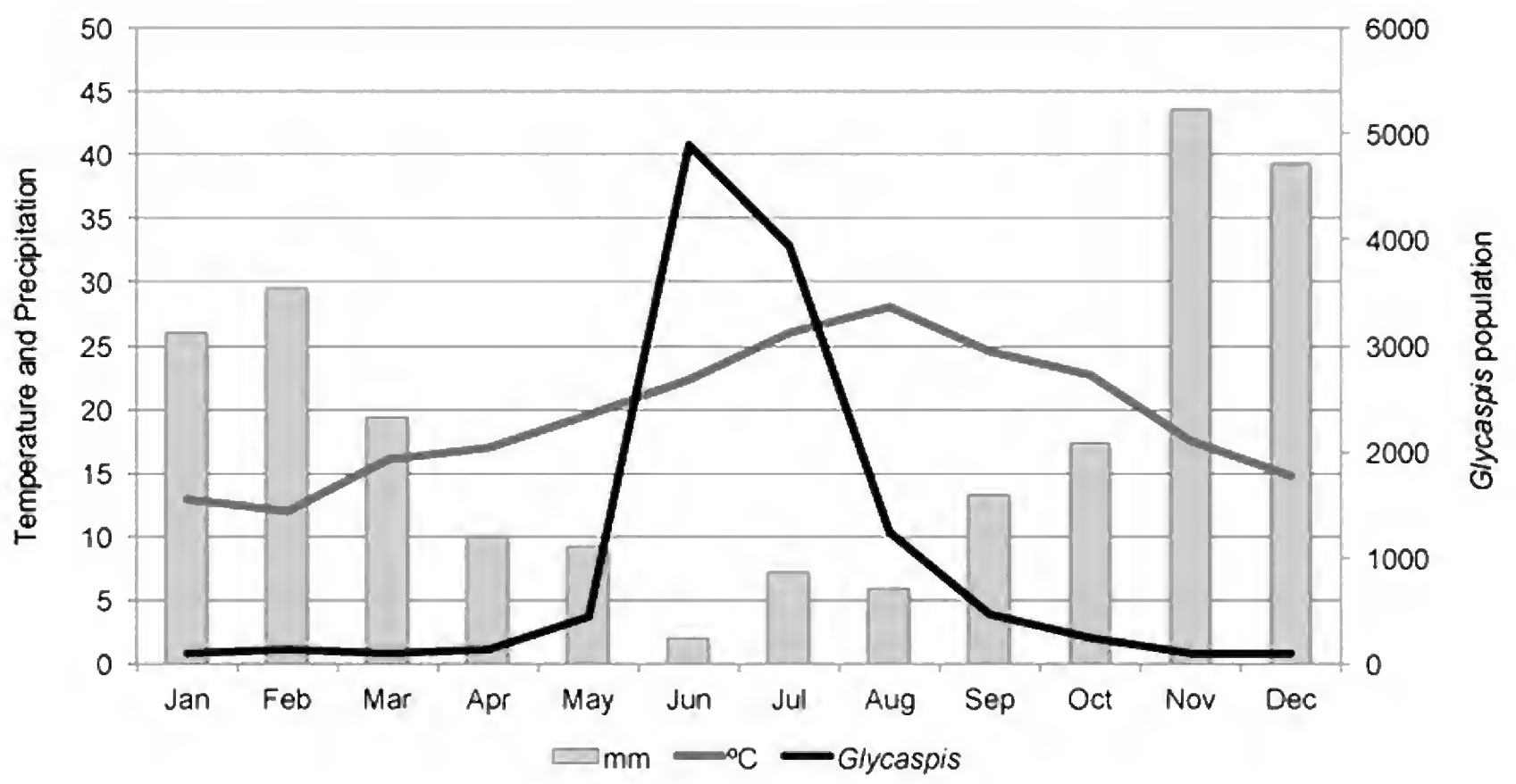


Figure 2. Evolution of the population of *Glycaspis brimblecombei* with temperature and precipitation in Algeria.

though it should be noted that further research is required. Although our research has not identified any significant effect on the trees' health-status, the attack of this sucking insect can indeed leave large quantities of honeydew on leaves, facilitating subsequent attacks by fungi resulting in fumagina syndromes. Moreover, when trees support high population levels, some discoloration of leaves or, at least, the adoption of a yellowish green colour has been detected. In fact, as time progresses, these fungi attacks produce leaf discoloration, falling, stunted growth and general abatement of plant

vigour. This general deterioration could facilitate further attacks by other insect pests or the death of branches or even whole trees (Bouvert et al., 2005; Ide et al., 2006; Hurtado & Reina, 2008).

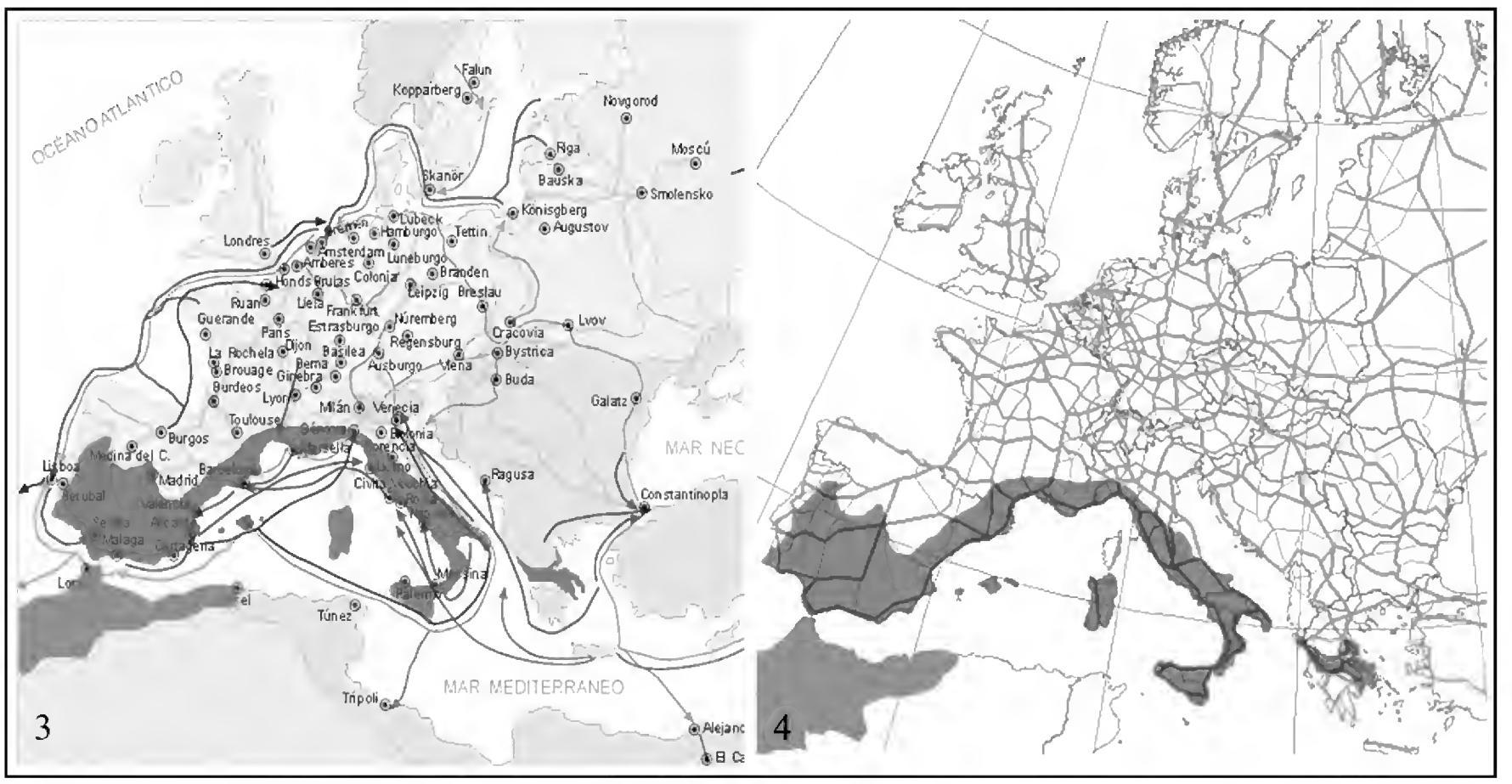
As a result, biological control programs using the natural wasp enemy *Psyllaephagus bliteus* has been used in Australia and California (Riek, 1962) and thus knowing the distribution of this encyrtid becomes relevant in the case of a pest. In Europe, this parasitoid wasp was discovered for the first time in different areas from Sicily (Italy) (Caleca et al., 2011) and Huelva (Spain) (Pérez-Otero et al., 2011) and this paper provides the first record in Algeria.

Once known *Glycaspis* biology, distribution and its expansion, next step was trying to answer the hypothesis about the means used for its dispersion. Countries connections were analysed finding that there were motorways and waterways linking all countries were *Glycaspis* was found (Figs. 3, 4).

On one hand, waterways data analyses demonstrate that Sea connection joins all Mediterranean countries were *Glycaspis* is present (Fig. 3). Checking carefully sea lanes it is possible to observe that there are numerous good routes from the Portuguese and Spanish area to other Spanish regions (i.e. Balearic Islands), areas (i.e. Sardinia) or countries (i.e. France, Greece, Italy or Algeria). On the other hand, motorways networks (Fig. 4) allow a good connection between Portugal, Spain, France and Italy thanks to the Mediterranean motorway. However, there is no connection with Greece, indicating that *Glycaspis* might have reached this country by the Mediterranean Sea. A similar situation could be applied to Italy, as the evolution of *G. brimblecombei* expansion shows it arrived to this area after being found in the Iberian Peninsula. However, in the central areas of Spain and Italy this possibility disappears and therefore a land-based expansion would be more feasible.

Despite that both motor and waterways are good candidates for explaining *Glycapsis* distribution, there is a lack of knowledge about the species biology and thus it is not possible to ignore ways of dispersion used by other arthropods such as the Aphids, which rely on the wind to colonize other trees. These data suggest that *Glycaspis* expansion was done via sea and land: the maritime route would have dominated in coastal areas while the land route would have encouraged its dispersion to offshore areas.

The rapid colonization of Mediterranean countries by *G. brimblecombei* demands the conduction of organic studies aimed at obtaining a better knowledge of its distribution, population characteristics, possible impact and potential natural enemies. Once these aspects are clarified, appropriated



Figures 3, 4. Waterways (Fig. 3) and motorways (Fig. 4) connections in Mediterranean countries with *Glycaspis*.

control measures should be adopted to prevent significant damage on trees and economic loss.

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Biodiversity Journal, 2013, 4 (4): 507–552

MONOGRAPH

First report on the herpetofauna of Tay Yen Tu Nature Reserve, northeastern Vietnam

Vera L. Hecht[1], Cuong T. Pham[2], Tao T. Nguyen[3], Truong Q. Nguyen[2,4], Michael Bonkowski[4] & Thomas Ziegler[1,4,*]

[1]AG Zoologischer Garten Köln, Riehler Strasse 173, - 50735 Cologne, Germany; e-mail: ziegler@koelnerzoo.de
[2]Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet Road, Hanoi, Vietnam; e-mail: nqt2@yahoo.com
[3]Vietnam National Museum of Nature, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet Road, Hanoi, Vietnam; e-mail: nguyenthientao@gmail.com
[4]Zoological Institute, University of Cologne, Zülpicher Strasse 47b, D-50674 Cologne, Germany; email: m.bonkowski@uni-koeln.de
[*]Corresponding author

ABSTRACT

A total number of 76 species of amphibians and reptiles were recorded during recent field surveys from the Tay Yen Tu Nature Reserve in Bac Giang Province, northeastern Vietnam, comprising one caecilian species, one newt species, 34 species of anurans, 18 species of lizards, and 22 species of snakes. Thirty species are reported for the first time from Yen Tu Nature Reserve as well as for Bac Giang Province. Among the recorded species, five are currently known only from Vietnam. A high level of species diversity and endemism of the herpetofauna underlines the importance of biodiversity conservation in this nature reserve, which covers a major part of the remaining lowland evergreen forest in northeastern Vietnam.

KEY WORDS Amphibians; Bac Giang Province; diversity; new records; reptiles.

Received 24.10.2013; accepted 30.11.2013; printed 30.12.2013

INTRODUCTION

The Tay Yen Tu Nature Reserve is located in Bac Giang Province, about 100 km northeast of Hanoi (Tordoff et al., 2004; Ha et al., 2010). This nature reserve is situated in the western side of the Yen Tu massif, which is known as the largest granite formation in northeastern Vietnam (Ha et al., 2010; Fig. 1). The main habitat type of the Yen Tu massif is evergreen broad-leaved tropical forest (Averyanov et al., 2003; Tordoff et al., 2004; Fig. 2). The total area of the Tay Yen Tu Nature Reserve comprises 16,466 ha and includes two non-contiguous sectors: the Thanh Son-Luc Son sector and the Khe Ro sector. The Thanh Son-Luc Son sector is centered on the 1,068 m high Mount Yen Tu, whereas the Khe Ro sector is allocated around the 886 m high Mount Da Bac (Tordoff et al., 2004).

A comprehensive study on the biodiversity has not been conducted in Tay Yen Tu Nature Reserve to date, however, the results of preliminary field research have indicated that this area supports a number of species of national or global conservation concern (Ha et al., 2010). Four new species have been discovered from Yen Tu Mountain in the last decade: *Sphenomorphus cryptotis* Darevsky, Orlov et Cuc, 2004, *Scincella devorator* Darevsky, Orlov et Cuc, 2004 (Darevsky et al., 2004), *Tylototriton*

vietnamensis Böhme, Schöttler, Nguyen et Köhler, 2005 (Böhme et al., 2005), and *Odorrana yentuensis* Tran, Orlov et Nguyen, 2008 (Tran et al., 2008). In addition, three new country records were recently reported from this nature reserve: *Shinisaurus crocodilurus* Ahl, 1930, *Amphiesmoides ornaticeps* (Werner, 1924), and *Rhacophorus maximus* Günther, 1858 (Le & Ziegler, 2003; Nguyen et al., 2008; Nguyen et al., 2010a). The discoveries of new reptiles and amphibians from Yen Tu Mountains underscore the unrealized biodiversity of northeastern Vietnam. Based on the results of our recent field surveys in the period between 2008 and 2010, we herein provide the first list of amphibians and reptiles recorded from Tay Yen Tu Nature Reserve.

MATERIALS AND METHODS

Field surveys in the Tay Yen Tu Nature Reserve took place in April 2008, in May and October 2009, and from April to July 2010. Survey transects were set up along streams, ponds, and forest paths within both sectors of the nature reserve. The habitat surrounding the ponds consisted of bamboo forest or mixed forest of bamboo and secondary forest; the streams were located in disturbed primary forest or secondary low-land forest (Figs. 3–5). In the Thanh Son - Luc Son Sector, the following streams were surveyed: Suoi Tuyen I (= stream 2); Suoi Tuyen II (= stream 1); Khe cam 1 (= stream 3); stream 4; stream 5; Ba Bep Stream (= stream 6). In addition, the surroundings of the following ponds were surveyed: Ao Cua; Khe Cam 1; Khe Cam 3; Deo Gio; Ba Bep; May Khoan; Da Lua 1; Da Lua 2; Lai Am 1 and Lai Am 2. In the Khe Ro Sector, night excursions were conducted in the forest near the Vung Tron Ranger Station; further surveys took place nearby Dong Ri and Dong Thong Ranger Stations. Surveyed sites are situated at elevations between 75 and 600 m above sea level.

Specimens collected during field surveys were deposited in the museum collections. Taxonomic identifications were made following Boulenger (1912), Pope (1935), Smith (1935, 1943), Bourret (1936, 1942, 2009), Manthey & Grossmann (1997), Ziegler (2002), Bain & Nguyen (2004a, b), Darevsky et al. (2004), Tran et al. (2008), Vogel et al. (2009), Nguyen et al. (2011a, b), and Nguyen et al. (2012). Ventral scales of snakes were counted according to Dowling (1951). Systematics and nomenclature generally followed Nguyen et al. (2009) and Zaher et al. (2009). The gender was identified based on external sexual characters, and if required, from the inspection of the gonads after dissection.

ABBREVIATIONS. Abbreviations of collectors. NQT: T.Q. Nguyen; NTT: T.T. Nguyen; NVS: S.V. Nguyen; PTC: C.T. Pham; TTT: T.T. Tran; TZ: T. Ziegler; VH: V.L. Hecht.

Collections. Institute of Ecology and Biological Resources (IEBR), Hanoi, Vietnam; Vietnam National Museum of Nature (VNMN), Hanoi, Vietnam; Vinh Phuc College of Education, Vietnam (TYT numbers); and Zoologisches Forschungsmuseum Alexander Koenig (ZFMK), Bonn, Germany.

Others abbreviations. NR: nature reserve; asl: above sea level; ED: horizontal eye diameter (eye length); EN: distance between anterior corner of eye and nostril; ET: distance between posterior corner of eye and tympanum; HL: head length; HW: head width; IN: internarial distance; IntOrb: interorbital distance; NtoS: distance between nostril and tip of snout; SL: snout length; SVL: snout-vent length (from tip of snout to cloaca); TaL: tail length (from posterior margin of cloaca to tip of tail); TD: maximum tympanum diameter; TiL: tibia length; TiW: tibia width; uEL: width of upper eyelid.

RESULTS

SYSTEMATICS

AMPHIBIA
GYMNOPHIONA
ICHTHYOPHIIDAE

Ichthyophis bannanicus Yang, 1984

EXAMINED MATERIAL. One adult male VNMN 1359 (SVL 233 mm), collected by NTT, 10 July 2010, 450 m asl (Fig. 6).

MORPHOLOGICAL CHARACTERS. Tail length 2.42 mm, tail width 2.98 mm, tail tip pointed; number of annuli: total annuli 365, annuli interrupted by vent 4, post-vent annuli 5. Colouration in life: dorsal surface of head, body and tail lilac; lateral stripe bright yellow, broad, interrupted posteriorly, extending from behind tentacle on upper jaw to posterior end

1

2

3

4

5

Figure 1. Map showing the Tay Yen Tu Nature Reserve in Bac Giang Province, Northern Vietnam. Figure 2. Vegetation type of the Tay Yen Tu Nature Reserve. Figures 3-5. Habitat types in Tay Yen Tu Nature Reserve. Photos by T. Ziegler and C.T. Pham.

of vent; ventral surface bright lilac (determination after Nishikawa et al., 2012).

DISTRIBUTION. This is a widespread species in northern Vietnam, from Cao Bang and Tuyen Quang provinces southwards to Hoa Binh Province. *I. bannanicus* was previously recorded from the eastern side of the Yen Tu Mountain in Hai Duong Province (Nguyen et al., 2009). Our finding represents the first record of this species from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, the species has been recorded from China and Laos (Nguyen et al., 2009; Nishikawa et al., 2012).

REMARKS. The specimen was found at night on the forest path near Ba Bep Stream in a bamboo forest near Mau Village.

CAUDATA

SALAMANDRIDAE

Tylototriton vietnamensis Böhme, Schöttler, Nguyen et Köhler, 2005

EXAMINED MATERIAL. Two adult males IEBR A.2013.57 (SVL 53 mm, TaL 55 mm), IEBR A.2013.58 (SVL 62 mm, TaL 65 mm) collected by PTC, June 2010 and July 2012, 200–500 m asl (Figs. 7, 8).

MORPHOLOGICAL CHARACTERS. Habitus moderately stout; head broader than body, slightly sloping in profile; snout short, truncate in dorsal view, rounded in profile and protruding beyond lower jaw; nostrils close to snout tip; upper lips thick, fleshy and overlapping lower lip under eye region; vomeropalatine teeth in two rows; tongue with poorly developed tongue pad, lacking a free posterior margin; a low vertebral tubercular ridge, extending from top of head to base of tail; two lateral rows of larger warts, extending from insertion of fore arms to base of tail; glands and warts relatively small, covering most of dorsal surfaces; venter almost smooth; parotoids greatly enlarged, slightly projecting backwards; gular fold absent; fingers without webbing, toes with basal webbing; tail laterally compressed; dorsal and ventral tail fin moderately developed; tail tip acuminate in profile. Colouration in life: dorsal and ventral surfaces brownish tan; finger and toe tips cream coloured; tail brownish tan with ventral tail fin creamy yellow; cloacal region bordered with cream-yellow (determination after Böhme et al., 2005; Nishikawa et al., 2013).

DISTRIBUTION. This species is currently known only from Lang Son, Bac Giang, and Phu Tho provinces in northern Vietnam (Nguyen et al., 2009; Nishikawa et al., 2013).

REMARKS. Eggs, larvae, subadults and adults were found in and around diverse ponds during day and night in secondary forests (Bernardes et al., 2013).

ANURA

BUFONIDAE

Duttaphrynus melanosticus (Schneider, 1799)

EXAMINED MATERIAL. Identification was based on direct observation in the field and photographs (Fig. 9): cranial crests conspicuous, black and more distinct on supraorbital region; parietal crest absent; parotoid gland prominent, elongated; tympanum distinct, rounded; dorsum and upper surface of limbs with conical, spiny warts; warts more rounded and smaller on flanks; ventral surface granular; fingers free of webbing, toes with webbing at base. Colouration in life: upper head and dorsum yellowish grey to dark brown with black spines; ventral cream (determination after Bourret, 1942; Ziegler, 2002).

DISTRIBUTION. This is a common species in Vietnam as well as in Asia (Nguyen et al., 2009). Therefore, we did not collect any voucher specimens.

REMARKS. Several individuals were found during the day and in the evening in the grassland near the Dong Thong Ranger Station.

Ingerophrynus galeatus (Günther, 1864)

EXAMINED MATERIAL. One subadult female ZMFK 92837 (SVL 39.04 mm), collected by TZ and NTT, October 2009, ca. 400 m asl (Fig. 10).

MORPHOLOGICAL CHARACTERS. Snout short, obtuse, protruding in profile; pupil horizontal; vomerine teeth absent; canthus rostralis with well developed bone-crest, continuing on supraorbital and parietal region, parietal crest absent; interorbital

distance narrower than upper eyelid width (IntOrb 3.23 mm, uEL 3.67 mm); a well-developed bone crest beyond eye above tympanum, reaching oval parotoid gland; tympanum distinct, smaller than eye length (TD 1.85 mm, ED 4.04 mm); dorsal skin with warts, ventral skin granular; finger I longer than II; toes 1/3-1/2 webbed; two metatarsal tubercles present; tarsal fold absent; tibio-tarsal articulation reaching eye. Colouration in life: dorsum grey with reddish warts and brown to dark grey marbling; lips with some bars; limbs with dark transverse bands, ventral surface pale yellowish grey with some dark markings (determination after Bourret, 1942; Inger et al., 1999; Ziegler, 2002; Tran et al., 2010).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai in the North to Dak Lak, Lam Dong, and Dong Nai provinces in the South. This is the first record of *I. galeatus* from Tay Yen Tu NR as well as from Bac Giang Province. Elsewhere, the species has been reported from China, Laos, and Cambodia (Nguyen et al., 2009).

REMARKS. A single specimen was found in the late afternoon on the forest ground near Suoi Tuyen I. Another juvenile was encountered on the forest ground near Ba Bep Pond in the afternoon on 3 June 2010.

MEGOPHRYIDAE

Leptobrachium* cf. *chapaense (Bourret, 1937)

EXAMINED MATERIAL. One adult female ZFMK 92838 (SVL 76.55 mm), collected by TZ and NQT, 27 May 2009, ca. 350 m asl (Fig. 11).

MORPHOLOGICAL CHARACTERS. Head large, flattened; snout round; pupil vertical; upper part of iris white; vomerine teeth absent; supratympanic fold distinct; tympanum indistinct (TD 4.69 mm); fore limbs long and slender, fingers free of webbing; webbing of toes rudimental; inner metatarsal tubercle present, outer metatarsal tubercle absent; tibio-tarsal articulation reaching tympanum; tibia length 26.72 mm; dorsal and ventral skin smooth. Colouration in life: dorsum reddish to greenish brown with some irregular black spots and marbling, flanks dark brown with white spots, upper surface of limbs lighter with dark bars; throat light reddish-brown, finely speckled with white, venter blackish grey with white spots (determination after Bourret, 1942; Ziegler, 2002; Bain & Nguyen, 2004a).

DISTRIBUTION. This species has been recorded from northern and central Vietnam. This is the first record of *L. chapaense* from Tay Yen Tu NR as well as from Bac Giang Province. Elsewhere, the species is known from China, Myanmar, Laos, and Thailand (Nguyen et al., 2009).

REMARKS. ZFMK 92838 was found on the path in the bamboo forest near Vung Tron Ranger Station. In October 2009, a tadpole of *L.* cf. *chapaense* was collected in the shallow part of a small stream.

Leptolalax nyx Ohler, Wollenberg, Grosjean, Hendrix, Vences, Ziegler et Dubois, 2011

EXAMINED MATERIAL. One adult female IEBR 3659 (SVL 33.94 mm), collected by NQT, 10 April 2008, ca. 350 m asl (Fig. 12).

MORPHOLOGICAL CHARACTERS. Head longer than wide (HL 11.27 mm, HW 10.71 mm); vomerine teeth present; snout longer than eye (SL 5.75 mm, ED 4.61 mm); interorbital distance slightly wider than upper eyelid width (IntOrb 4.09 mm, uEL 3.91 mm); nostrils oval, closer to tip of snout than to eye (NtoS 2.49 mm, EN 3.26 mm); tympanum distinct round, greater than distance between tympanum and eye (TD 3.32 mm, ET 2.44 mm); supratympanic fold distinct; small webbing on feet and narrow fringes on toes; dermal ridges under toes poorly developed; finger tips slightly enlarged; dorsum with glandular warts and short elongate ridges. Colouration in life: dorsal pattern distinct including dark outlines on warts and folding, a light W-shaped brown marking in the shoulder region; dark spots on flanks present; ventral surface whitish (determination after Ohler et al., 2011).

DISTRIBUTION. This species was previously known only from the type locality in Ha Giang Province, Vietnam (Ohler et al., 2011). This is the first record of the species from Tay Yen Tu NR as well as from Bac Giang Province.

REMARKS. Specimen was collected at night on a tussock grass in a rocky stream near Dong Ri Ranger Station.

Ophryophryne microstoma Boulenger, 1903

EXAMINED MATERIAL. Two adult males ZFMK 92839 and ZFMK 93906, collected by TZ and NQT, 26 May 2009, elevation 250 m asl; one adult female ZFMK 92840, collected by TZ and NTT, October 2009, 250–370 m asl; two adult males VNMN 1320 (SVL 34.72 mm) and VNMN 1340 (SVL 33.99 mm), collected by TZ and NTT, June 2010, 400–600 m asl (Fig. 13).

MORPHOLOGICAL CHARACTERS. Relatively large *Ophryophryne*, SVL 33.99–46.3 mm; head small; snout shorter than eye (SL 2.90–3.64 mm, ED 3.69–4.49 mm), obliquely obtuse, strongly pronounced; loreal region vertical, concave; nostril closer to tip of snout than to eye (EN 1.79–2.15 mm, NtoS 1.16–1.6 mm); interorbital distance as broad as upper eyelid; conical dermal appendix on upper eyelid present; eye larger than tympanum (ED 3.69–4.49 mm, TD 2.04–2.37 mm); tympanum distinct; arms and legs slender; palmar tubercle indistinct; subarticular tubercles indistinct; finger I shorter than II; tibio-tarsal articulation reaching eye or at least armpit; tibia about four times longer than wide (TiL 15.77–22.05 mm, TiW 3.48–4.81 mm); toe webbing rudimental; dorsal skin with small warts, with symmetric glandular ridges; males without externally visible vocal sacs. Colouration in life: dorsum greyish or light brown, upper surface of limbs with transverse bars; a light bar present below the eye; flanks with some small black spots; ventral surface cream with dark marbling (determination after Bourret, 1942; Ohler, 2003).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai and Ha Giang in the North southwards to Dak Lak and Lam Dong provinces. This is the first record of *O. microstoma* from Tay Yen Tu NR as well as from Bac Giang Province. Elsewhere, the species is known from China, Laos, Thailand, and Cambodia (Nguyen et al., 2009).

REMARKS. All five specimens were found at night on branches, ferns or stones near rocky streams. Ohler (2003) stated that vocal sacs are visible in the males of *O. microstoma*, however, they are indistinct in our specimens.

Xenophrys major (Boulenger, 1908)

EXAMINED MATERIAL. One adult male VNMN 1345 (SVL 77.23 mm), collected by TZ and NTT, 24 June 2010, 300 m asl.

MORPHOLOGICAL CHARACTERS. Head flat, slightly wider than long (HL 27.81 mm, HW 28.75 mm); snout obliquely obtuse, strongly pronounced; pupil vertical; tympanum distinct, approximately half of eye diameter (TD 3.52 mm, ED 8.23 mm); supratympanic fold distinct; nostrils closer to eye than to tip of snout (EN 4.61 mm, NtoS 5.10 mm); interorbital distance a bit narrower than upper eyelid width (IntOrb 6.93 mm, uEL 7.17 mm); tips of fingers and toes swollen; finger I longer than II; toes 1/4 webbed; tibio-tarsal articulation reaching the position between eye and tympanum; tibia length (TiL 39.27 mm), half of snout-vent length; dorsal skin nearly smooth, partly granular, glandular ridges on back and upper surface of limbs present; supratympanic fold present. Colouration in life: dorsal head and body brown, a dark brown triangular pattern present between the eyes; lateral sides of head dark brown; upper lip with a white stripe, running from nostril backward to shoulder; supratympanic fold edged in white; dorsal surface of limbs with dark bars; ventral surface white (determination after Bourret, 1942; Tran et al., 2010).

DISTRIBUTION. This is a widespread species in Vietnam, from Lao Cai and Ha Giang provinces southwards to Dak Lak and Dong Nai provinces. Elsewhere, the species has been reported from India, Bangladesh, China, Myanmar, Laos, and Thailand (Nguyen et al., 2009).

REMARKS. The single specimen was found at night on a dry and loamy forest path.

MICROHYLIDAE

Kalophrynus interlineatus (Blyth, 1854)

EXAMINED MATERIAL. One adult female ZFMK 92841 (SVL 46.61 mm), collected by TZ and NTT, October 2009, 160–180 m asl (Fig. 14).

MORPHOLOGICAL CHARACTERS. Snout pointed, slightly pronounced, somewhat longer than eye (SL 5.30 mm, ED 4.11 mm); vomerine teeth absent;

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Figure 6. *Ichthyophis bannanicus*. Figures 7, 8. Larvae and adult of *Tylototriton vietnamensis*. Figure 9. *Duttaphrynus melanostictus*. Figure 10. *Ingerophrynus galeatus*. Figure 11. *Leptobrachium* cf. *chapaense*. Figure 12. *Leptolalax nyx*. Figure 13. *Ophryophryne microstoma*. Photos by T. Ziegler and T.Q. Nguyen.

pupil horizontal; interorbital distance broader than upper eyelid (IntOrb 4.42 mm, uEL 2.99 mm); tympanum distinct, about 2/3 of eye length (TD 2.59 mm, ED 4.11 mm); fingers free of webbing; toes rudimentally webbed; subarticular tubercles distinct; inner and outer metatarsal tubercles present; tibio-tarsal articulation reaching to the middle position between axilla and groin; dorsal skin with tubercles, larger in size on belly and on upper surface of thighs; supratympanic fold indistinct; dorsolateral fold narrow and granular. Colouration in life: dorsal head and body light brown, one black spot present on each side of the hips; flanks dark brown; ventral surface whitish (determination after Bourret, 1942).

DISTRIBUTION. In Vietnam, this species has been reported from Lang Son, Phu Tho, Bac Giang, Ninh Binh, Quang Binh, Dong Nai, and Kien Giang provinces. Elsewhere, the species is known from India, China, Myanmar, Laos, Thailand, Cambodia, and Indonesia (Nguyen et al., 2009).

REMARKS. The female specimen was found in the late afternoon, on the ground near pond Khe Cam 1 in a bamboo forest. Our specimen differs from Bourret's (1942) description by its longer snout (versus a snout as long as eye) and the absence of black marking in the loreal region, under the dorsolateral fold, in the cloacal region and at the back of thigh.

Microhyla butleri Boulenger, 1900

EXAMINED MATERIAL. One adult male VNMN 1326 (SVL 22.39 mm), collected by TZ and NTT, July 2010, ca. 400 m asl; one adult female IEBR A.2013.59 (SVL 25.55 mm), collected by VH, 3 July 2010, 450 m asl (Fig. 15).

MORPHOLOGICAL CHARACTERS. Snout rounded, pronounced, longer than eye (SL 3.14–3.55 mm, ED 1.68–2.02 mm); vomerine teeth absent; pupil horizontal; interorbital distance 1.9–2.6 times broader than upper eyelid (IntOrb 2.48–2.85 mm, uEL 0.96–1.47 mm); tympanum invisible; fingers free of webbing, with slightly developed discs; toes with small discs, webbed at base; subarticular tubercle prominent; inner and outer metatarsal tubercles present; tibio-tarsal articulation reaching between eye and tip of snout; dorsal skin smooth; supratympanic fold present; ventral skin smooth, cloacal region granular; males with visible vocal sacs. Colouration in life: dorsal head and body grey with brownish and reddish markings; one whitish stripe from eye to beginning of arm; limbs with dark transverse bars; ventral surface whitish, throat and chest mottled with dark brown (determination after Bourret, 1942; Manthey & Grossmann, 1997; Ziegler, 2002; Bain & Nguyen, 2004b).

DISTRIBUTION. This is a widespread species in Vietnam. Elsewhere, the species has been reported from China, Myanmar, Laos, Thailand, Cambodia, Malaysia, and Singapore (Nguyen et al., 2009).

REMARKS. VNMN 1326 was found on a stone covered by moss in Suoi Tuyen I at night while IEBR A.2013.59 was collected on the ground of the bamboo forest near Lai Am Pond in the evening.

Microhyla heymonsi Vogt, 1911

EXAMINED MATERIAL. One adult male VNMN 1327 (SVL 20.23 mm) collected by TZ and NTT, 4 June 2010, 440 m asl; one adult male IEBR A.2013.60 (SVL 21.21 mm) collected by VH, 7 June 2010, ca. 400 m asl (Fig. 16).

MORPHOLOGICAL CHARACTERS. Snout obtusely pointed, pronounced, somewhat longer than eye (SL 2.84–2.90 mm, ED 2.08–2.30 mm); vomerine teeth absent; interorbital distance 1.2–1.5 times broader than upper eyelid (IntOrb 2.06–2.30 mm, uEL 1.54–1.72 mm); tympanum hidden; fingers free of webbing, with small discs; finger I shorter than II; palmar tubercle present; toes webbed rudimentally; subarticular tubercles well developed; inner and outer metatarsal tubercles small; tibio-tarsal articulation reaching between eye and tip of snout; dorsal and ventral skin smooth; supratympanic fold indistinct. Colouration in life: dorsal head and body grey or light brown, with a white stripe from tip of snout to cloaca, and a small dark spot in the center of the back; lateral sides of head and flanks dark brown to black; anterior part of thighs, cloacal region and lower parts of feet black; limbs with thin transverse bars; ventral surface white to grey; males with black vocal sacs (determination after Bourret, 1942; Manthey & Grossmann, 1997).

DISTRIBUTION. This is a widespread species in Vietnam. However, this is the first record of *M. heymonsi* from Tay Yen Tu NR as well as from Bac Giang Province. Elsewhere, the species has been recorded from India, China, Laos, Thailand, Cambodia, Malaysia, and Indonesia (Nguyen et al., 2009).

REMARKS. Specimens were found during the day time or at night on the ground near small ponds in the bamboo forest.

Microhyla pulchra (Hallowell, 1861)

EXAMINED MATERIAL. One subadult ZFMK 93905 (SVL 17.58 mm), collected by VH, 8 June 2010, 75 m asl (Fig. 17).

MORPHOLOGICAL CHARACTERS. Snout obtusely pointed, slightly pronounced, longer than eye (SL 2.52 mm, ED 2.04 mm); vomerine teeth absent; pupil round; interorbital distance broader than upper eyelid (IntOrb 1.84 mm, uEL 1.41 mm); tympanum indistinct; tips of fingers not enlarged; fingers free of webbing, finger I shorter than II; toes almost 1/2 webbed; subarticular tubercles well developed; metatarsal tubercle large; tibio-tarsal articulation reaching between eye and tip of snout; dorsal skin smooth; a distinct fold present between posterior edges of the eyes; ventral skin smooth; cloacal region granular. Colouration in life: dorsum light brown, with a dark brown Λ-shaped pattern on the back, containing several dark and light lines, outer part bordered by several light lines; canthus rostralis and flanks dark brown; limbs with transverse bars; groin and anterior part of thigh yellow; ventral surface whitish yellow, chin and throat with black marbling (determination after Bourret, 1942; Ziegler, 2002; Bain & Nguyen, 2004b).

DISTRIBUTION. This is a common species in Vietnam. Elsewhere, the species is known from India, China, Laos, Thailand, and Cambodia (Nguyen et al., 2009).

REMARKS. A single specimen was found in the morning on grassland near the Dong Thong Ranger Station. Our specimen well matched the descriptions of Bourret (1942) and Ziegler (2002), but it differs in having only one metatarsal tubercle instead of two small ones.

DICROGLOSSIDAE

Fejervarya limnocharis (Gravenhorst, 1829)

EXAMINED MATERIAL. One adult male ZFMK 93908 (SVL 46.05 mm), collected by TZ and NQT, 27 May 2009; one subadult ZFMK 93907 (SVL 24.73 mm), collected by Marta Bernardes, 7 June 2010, 75–90 m asl (Fig. 18).

MORPHOLOGICAL CHARACTERS. Head long, narrow; snout pointed, longer than eye (SL 4.44–7.40 mm, ED 3.34–5.53 mm); tongue bifid; vomerine teeth present; canthus rostralis obtuse; loreal region oblique; internostril and upper eyelid broader than interorbital distance (IN 2.52–2.93 mm, uEL 2.27–3.77 mm, IntOrb 1.66–2.29 mm); tympanum distinct (TD 1.72–2.48 mm); supratympanic fold distinct; tips of fingers and toes pointed; finger I longer than II; toes half webbed; outer metatarsal tubercle very small; tibio-tarsal articulation reaching eye; tibia 3–4 times longer than broad (TiL 13.08–23.99 mm, TiW 3.17–7.44 mm); dorsal skin granular, with several irregular dermal folds; nuptial pad present in males. Colouration in life: dorsal head and body greyish green with camouflage-pattern; light vertebral stripe present or absent; lips with dark vertical bars; limbs with transverse bars or spots; ventral surface white; throat marbled with black in males (determination after Bourret, 1942; Manthey & Grossmann, 1997; Ziegler, 2002; Goodall & Faithfull, 2010).

DISTRIBUTION. This is a common species not only in Vietnam but also in Asia, from Afghanistan, Pakistan, India eastwards to China and Japan, southwards to Malaysia, Indonesia, and the Philippines (Nguyen et al., 2009).

REMARKS. The adult male was found on a stone in a stream and the subadult was found on grassland about 30 m away from a small stream at night.

Limnonectes bannaensis Fitzinger, 1843

EXAMINED MATERIAL. One adult female IEBR A.2013.61 (SVL 47.43 mm), collected by PTC, June 2010, ca. 350 m asl (Fig. 19).

MORPHOLOGICAL CHARACTERS. Head large, flattened, wider than long (HL 19.70 mm, HW 20.9 mm); snout rounded, longer than eye diameter (SL 7.64 mm, ED 6.96 mm); canthus rostralis absent; loreal region oblique and slightly concave; vomerine teeth present; tongue bifurcated posteriorly; lower jaw with two tooth-like, bony structures; tympanum hidden; supratympanic fold present; arms short, fingers without webbing, tips of fingers obtuse or slightly swollen, finger I as long as finger

II, finger II and III with lateral skin-ridges; subarticular tubercles on fingers and toes large; hind limbs short; tibio-tarsal articulation reaches tympanum or eye; toes short, nearly full-webbed tips of toes dilated into small discs; subarticular tubercles fairly large; inner metatarsal tubercle large, outer metatarsal tubercle absent; specimen with smooth skin above. Colouration in life: dorsal head and back greenish brown with small dark blotches; limbs with dark brown bars; a short, dark transverse line present between eyes; upper and lower lip with vertical dark stripes; ventral surface whitish or yellowish and with numerous light grey or brownish blotches on throat, chest and limbs (determination after Ye et al., 2007; McLeod, 2010).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai Province in the North to Dong Nai and Kien Giang provinces in the South. Elsewhere, it is known from China, presumably to be found in Myanmar, and Laos (Nguyen et al., 2009; McLeod, 2010).

REMARKS. The specimen was found on stone in the stream Suoi Tuyen II in the evening. McLeod (2010) stated that *Limnonectes kuhlii* (Tschudi, 1838) is a complex of cryptic species. The "true" *L. kuhlii* is known only from the type locality in Java, Indonesia, and specimens identified as *L. kuhlii* from China and Vietnam should be assigned to *L. bannaensis*.

Quasipaa acanthophora Dubois et Ohler, 2009

EXAMINED MATERIAL. One male IEBR A.2013.62 (SVL 102.23 mm), two females IEBR A.2013.63 (SVL 87.26 mm), IEBR A.2013.64 (SVL 89.59 mm) collected by PTC, June 2010, 300–500 m asl; one subadult ZFMK 92843 (SVL 57.46 mm) collected by TZ and NTT, October 2009, ca. 350 m asl (Fig. 20).

MORPHOLOGICAL CHARACTERS. Head wider than long (HW 32.16–39.93 mm, HL 29.77–36.5 mm); snout rounded, slightly protruding, longer than eye diameter (SL 12.28–15.10 mm, ED 8.44–11.46 mm); vomerine teeth present; canthus rostralis indistinct; loreal region concave; nostrils oval, with flap of skin laterally; nostrils closer to eyes than to tip of snout (EN 5.08–5.93 mm, NtoS 4.50–4.76 mm); interorbital distance narrower than internarial distance and upper eyelid (IN 7.14–8.54 mm, IntOrb 5.08–5.93 mm, uEL 7.32–9.08 mm); tympanum indistinct; supratympanic fold prominent; pineal ocellus present, between anterior borders of eyes; arm short; fingers free of webbing; finger I longer than II; tips of fingers rounded, slightly enlarged, without discs; toes short and thin; tips of toes rounded, distinctly enlarged, without discs; toes fully webbed; dorsal head, body and limbs shagreened with regularly disposed glandular warts; upper part of flanks shagreened with elongated glandular warts, lower part with foldings; dorsolateral folds absent; thigh shagreened with thin foldings; legs shagreened with thin foldings and horny spinules; tarsus smooth; ventral surface smooth; belly with transversal foldings. Colouration in life: dorsal surface light brown, with grey spots; dorsal surface of limbs with transverse bars; supratympanic fold darker; lips with vertical bars ventral surface yellowish white, gular region with black marbling (determination after Dubois & Ohler, 2009). The males are larger in size, black nuptial spines present on prepollex and finger I (two separated pads).

DISTRIBUTION. This species was previously known only from the type locality in Lang Son Province, Vietnam (Dubois & Ohler, 2009). This is the first record of this species from Tay Yen Tu NR as well as from Bac Giang Province.

REMARKS. The specimens were found on stones in the stream Suoi Tuyen I and Suoi Tuyen II in the evening.

Occidozyga martensii (Peters, 1867)

EXAMINED MATERIAL. One adult female ZFMK 92844 (SVL 24.95 mm), collected by TZ, 29 May 2009, 200 m asl (Fig. 21).

MORPHOLOGICAL CHARACTERS. Head longer than wide (HL 9.37 mm, HW 7.88 mm); vomerine teeth absent; tongue rounded posteriorly; eyes directing laterally; tympanum hidden; supratympanic fold weakly developed; fingers and toes with small discs; finger I longer than II; tibio-tarsal articulation reaching eye; toes fully webbed, except toes IV and V; intercalary cartilage tubercles absent; inner metatarsal tubercle present; dorsal skin smooth anteriorly with some tubercles on the posterior part of back; ventral skin smooth. Colouration in life: dorsum beige grey, with a darker stripe between eyes; one light vertical bar from eye to snout; limbs with

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Figure 14. *Kalophrynus interlineatus*. Figure 15. *Microhyla butleri*. Figure 16. *M. heymonsi*. Figure 17. *M. pulchra*. Figure 18. *Fejervarya limnocharis*. Figure 19. *Limnonectes bannaensis*. Figure 20. *Quasipaa acanthophora*. Figure 21. *Occidozyga martensii*. Photos by T. Ziegler and C.T. Pham.

transverse bars; ventral surface white, gular region marbled with black (determination after Bourret, 1942; Manthey & Grossmann, 1997; Ziegler, 2002).

DISTRIBUTION. This is a widespread species in Vietnam, from Lao Cai Province in the North to Dong Nai and Ba Ria-Vung Tau provinces in the South. However, this is the first record of *O. martensii* from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, the species is known from China, Laos, Thailand, and Cambodia (Nguyen et al., 2009).

REMARKS. The specimen was found in the stream. Some other individuals were sighted in the water or the riverine of ponds during the day time.

RANIDAE

Amolops ricketti (Boulenger, 1899)

EXAMINED MATERIAL. One subadult female ZFMK 92845 (SVL 33.75 mm), collected by TZ and NQT, 25–29 May 2009, 300–400 m asl (Figs. 22, 23).

MORPHOLOGICAL CHARACTERS. Head somewhat longer than broad (HL 12.58 mm, HW 11.91 mm); snout round, pronounced, longer than eye length (SL 5.28 mm, ED 4.07 mm); vomerine teeth present; canthus rostralis distinct; loreal region concave; nostril at the midway between eye and tip of snout (EN 2.89 mm, NtoS 2.62 mm); interorbital distance narrower than internarial distance, but broader than upper eyelid (IN 4.41 mm, IntOrb 3.21 mm, uEL 2.91 mm); tympanum indistinct, about 1/3 of eye length (TD 1.17 mm); finger short, with lateral dermal fringe, with enlarged discs, discs with circummarginal groove as wide as tympanum diameter; finger I shorter than II; subarticular tubercles small; tibio-tarsal articulation reaching to tip of snout; heels overlapping; tibia four times longer than wide, about 2/3 of SVL (TiL 20.44 mm, TiW 5.00 mm); toes fully webbed, without tarsal fold; intercalary cartilage tubercles absent; toe discs with circummarginal groove, smaller than finger discs; inner metatarsal tubercle oval; outer metatarsal tubercle absent; dorsal skin with flattened granules; supratympanic fold distinct; ventral surface granular. Colouration in life: dorsum yellowish grey with larger reddish spots; upper surface of limbs with darker transverse bars; ventral surface yellowish white, gular region marbled (determination after Bourret, 1942).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai and Ha Giang provinces southwards to Hoa Binh Province (Nguyen et al., 2009). Records of this species in northwestern and central Vietnam must be confirmed, as it looks similar to *A. cremnobatus* Inger et Kottelat, 1998 and *A. spinapectoralis* Inger, Orlov et Darevsky, 1999. This is the first record of *A. ricketti* from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, this species is known from China (Nguyen et al., 2009).

REMARKS. The specimen was found near a rocky stream near Vung Tron Ranger Station. Further individuals were observed on branches and stones inside and nearby streams and cascades. The specimen matched the description of Bourret (1942) well, but its snout is longer than the eye length instead of being shorter than the eye length.

Babina chapaensis (Bourret, 1937)

EXAMINED MATERIAL. Four adult males ZFMK 92846, VNMN 1318, ZFMK 92847 and VNMN 1321, collected by TZ, 25 July 2010, 450–500 asl (Fig. 24).

MORPHOLOGICAL CHARACTERS. SVL 36.78–42.58 mm; head flattened, as long as or longer than wide (HL 13.22–16.16 mm, HW 13.14–15.50 mm); snout obtuse, round, longer than eye length (SL 6.28–6.89 mm, ED 4.18–4.70 mm); vomerine teeth present; canthus rostralis distinct; loreal region concave; nostrils at the midway between eye and tip of snout (EN 2.71–3.10 mm, NtoS 2.78–3.27 mm); internarial distance as broad as or broader than interorbital distance and wider than upper eyelid (IN 4.78–5.31 mm, IntOrb 3.58–4.55 mm, uEL 2.99–3.18 mm); tympanum distinct, smaller than eye (TD 3.14–3.86 mm, TD/ED 0.73–0.90); tip of fingers with small discs; tibiotarsal articulation reaching tip of snout; heels overlapping; tibia 3.84–4.30 times longer than wide (TiL 21.56–24.83 mm, TiW 5.40–6.26 mm); toe tips with small discs, with circummarginal groove; toes half webbed; inner metatarsal tubercle present; outer metatarsal tubercle small; dorsal skin smooth, with fine granular pattern on back, thigh and cloacal region; dorsolateral fold distinct; upper lip with a fold from below the nostril to anterior axilla, ending in a small wart. Colouration

in life: dorsum brown, with a light vertebral stripe from interorbital region to cloaca; a narrow black line from nostrils to groin, bordering dorsolateral fold; loreal region and tympanum dark brown; flanks yellowish green or grey, with some black spots; upper surface of limbs reddish brown with transverse dark bars; back of thigh with brown marbling; dermal fold on upper lip white; ventral surface white, yellow in posterior part; lower surface of arms with grey or black spots (determination after Bourret, 1942).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai, Bac Giang, Ha Tinh, Kon Tum, Gia Lai, and Dak Lak provinces. Elsewhere, the species is known from Laos and Thailand (Nguyen et al., 2009).

REMARKS. Specimens were found at night on the ground in the bamboo forest near Da Lua Pond.

Hylarana guentheri (Boulenger, 1882)

EXAMINED MATERIAL. Two adult males IEBR A.2013.65 (SVL 71.31 mm), IEBR A.2013.66 (SVL 72.85 mm) collected by PTC, June 2010; one adult female IEBR A.3013.67 (SVL 73.10 mm) collected by PTC, October 2011, 100–300 m asl (Fig. 25).

MORPHOLOGICAL CHARACTERS. Head wider than long (HL 19.71–20.11 mm, HW 25.59–26.75 mm); vomerine teeth present; internarial distance broader than upper eyelid (IntOrb 6.32–6.63 mm, uEL 4.50–5.30 mm); tip of snout pointed, strongly projecting; canthus rostralis distinct; loreal region moderately oblique, concave; nostril closer to tip of snout than to eye (EN 6.10–7.95 mm, NtoS 3.10–5.91 mm); tympanum distinct (TD 6.14–6.50 mm); supratympanic fold prominent; fingers slender and rather long, free of weebing, finger tips swollen, finger I longer than finger II, subarticular tubercles large; toes 3/4 webbed, tips of toes dilated into small discs, with a median groove, subarticular tubercles rather small, tarsal fold absent; inner metatarsal tubercle present, outer metatarsal tubercle very small; skin above and below smooth; dorsolateral fold distinct. Colouration in life: dorsal surface of head and body grey, light brown, golden to reddish brown, uniform or with dark brown spots; lateral head and flanks with a dark line or band, bordering the dorsolateral fold; tympanum dark brown or reddish; limbs with brown crossbars, back of thighs yellow with black mottling; ventral surface white or yellow, throat or chest speckled with brown (determination after Bourret, 1942; Ziegler, 2002).

DISTRIBUTION. This is a common species in lowland areas of Vietnam. Elsewhere, the species has been reported from China, Taiwan, Myanmar, and Laos (Nguyen et al., 2009).

REMARKS. The specimens were found in a small stream near Mau village.

Hylarana maosonensis Bourret, 1937

EXAMINED MATERIAL. One adult male ZFMK 92850 (SVL 40.43 mm), collected by TZ and NTT, October 2009, ca. 500 m asl (Fig. 26).

MORPHOLOGICAL CHARACTERS. Head longer than wide (HL 15.40 mm, HW 14.24 mm); vomerine teeth present; snout round, slightly pronounced, shorter than eye length (SL 6.05 mm, ED 6.14 mm); loreal region oblique, concave; nostril closer to tip of snout than to eye (EN 3.50 mm, NtoS 2.60 mm); interorbital distance narrower than internarial distance and upper eyelid (IN 4.17 mm, IntOrb 3.33 mm, uEL 3.90 mm); tongue notched posteriorly; pupil rounded; tympanum distinct, half of eye length (TD 3.04 mm); fingers free of webbing, with small discs; subarticular tubercle round, distinct; tibiotarsal articulation reaching between eye and tip of snout; discs of toes larger than discs of fingers; toes 3/4 webbed; intercalary cartilage tubercles absent; tibia 4 times longer than wide (TiL 22.65 mm, TiW 5.23 mm); subarticular tubercles small, round; inner metatarsal tubercle small, elongated; outer metatarsal tubercle small; tarsal fold absent; dorsolateral fold distinct, interrupted posteriorly; tubercles present on dorsal surface of body and thighs and upper part of flanks; supratympanic fold prominent; a large tubercle in posterior corner of the mouth; flanks with elongated warts below dorsolateral fold; two rows of elongated warts on each thigh; ventral surface smooth. Colouration in life: dorsum yellowish brown, flanks lighter with black spots; limbs with dark transverse bars; tympanum brown; lips white with small black spots; ventral surface whitish, chin mottled with dark brown (determination after Bourret, 1942; Inger et al., 1999).

DISTRIBUTION. This species has been recored in northern and central Vietnam, from Lao Cai and Ha Giang provinces southwards to Quang Tri and Thua

Thien-Hue provinces. Elsewhere, the species is known from Laos (Nguyen et al., 2009).

REMARKS.The specimen was found at night in Suoi Tuyen I.

Hylarana cf. ***nigrovitatta*** (Blyth, 1856)

EXAMINED MATERIAL. One adult female IEBR A.2013.68 (SVL 46.43 mm), collected by TZ and NQT, 28 May 2009, 200 m asl (Fig. 27).

MORPHOLOGICAL CHARACTERS. Head longer than wide (HL 18.26 mm, HW 15.91 mm); vomerine teeth present; snout round, longer than eye (SL 6.70 mm, ED 5.93 mm); loreal region oblique, concave; nostril closer to tip of snout than to eye (EN 3.57 mm, NtoS 3.13 mm); internarial distance broader than interorbital distance and upper eyelid (IN 4.60 mm, IntOrb 4.17 mm, uEL 3.66 mm); tongue notched posteriorly; pupil rounded; tympanum distinct (TD 3.70 mm); fingers free of webbing, tips of fingers swollen; toes 3/4 webbed; subarticular tubercles small; inner metatarsal tubercle small, elongated; outer metatarsal tubercle small; dorsolateral fold distinct; skin above and below smooth. Colouration in life: dorsal head and body greyish brown, a dark stripe present on each side of head and upper part of flanks, bordering the dorsolateral fold; tympanum brown; limbs with dark crossbars, back of thighs yellow with black mottling; ventral surface whitish (determination after Bourret, 1942; Inger et al., 1999).

DISTRIBUTION. In Vietnam, this species complex has been recorded from Cao Bang and Lang Son provinces in the North to Dong Nai and Kien Giang provinces in the South. This is the first record of *H.* cf. *nigrovittata* from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, the species is known from India, Nepal, China, Myanmar, Laos, Thailand, Cambodia, and Malaysia (Nguyen et al., 2009).

REMARKS. The specimen was found at night in a rocky stream near Vung Tron Ranger Station. *H. nigrovittata* represents a so far only partly understood complex of cryptic species (e.g., Gawor et al., 2009).

Hylarana taipehensis (Van Denburgh, 1909)

EXAMINED MATERIAL. Three adult males IEBR A.2013.69 (SVL 27.27 mm), IEBR A.2013.70 (SVL 28.56 mm), IEBR A.2013.71 (SVL 25.14 mm); one adult female IEBR A. 2013.72 (SVL 37.71 mm) collected by PTC, October 2011, 200–300 m asl (Fig. 28).

MORPHOLOGICAL CHARACTERS. Head longer than wide (HL 10.19–14.42 mm, HW 7.80–10.15 mm); vomerine teeth present; nostril closer to tip of snout than to eye (EN 2.76–4.20 mm, NtoS 1.96–2.32 mm); interorbital distance wider than upper eyelid (IntOrb 3.45–5.17 mm, uEL 2.32–3.56 mm); tympanum distinct, about 2/3 of eye diameter (TD 2.13–2.80 mm, ED 2.83–3.47 mm); fingers small, free of webbing, tips of fingers swollen; toes 3/4 webbed; dorsolateral fold distinct; skin above and below smooth. Colouration in life: dorsum green, with two stripes from behind the eyes to groins; ventral surface white or yellow (determination after Bourret, 1942; Inger et al., 1999).

DISTRIBUTION. This is a widespread species in Vietnam, from Lao Cai and Ha Giang provinces southwards to Dong Nai and Kien Giang provinces. Elsewhere, the species has been reported from India, Nepal, Bangladesh, China, Taiwan, Myanmar, Laos, Thailand, and Cambodia (Nguyen et al., 2009).

REMARKS. The specimens were found at night in Ba Bep.

Odorrana bacboensis Bain, Lathrop, Murphy, Orlov et Ho, 2003

EXAMINED MATERIAL. Two adult females IEBR A.2013.73 (SVL 106.19 mm) and ZFMK 92848 (SVL 108.44 mm), collected by TZ and NQT, 26–27 May 2009, 300–500 m asl (Fig. 29).

MORPHOLOGICAL CHARACTERS. Head longer than wide (HL 37.27–39.46 mm, HW 35.65–36.00 mm); vomerine teeth present; tongue notched posteriorly; snout round, slightly prominent, longer than eye (SL 15.58–16.72 mm, ED 10.14–11.80 mm); canthus rostralis distinct; interorbital distance narrower than internarial distance but broader than upper eyelid (IntOrb 9.00–10.24 mm, IN 10.37–10.92 mm, uEL 7.55–8.90 mm); pupil round; tympanum distinct, half of eye diameter (TD 4.83–5.08 mm, ED 10.14–11.80 mm); supratympanic fold distinct; fingers free of webbing; finger discs larger than those of toes, with circummarginal groove; tibiotarsal articulation reaching tip of snout; tibia 4 times longer than wide (TiL 60.90–61.45 mm, TiW 15.55–15.60 mm); toes fully webbed; outer metatarsal tubercle absent; inner

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Figures 22, 23. *Amolops ricketti*. Figure 24. *Babina chapaensis*. Figure 25. *Hylarana guentheri*. Figure 26. *H. maosonensis*. Figure 27. *H.* cf. *nigrovitatta*. Photos by T. Ziegler and C.T. Pham.

metatarsal tubercle large, flat; tarsal fold absent; dorsal skin smooth; dorsolateral fold distinct. Colouration in life: dorsum brown to dark brown, with tiny, irregular, black blotches; flanks brown, with some large black spots; throat and chest region white (determination after Bain et al., 2003).

DISTRIBUTION. In Vietnam, this species has been recorded in Lao Cai, Tuyen Quang, Bac Kan, and Nghe An provinces (Nguyen et al., 2009). This is the first record of *O. bacboensis* from Tay Yen Tu NR and from Bac Giang Province.

REMARKS. The specimens were found on the rock in a small cascade stream (Suoi Tuyen I).

Odorrana graminea (Boulenger, 1900)

EXAMINED MATERIAL. One adult female VNMN 1346 (106.68 mm), collected by TZ and NTT, June 2010; one adult female ZFMK 92849 (SVL 80.37 mm), collected by TZ and NTT, October 2009, 300–500 m asl (Fig. 30).

MORPHOLOGICAL CHARACTERS. Head longer than wide (HL 30.47–35.14 mm, HW 26.89–32.93 mm); vomerine teeth present; tongue notched posteriorly; snout round, longer than eye (SL 12.72–16.40 mm, ED 7.40–9.67 mm); canthus rostralis distinct; interorbital distance wider than internarial distance and upper eyelid (IntOrb 8.08–11.45 mm, IN 7.44–10.11 mm, uEL 6.84–7.14 mm); pupil round; tympanum distinct, approximately half of eye diameter (TD 4.17–4.22 mm, ED 7.40–9.67 mm); supratympanic fold distinct; fingers free of webbing; finger discs larger than discs of toes, with circummarginal groove; tibiotarsal articulation reaching beyond tip of snout; tibia about 4.64–5.91 times longer than wide (TiL 52.27–65.11 mm, TiW 8.85–14.02 mm); toes fully webbed; outer metatarsal tubercle absent; inner metatarsal tubercle elongate; dorsal skin smooth, flank with tubercles; dorsolateral fold absent. Colouration in life: dorsum green with black spots; sides of head and flanks brownish grey; lips white; hind limbs with distinct dark bars; webbing dark grey; ventral surface whitish (determination after Bourret, 1942; Bain et al., 2003).

DISTRIBUTION. In Vietnam, this species has been recorded from Bac Kan, Lang Son, and Lam Dong provinces. This is the first record of *O. graminea* from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, the species is known from China (Nguyen et al., 2009).

REMARKS. The specimens were collected at night time in a small cascade stream.

Odorrana nasica (Boulenger, 1903)

EXAMINED MATERIAL. One adult male IEBR A.2013.74 (SVL 73.45 mm), collected by TZ and NTT, October 2009, 300–500 m asl (Fig. 31).

MORPHOLOGICAL CHARACTERS. Head longer than wide (HL 27.04 mm, HW 23.77 mm); vomerine teeth present; snout obtusely pointed, prominent, longer than eye (SL 12.75 mm, ED 8.22 mm); canthus rostralis distinct; internarial distance broader than interorbital distance and upper eyelid (IN 8.41 mm, IntOrb 6.14 mm, uEL 5.17 mm); tympanum distinct, half of eye diameter (TD 4.52 mm, ED 8.22 mm); supratympanic fold absent; fingers free of webbing; finger I longer than II; finger discs larger than those of toes, with circummarginal groove; tibiotarsal articulation reaching beyond tip of snout; tibia 4.48 times longer than wide (TiL 44.48 mm, TiW 9.92 mm); toes fully webbed; outer metatarsal tubercle absent; inner metatarsal tubercle elongate; dorsal skin smooth; dorsolateral fold present; external gular sacs absent; nuptial pads present. Colouration in life: dorsum dark green; dorsolateral fold and canthus rostralis white; sides of head and flanks brownish grey; lips whitish; tympanum dark brown; limbs with dark bars; ventral surface white (determination after Bourret, 1942; Bain et al., 2003).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai and Cao Bang provinces southwards to Ha Tinh and Thua Thien-Hue provinces. This is the first record of *O. nasica* from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, this species is known from China, Laos, and Thailand (Nguyen et al., 2009).

REMARKS. IEBR A.2013.74 was found at night in a broad, deep part of a rocky stream near the Dong Thong Ranger Station.

Odorrana yentuensis Tran, Orlov et Nguyen, 2008

EXAMINED MATERIAL. One adult male ZFMK 92851 (SVL 43.14 mm) and two adult females ZFMK 92852 (SVL 63.01 mm) and IEBR

A.2013.76 (SVL 59.29 mm) collected by TZ and NTT, October 2009, 400–600 m asl; two adult males VNMN 1320 (SVL 46.00 mm) and VNMN 1344 (SVL 45.72 mm) collected by TZ and NTT, June 2010, 350–600 m asl (Fig. 32).

MORPHOLOGICAL CHARACTERS. Males smaller than females (SVL males 43.14–46.00 mm, females 59.29–63.1 mm); head longer than wide (HL 16.21–22.83 mm, HW 13.43–20.45 mm); snout long, rounded anteriorly; vomerine teeth present; eye larger than tympanum (TD/ED 0.47–0.72); fingers free of webbing, with small discs, with circummarginal groove; finger I longer than II; subarticular tubercles round, prominent; toes almost fully webbed; subarticular tubercles distinct, rounded; dorsal skin rough, posterior part of back with small tubercles; ventral skin smooth; dorsolateral fold distinct; supratympanic fold distinct; males with nuptial pad and external vocal sacs. Colouration in life: dorsum brownish grey, with several irregular brown and/or green spots; lips white; dorsolateral fold bordered by a black line, discontinuous posteriorly; limbs with transverse bars; webbing grey; belly and ventral surface of limbs immaculate yellowish white (determination after Tran et al., 2008).

DISTRIBUTION. This species is currently known only from Bac Giang Province, Vietnam (Tran et al., 2008; Nguyen et al., 2009).

REMARKS. Four specimens were found on rocks at night in Suoi Tuyen I and II or at the shore of Suoi Tuyen I. The specimens matched the description of Tran et al. (2008) well but differ in a lower ratio of tympanum diameter to eye diameter (0.47–0.72 instead of 0.81–0.84).

Rana johnsi Smith, 1921

EXAMINED MATERIAL. One adult male ZFMK 92853 (SVL 45.76 mm), collected by TZ and NTT, October 2009, 250-300 m asl (Fig. 33).

MORPHOLOGICAL CHARACTERS. Head as broad as long (HW 15.48 mm, HL 15.70 mm), flattened; snout obtusely pointed, pronounced, longer than eye (SL 6.97 mm, ED 5.61 mm); tympanum distinct, about 3/4 of ED (TD 4.09 mm); interorbital distance broader than internostril distance and upper eyelid (IntOrb 4.00 mm, IN 3.60 mm, uEL 3.04 mm); pupil horizontal; vomerine teeth present; fingers free of webbing without discs; subarticular tubercles prominent; tibio-tarsal articulation reaching beyond tip of snout; heels overlapping; tibia five times longer than wide (TiL 30.22 mm, TiW 5.63 mm); toes with small discs, almost fully webbed; tarsal fold absent; subarticular tubercles distinct; inner metatarsal tubercle oval, prominent; outer metatarsal tubercle absent; dorsal skin smooth, with some small tubercles; some short, oblique dermal folds on limbs; a Λ-shaped fold between shoulders; supratympanic fold present; dorsolateral fold distinct anteriorly, interrupted on hip. Colouration in life: dorsum light brown, upper surface of limbs with greyish transverse bars; flanks whitish brown; a small black stripe from nostril to eye; tympanum covered by a black lozenge; sides of limbs with dark pattern; ventral surface white or cream; gular region marbled with grey; thigh yellow (determination after Bourret, 1942).

DISTRIBUTION. This is a widespread species in Vietnam, from Lao Cai and Ha Giang provinces southwards to Lam Dong and Dong Nai provinces. Elsewhere, this species is known from China, Taiwan, Laos, Thailand, and Cambodia (Nguyen et al., 2009).

REMARKS.The specimen was found on the ground of broad leaved forest. Another, most likely a female, was observed at Ba Bep Pond during the day time.

RHACOPHORIDAE

Chiromantis vittatus (Boulenger, 1887)

EXAMINED MATERIAL. Two adult males VNMN 1341–1342, collected by TZ and NTT, June 2010, 350–400 m asl; one adult male IEBR A.2013.77, collected by VH, 7 June 2010, 400 m asl (Fig. 34).

MORPHOLOGICAL CHARACTERS. SVL 19.52–25.91 mm; vomerine teeth absent; tongue bifid; pupil horizontal; tympanum indistinct, 0.34–0.60 times of ED (TD 1.05–2.21 mm, ED 3.06–3.69 mm); snout pointed, as long as diameter (SL 3.38–3.94 mm); canthus rostralis obtuse; loreal region slightly oblique; nostrils closer to tip of snout than to eye (EN 1.85–2.41 mm, NtoS 1.58–1.91 mm); interorbital distance as broad as or broader than upper eyelid (IntOrb 2.67–3.25 mm, uEL 1.90–2.85 mm); fingers free of webbing, tips of fingers with enlarged discs; finger I shorter than II; tibio-tarsal articulation

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Figure 28. *Hylarana taipehensis*. Figure 29. *Odorrana bacboensis*. Figure 30. *Odorrana graminea*. Figure 31. *Odorrana nasica*. Figure 32. *Odorrana yentuensis*. Figure 33. *Rana johnsi*. Photos by C.T. Pham, T. Ziegler, and T.Q. Nguyen.

reaching eye or beyond but not to tip of snout; limbs without fringes; toes 3/4 webbed, discs well developed; cloacal fold absent; inner metatarsal tubercle tiny; skin smooth; gular region, posterior part of ventral surface and posterior parts of femur granular; nuptial pads absent. Colouration in life: dorsum yellow or brown with light yellow stripes from nostril over eye to groin; flanks yellowish; ventral surface whitish (determination after Bourret, 1942; Ziegler, 2002).

DISTRIBUTION. This is a widespread species in Vietnam, from Lang Son Province southwards to Dong Nai and Ba Ria-Vung Tau provinces. Elsewhere, this species is known from India, China, Myanmar, Laos, Thailand, and Cambodia (Nguyen et al., 2009).

REMARKS. All three specimens were found at night on plants about 1–2 m above the ground near the ponds.

Kurixalus bisacculus (Taylor, 1962)

EXAMINED MATERIAL. Two adult males IEBR A.2013.78 (SVL 29.13 mm) IEBR A. 2013.79 (SVL 29.75 mm) collected by PTC, June 2010, 300–500 m asl (Figs. 35, 36).

MORPHOLOGICAL CHARACTERS. Head longer than wide (HL 10.66–12.80 mm, HW 9.62–11.66 mm); snout pointed anteriorly; tympanum distinct, smaller than eye (ED 4.21–4.49 mm, TD 2.41–2.75 mm); internarial distance narrower than interorbital distance (IN 3.30–3.39 mm, IntOrb 4.07–4.41 mm); vomerine teeth in two low ridges, arising near inner edges of choanae; fingers free of webbing, tips of fingers with enlarged discs; toes 3/4 webbed, discs well developed; dermal fringes along outer edges of fore arm and tarsus present; some scattered flat tubercle present on head, eyelids, and occiput, sparse on dorsum, more dense and larger on flanks, finely granuler on rump; chin granular, chest nearly smooth; venter and lower part of sides granular; vocal sacs present in males. Colouration in life: dorsal head and body light or reddish brown with green marking, occiput with a dark green marking in triangular shape; tympanum brownish; chin cream with dark spots; throat, chest, venter, and underside of limbs cream (determination after Taylor, 1962; Yu et al., 2010).

DISTRIBUTION. This species has been reported from Lao Cai and Ha Giang provinces in the North to Gia Lai Province in the South. However, the extent of this species in Central Vietnam needs to be confirmed, as it looks similar to *K. banaensis* (Bourret, 1939). Elsewhere, the species is known from China, Myanmar, Laos, Thailand, and Cambodia (Nguyen et al., 2009).

REMARKS. Specimens were found at night on the tree branches and shrubs near ponds or streams. Yu et al. (2010) regarded the previous records of *K. verrucosus* (Boulenger, 1893) in Vietnam as *K. bissaculus*.

Polypedates megacephalus Hallowell, 1861

EXAMINED MATERIAL. One adult female VNMN 1322 (SVL 70.15 mm), collected by TZ and NTT, 26 June 2010, ca. 350 m asl (Fig. 39).

MORPHOLOGICAL CHARACTERS. Head slightly longer than wide (HL 26.30 mm, HW 25.12 mm); vomerine teeth present; snout obtusely rounded, longer than eye (SL 11.93 mm, ED 6.61 mm); canthus rostralis distinct; loreal region vertical; nostrils closer to tip of snout than to eye (EN 7.45 mm, NtoS 3.66 mm); interorbital distance wider than internarial distance and upper eyelid (IntOrb 9.57 mm, IN 5.27 mm, uEL 4.93 mm); tympanum distinct, as large as eye (TD 5.04 mm); fingers free of webbing; disc of finger III half of TD (disc of finger III 2.00 mm); toes almost fully webbed; lateral dermal fringes present; subarticular tubercles present; outer metatarsal tubercle present; tibio-tarsal articulation reaching tip of snout; skin smooth; supratympanic fold distinct; vocal sacs absent. Colouration in life: dorsum orange brown, with some black blotches and sometimes with a X-shaped pattern on neck; upper surface of limbs orange brown with transverse bars; flanks and posterior side of thigh with distinct dark reticulation; throat and chest mottled in brown; ventral surface white (determination after Bourret, 1942; Manthey & Grossmann, 1997; Kuraishi et al., 2012).

DISTRIBUTION. In Vietnam, this species has been recorded from Cao Bang, Vinh Phuc, and Hai Duong provinces. Kuraishi et al. (2012) suggested that the populations of the *P. leucomystax* complex in southern China and northern Vietnam contain at least two species, *P. megacephalus* and *P. mutus*. Elsewhere, the species is known from India, China, Myanmar, Taiwan, Laos, Thailand, and Japan (Nguyen et al., 2009).

REMARKS. A single specimen was found at night on a tree branch in Suoi Tuyen II.

Polypedates mutus (Smith, 1940)

EXAMINED MATERIAL. One female VNMN A.2013.14 (SVL 89.44 mm), two males IEBR A.2013.80 (SVL 62.92 mm), ZFMK 92854 (SVL 65.36 mm), collected by TZ and NQT, 27 May 2009, 200–500 m asl (Figs. 37, 38).

MORPHOLOGICAL CHARACTERS. SVL 62.92–89.44 mm; head longer than wide (HL 21.51–30.89 mm, HW 19.36–29.13 mm); vomerine teeth present; snout pointed, longer than eye (SL 10.10–14.03 mm, ED 6.31–10.29 mm); canthus rostralis distinct, slightly concave; loreal region vertical; nostrils closer to tip of snout than to eye (EN 6.46–9.42 mm, NtoS 2.75–3.90 mm); interorbital distance wider than internarial distance and upper eyelid (IntOrb 5.52–8.14 mm, IN 3.90–5.73 mm, uEL 5.51–7.73 mm); tympanum distinct, approximately half of eye diameter (TD 3.44–5.36 mm); fingers free of webbing; disc of finger III as large as tympanum (disc of finger III 2.6–5.2 mm); toes almost fully webbed; toe discs smaller than finger discs; lateral dermal fringe present; subarticular tubercles present; outer metatarsal tubercle present; tibio-tarsal articulation reaching tip of snout; dorsal skin smooth; upper surface of limb granular; ventral surface smooth; supratympanic fold present; vocal sacs absent. Colouration in life: dorsum beige yellow or brown, with or without dark blotches; a X-shaped pattern present on neck; limbs with dark transverse bars; dark brown stripe bordering supratympanic fold from eye beyond arm; flanks sometimes with few dark brown spots; back of thigh with large white spots; belly yellowish white; throat finely mottled or spottet (determination after Ziegler, 2002; Ziegler et al., 2006; Kuraishi et al., 2012).

DISTRIBUTION. This is a widespread species in Vietnam. Elsewhere, this species is known from China, Myanmar, Laos, and Thailand (Nguyen et al., 2009).

REMARKS. All three specimens were found at night on tree branches in about 1.5–2 m above a stream. A couple of *P. mutus* in amplexus was photographed on the forest path in June 2010. Further individuals were sighted on tree trunks or leaves between 0.5 and 3 m above the streams or around ponds during the day and at night time.

Rhacophorus maximus Inger, 1966

EXAMINED MATERIAL. Two adult males IEBR 3653, IEBR 3680, collected by NQT, 10–13 May 2008; one adult male VNMN 1535 and one adult female VNMN 1538, collected by NTT, June 2009, 250–500 m asl (Fig. 40).

MORPHOLOGICAL CHARACTERS. SVL 74.34–131.0 mm; head broader than long (HW 28.1–36.74 mm, HL 26.4–34.48 mm); vomerine teeth present; nostril oval, closer to tip of snout than to eye; tympanum round, smaller than eye diameter (TD 4.4–5.64 mm, ED 7.16–9.41 mm); interorbital distance wider than internarial distance (IntOrb 9.5–11.97 mm, IN 7.9–10.72 mm); supratympanic fold distinct; fingers and toes completely webbed; metacarpal tubercle well developed in males; males with vocal sacs. Colouration in life: dorsal surface of head and body uniformly green; a narrow white stripe present along the flanks; ventral surface cream (determination after Anders & Rai, 2002; Nguyen et al., 2008).

DISTRIBUTION. In Vietnam, this species has been recorded from Bac Giang and Nghe An provinces. Elsewhere, the species is known from India, Nepal, China, and Thailand (Nguyen et al., 2009).

REMARKS. Specimens were found on trees and shrubs (ca. 1–3 m above the ground) near Ao Cua pond or streams in secondary forests near Dong Ri Ranger Station.

Rhacophorus rhodopus (Liu et Hu, 1960)

EXAMINED MATERIAL. Two adult males ZFMK 92855, IEBR A.2013.81 (VH28) collected by TZ and NQT, 27 May 2009, 400 m asl; one adult male VNMN A.2013.15, collected by VH, 7 June 2010, ca. 430 m asl (Fig. 41).

MORPHOLOGICAL CHARACTERS. SVL 39.89–40.17 mm; head as long as or longer than wide (HL 14.41–14.81 mm, HW 13.18–14.63 m); vomerine teeth present; tongue notched posteriorly; snout pointed, longer than eye diameter (SL 6.44–6.69 mm, ED 4.53–5.57 mm); pupil rounded; nostril closer to eye than to tip of snout (EN 2.65–3.27 mm, NtoS 3.00–3.11 mm); interorbital distance broader than internarial distance and upper eyelid (IntOrb 6.44–6.69 m, IN 3.87–4.17 mm, uEL 3.60–4.46 mm); tympanum distinct, about

half of eye diamter (TD 1.79–2.45 mm); fingers almost fully webbed; finger I shorter than II; subarticular tubercles distinct; toes fully webbed; tarsal fold present; inner metatarsal tubercle present, outer metatarsal tubercle absent; subarticular tubercles small, distinct; tibio-tarsal articulation reaching between eye and tip of snout; tibia about five times longer than wide (TiL 19.09–19.63 mm, TiW 3.52–3.74 mm); cloacal dermal fringe present; skin smooth. Colouration in life: dorsum reddish brown with or without small black spots; large black blotches on axilla and flanks present or absent; transverse bands on hind limbs absent or indistinct; ventral yellowish white; webbing of fingers and toes reddish orange (determination after Bourret, 1942; Lui & Hu, 1960).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai Province southwards to Lam Dong and Dong Nai provinces. The first record of *R. rhodopus* from Tay Yen Tu NR was reported by Nguyen et al. (2008). Elsewhere, the species is known from India, China, Myanmar, Laos, Thailand, and Cambodia (Nguyen et al., 2009).

REMARKS. All specimens were found at night on trees and bushes, ca. 0.5–1.5 m above the ground, around ponds in secondary forest. The female is bigger than the male. The female has yellowish orange flanks with some black blotches. Our specimens match the descriptions of Bourret (1942) and Lui & Hu (1960), but show some differences: toes not fully webbed, transverse bands on hind limbs indistinct and black blotches on axilla and flanks absent in some individuals.

Theloderma asperum (Boulenger, 1886)

EXAMINED MATERIAL. Two adult males IEBR A.2013.82 (SVL 31.92 mm, IEBR A.2013.83 (SVL 32.32 mm), collected by PTC, 8 July 2012, elevations 300–500 m asl (Fig. 42).

MORPHOLOGICAL CHARACTERS. Head broader than long (HW 11.73–12.01 mm, HL 10.59–11.81 mm); snout rounded, as long as the eye (SL 3.66–4.20 mm, ED 3.63–3.79 mm); canthus rostralis indistinct; loreal region slightly concave; nostril closer to tip of snout than to eye (NtoS 1.05–1.48 mm, EN 2.61–2.71 mm); interorbital distance wider than upper eyelid (IntOrb 4.69–4.81 mm, uEL 2.3–2.4 mm); tympanum distinct (TD 2.45–3.20 mm); vomerine teeth absent; tongue notched behind; fingers free of webbing, tips of fingers with enlarged discs; toes 3/4 webbed, tips of toes with large discs; inner metatarsal tubercle present, small; tibiotarsal articulation reaching tip of snout; skin on dorsum and flanks with granular tubercles; throat smooth; venter granular. Colouration in life: dorsal surface blackish or greyish brown with large white blotches covering head, loreal regions, anterior parts of dorsum, upper part of flanks and hip; dark transverse bars on hind limbs present; head with short transverse brown line between eyes; ventrally body and limbs blackish with whitish marbling; iris pinkish brown (determination after Bourret, 1942; Taylor, 1962; Neang & Holden, 2008).

DISTRIBUTION. This is a widespread species in Vietnam, from Lai Chau, Lao Cai, and Ha Giang provinces in the North to Lam Dong and Dong Nai provinces in the South. *T. asperum* was previously known from the eastern side of the Yen Tu Mountain in Hai Duong Province (Nguyen et al., 2009). Our finding represents the first record of this species from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, this species is known from India, China, Myanmar, Laos, Thailand, Cambodia, and Malaysia (Nguyen et al., 2009).

REMARKS. Specimens were collected in a tree hole in bamboo forest near Mau village.

Theloderma corticale (Boulenger, 1903)

EXAMINED MATERIAL. Two adult males IEBR A.2013.84 (SVL 67.68 mm), IEBR A.2013.85 (SVL 57.48 mm) collected by PTC, 10 July 2012, elevations 300–500 m asl (Fig. 43).

MORPHOLOGICAL CHARACTERS. Head wider than long (HL 25.07–26.72 mm, HW 27.5–28.82 mm); snout longer than eye diameter (SL 10.43–12.19 mm; ED 6.37–7.14 mm); canthus rostralis rounded; loreal region concave; interorbital distance wider than internarial distance (IntOrb 7.78–8.87 mm, IN 4.19–4.67 mm); nostril closer to tip of snout than to eye (NtoS 2.21–2.85 mm; EN 9.22–9.34 mm); tympanum oval, greater than tympanum-eye distance (TD 5.29–5.30 mm, ET 3.69–4.32 mm); vomerine teeth present; tongue notched posteriorly; tips of fingers and toes enlarged into round discs; webbing present at base of fingers III and IV; dermal fringe along outer sides of arm and tarsus

present; palmar tubercles distinct; toes almost fully webbed; subarticular tubercles present; inner metatarsal tubercle present; outer metatarsal tubercle absent; dorsal surface of head, body and limbs covered with tubercles or warts of different sizes; ventral skin with small tubercles; nuptial pad present; external vocal sac absent. Colouration in life: dorsal surface green marbled with reddish brown spots; dark brown bars present on upper surface of fore and hind limbs; ventral surface yellow with green marbling (determination after Inger et al., 1999; Orlov et al., 2006).

DISTRIBUTION. This species has been recorded only from Northern Vietnam: Ha Giang, Tuyen Quang, Cao Bang, Lang Son, Vinh Phuc, and Son La provinces (Nguyen et al., 2009). This is a new record for Tay Yen Tu NR and for Bac Giang Province.

REMARKS. Specimens were discovered in a tree hole in secondary forest near Dong Thong Ranger Station.

Theloderma lateriticum Bain, Nguyen et Doan, 2009

EXAMINED MATERIAL. Two adult males VNMN 1215 (SVL 21.8 mm) and VNMN 1216 (SVL 23.1 mm), collected by PTC and NTT, 10 April 2010, elevation ca. 300 m asl (Fig. 44).

MORPHOLOGICAL CHARACTERS. Head longer than wide (HW 7.5–8.4 mm, HL 8.3–9.0 mm); vomerine teeth absent; nostril nearer to tip of snout than to eye; interorbital distance greater than width of upper eyelid; tympanum distinct, with distinct tympanic annulus (TYD 2.0–2.6 mm); fingers free of webbing; toes 1/4 webbed; outer metatarsal tubercle present; dorsal skin granular, bearing keratinized spicules, raised on small, isolated bumps; dermal fringes on the post axial portions of the limbs absent; nuptial pad present on finger I; vocal sacs absent. Colouration in life: dorsum rusty brown with a mid-dorsal black spot; lip with small white spots; upper portion of flanks with black blotches; throat, chest and belly grey-brown with cream spots (identification after Bain et al., 2009).

DISTRIBUTION. This species is known only from the type locality in Lao Cai Province, Vietnam (Bain et al., 2009). This is the first record of *T. lateriticum* from Tay Yen Tu NR as well as from Bac Giang Province.

REMARKS. Two specimens were found at night time on the tree near a rocky stream, surrounded by the mixed secondary forest of small hardwoods and shrubs near Dong Ri Ranger Station.

SQUAMATA
SAURIA
AGAMIDAE

Acanthosaura lepidogaster (Cuvier, 1829)

EXAMINED MATERIAL. One subadult female IEBR 3660 collected by NQT on 10 April 2008, ca. 350 m asl; one juvenile ZFMK 92831, collected by TZ and NQT, 28 May 2009, 200 m asl; and one juvenile VNMN 1348, collected by TZ and NTT, May 2010, ca. 400 m asl (Fig. 45).

MORPHOLOGICAL CHARACTERS. SVL subadult female 69.31 mm, juveniles 29.14–34.31 mm (n = 2), TaL subadult female 114.00 mm, juveniles 43.41–46.99 mm (n = 2); head large; postorbital spine small, shorter than half the diameter of orbit; two spines present above tympanum; nuchal crest spines 8; dorsal crest present, low; supralabials 9–14; infralabials 9–13; tympanum visible; mental small, pentagonal; body compressed, not flattened; dorsal scales heterogeneous, keeled; ventral scales strongly keeled, midbody scales in 114–123 rows; femoral pores absent; lamellae 17–19 under finger IV, 20–22 under toe IV; hind limbs long, reaching up to or over tip of snout. Colouration in life: dorsum green to dark brown, a bright rhombic pattern usually present on the neck; back and tail with dark cross bars (determination after Ziegler, 2002; Bourret, 2009).

DISTRIBUTION. This is a common species in Vietnam, from Lao Cai and Ha Giang provinces southwards to Binh Phuoc and Dong Nai provinces. Elsewhere, the species is known from China, Myanmar, Laos, Thailand, and Cambodia (Nguyen et al., 2009).

REMARKS. Specimens were collected during the day or at night on trees in mixed secondary forests of hardwood, bamboo and shrub.

Draco maculatus (Gray, 1845)

EXAMINED MATERIAL. One adult male IEBR 3671, collected by NQT, 12 April 2008, 150 m asl;

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Figure 34. *Chiromantis vittatus*. Figures 35, 36. *Kurixalus bisacculus*. Figures 37, 38. *Polypedates mutus*. Photos by T. Ziegler and C.T. Pham.

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Figure 39. *Polypedates megacephalus*. Figure 40. *Rhacophorus maximus*. Figure 41. *R. rhodopus*. Figure 42. *Theloderma asperum*. Figure 43. *T. corticale*. Figure 44. *T. lateriticum*. Photos by T. Ziegler and C.T. Pham.

one adult female IEBR A.0946, collected by TZ and NQT, 27 May 2009, 150 m asl; and one adult female VNMN 1347, collected by TZ and NTT, May 2010, ca. 350 m asl (Fig. 46).

MORPHOLOGICAL CHARACTERS. SVL male 71.93 mm, females 75.75–78.97 mm (n = 2), TaL male 116.29 mm, females 113.18–131.51 mm (n = 2); head small; upper head scales heterogeneous, strongly keeled; one spiny scale present on the back of the eyebrow arch; tympanum covered by small scales: two incisors on the upper jaw; nostrils directing laterally outwards; supralabials 7–9, smooth; infralabials 8–9; gular pouch triangular, covered by small scales, very long in males (often twice longer than head length), shorter in females; patagium supported by five ribs; dorsal scales heterogeneous, mostly smooth; lateral scales enlarged; scales on the back edges of thighs and tail base fringe-like; ventral scales smooth or feebly keeled, as large as or slightly smaller than dorsal scales; forelimbs reaching over the tip of the snout, hind limbs reaching to elbow or armpit. Colouration in life: dorsal head and body greyish-brown; patagium with variable markings, varying in form and colour (determination after Boulenger, 1912; Manthey & Grossmann, 1997; Bourret, 2009).

DISTRIBUTION. This is a widespread species in Vietnam, from Bac Kan Province in the North to Lam Dong and Ba Ria-Vung Tau provinces in the South. This is the first record of *D. maculatus* from Tay Yen Tu NR and also from Bac Giang Province. Elsewhere, the species is known from India, China, Myanmar, Laos, Thailand, Cambodia, and Malaysia (Nguyen et al., 2009).

REMARKS. Specimens were collected during the day in the secondary forest.

Physignathus cocincinus Cuvier, 1829

Adult males, females as well as juveniles were observed during our field work in Yen Tu NR (Fig. 47). They can be easily identified due to their characteristic colour pattern, the large sizes, and the long tail, gular pouch and supraorbital spines absent; dorsal crest well developed in males. Colouration in life: dorsal surface green with a touch of rost-brown and several very narrow transverse white stripes on the body and anterior part of the tail of which the first ones on the body directing backwards; wide black rings on tail; throat whitish; belly yellowish green (determination after Ziegler, 2002).

REMARKS. Several individuals of *P. cocincinus* were seen on trees, about 1–2 m above the water in Suoi Tuyen I and other large streams in Ba Bep area.

EUBLEPHARIDAE

Goniurosaurus lichtenfelderi (Mocquard, 1897)

EXAMINED MATERIAL. Three adult males IEBR 3695, ZFMK 89229, IEBR A.0827 and two adult females IEBR 3696, ZFMK 89228, collected by NQT between 12 and 15 April 2008, 250–300 m asl (Fig. 48).

MORPHOLOGICAL CHARACTERS. Body shape robust, SVL 77.1–104.3 mm; external nares bordered by 5–6 nasal scales; supraorbital region with a row of slightly enlarged tubercles; outer surface of upper eyelid composed of granular scales, about one-half the size of those on top of head and without enlarged tubercles; internasals 1–2; supralabials 8–10; preorbital scales 15–19; eyelid fringe scales 51–58; postmentals 2–5; gular region below lower jaws without enlarged tubercles; paravertebral tubercles 21–27; scale rows around midbody 117–130, granular scales surrounding tubercles 11–13; axillary pockets shallow; subdigital lamellae under toe IV 18–22; precloacal pores in males 30–32, in females 17–21. Colouration in life: iris reddish-brown; dorsal ground colour of head, body and limbs brown, without small dark brown blotches; nuchal loop thin, posteriorly rounded (in U-shape); dorsal body bands between limb insertions 2, thin, immaculate yellow; gular region without dark spots (Smith, 1935; Ziegler et al., 2008c; Nguyen, 2011).

DISTRIBUTION. This species has been recorded only from northeastern Vietnam (Nguyen et al., 2009; Nguyen, 2011).

REMARKS. Specimens of *G. lichtenfelderi* were collected on the forest floor, under decayed trees or under rocks near streams. This species is nocturnal and it inhabits the mixed forest of wooden trees, bamboo, and shrubs.

GEKKONIDAE

Hemidactylus frenatus Schlegel, 1836

EXAMINED MATERIAL. Two adult females IEBR A.2013.86 and ZFMK 92832, collected by TZ and NQT, 26 May 2009, 150 m asl (Fig. 49).

MORPHOLOGICAL CHARACTERS. SVL 58.43–59.08 mm (n = 2), tail regenerated; head covered with small scales; snout obtuse, longer than distance between eye and tympanum (SL 7.68–8.30 mm, ET 4.23–4.57 mm); eye covered by transparent membrane, without moveable eyelid; tympanum small, rounded, longer than half of ED (TD 2.25 mm, ED 3.44–3.77 mm); supralabials 10–11 + 5–7; infralabials 8–10 + 3–7; dorsal scales small, grainy; ventral scales imbricate; finger more or less paddle-like, broadened at base, with divided transverse or oblique lamellae under fingers; 5–6 divided lamellae under thumb; 9–10 divided lamellae under finger IV; terminal segments of finger I to V free, with claw; 12–13 broadened lamellae under toe IV; midbody scales in 119–121 rows; 10–12 broadened femoral scales on each side; tail strongly dorsoventrally compressed, with lateral denticulation (determination after Bourret, 2009).

DISTRIBUTION. This is a common species in Vietnam. Elsewhere, the species is known from India, Nepal, Sri Lanka, Maldives, China, Taiwan, Myanmar, Thailand, Malaysia, Indonesia, Philippines, New Guinea, Australia, Japan, Polynesia, Micronesia, Melanesia, Solomon Islands, Somalia, Madagascar, Mauritius, Reunion, Rodrique, Comoro Island, Samoa, and New Caledonia (Nguyen et al., 2009).

REMARKS. Both specimens were found at night on the walls of Vung Tron Ranger Station.

Gekko palmatus Boulenger, 1907

EXAMINED MATERIAL. One adult female IEBR 3638 (SVL 73.53 mm) collected by NQT and PTC on 8 April 2008 and one adult male IEBR A.2013.75 (SVL 64.32 mm) collected by TZ, NTT and PTC in October 2009, ca. 300 m asl (Fig. 50).

MORPHOLOGICAL CHARACTERS. Moderate-sized gecko (SVL < 80 mm); nares in contact with rostral; internasal single, smaller than supranasal; postmentals enlarged; interorbital scales between anterior corners of the eyes 30 and 36; dorsal tubercle rows 9 and 11; ventral scales between mental and cloacal slit 163 and 183; midbody scale rows 123 and 142; ventral scale rows 40 and 44; subdigital lamellae under toe I 11 or 12, under toe IV 12 or 13; finger and toe webbing present at base; tubercles absent on upper surface of fore and hind limbs; precloacal pores 24 in the male, absent in the female; postcloacal tubercle single; tubercles present on dorsal surface of tail base; subcaudals enlarged. Colouration in life: dorsal surface of head and body grey with a small light blotch on neck and four larger blotches between shoulder and sacrum; flanks with some small light spots between limb insertions; limbs with light spots and bars; dorsal tail with 8 or 9 light bands; throat, venter, and precloacal region yellowish cream with dark dots (identification after Nguyen et al., 2013).

DISTRIBUTION. In Vietnam, this species has been recorded from Yen Bai, Lang Son, Vinh Phuc, Quang Ninh, and Quang Binh provinces. The record of *G. palmatus* from Bac Giang Province was previously confused with *G. chinensis* Gray, 1842 (Nguyen et al., 2009, 2013). Elsewhere, the species is known from China (Nguyen et al., 2009).

REMARKS. Both specimens were found at night on rocky walls along a stream near Dong Ri Ranger Station.

LACERTIDAE

Takydromus kuehnei Van Denbourgh, 1909

EXAMINED MATERIAL. One adult male VNMN 1330, collected by TZ and NTT, May 2010, ca. 200 m asl (Fig. 51).

MORPHOLOGICAL CHARACTERS. SVL 52.95 mm, TaL 167.32 mm; supralabials 7; infralabials 6–7; chin shields in 4 pairs; dorsal scales in 6 rows at midbody, without a non-contiguous vertebral row of smaller scales; ventral scales widened, in 6 rows at midbody; lateral scales in 12 rows at midbody on each sides, smaller in size than dorsal and ventral scales; femoral pores 4 on each side; subdigital lamellae broadened. Colouration in life: upper surface of head and body brown, ventral surface whitish-cream, dorsal surface of limbs and tail base with black spots; upper part of flanks black with numerous yellowish spots, upper part of flanks light brown; head dark brown with

some black spots (determination after Ziegler & Bischoff, 1999; Ziegler, 2002).

DISTRIBUTION. In Vietnam, this species has been recorded from Quang Ninh, Son La, Hoa Binh, Ninh Binh, Thanh Hoa, Nghe An, and Ha Tinh provinces. This is the first record of *T. kuehnei* from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, the species has been reported from China (Nguyen et al., 2009).

REMARKS. The specimen was collected in the evening, on a ferny leaf in the secondary forest.

SHINISAURIDAE

Shinisaurus crocodilurus Ahl, 1930

During our night excursions in summer 2010, several individuals of crocodile lizards have been found and susequently released after taking measurements and photographs. Maximum SVL was 167.97 mm, maximum TaL was 208.91 mm. The morphological characters accorded with the descriptions provided by Le & Ziegler (2003) and Ziegler et al. (2008a) (Fig. 52).

DISTRIBUTION. This species is only known from southern China and northeastern Vietnam (Nguyen et al., 2009).

REMARKS. Most specimens of *S. crocodilurus* were found on branches or palm tree leaves above rocky streams in the evergreen forest at elevations between 364–450 m asl, only one was seen hiding under a rock. Further ecological data of this species from Tay Yen Tu NR will be published elsewhere.

SCINCIDAE

Ateuchosaurus chinensis Gray, 1845

EXAMINED MATERIAL. One juvenile female IEBR A.0947, collected by TZ and NTT, October 2009, 150 m asl (Fig. 53).

MORPHOLOGICAL CHARACTERS. SVL 43.14 mm, tail lost; supranasals absent; prefrontals small, separated, touching both loreals laterally; frontal anteriorly truncated, approximately three times longer than wide, twice longer than frontoparietal and interparietal together, twice longer than its distance to tip of snout; frontoparietals separated from each other, as long as interparietal; a small transparent spot present on interparietal; parietals small, in contact; nuchals absent; nostril in a single nasal; supraoculars 4; supralabials 6; infralabials 7; postmental undivided; chin shields in 2 pairs; lower eyelid scaly; tympanum deeply sunken; ventral scales in 30 rows at midbody; paravertebral scales 53; limbs with short lamellae, 17–18 under toe IV. Colouration in life: dorsum brown, each scale with a darker spot in the center; flanks mottled with black and white spots; ventral surface cream (determination after Nguyen et al., 2008; Bourret, 2009).

DISTRIBUTION. In Vietnam, this species has been recorded from Ha Giang, Lang Son, Bac Giang, and Nghe An provinces. Elsewhere, the species is known from China (Nguyen et al., 2009).

REMARKS. The juvenile female was found at night (22:00), under leaf litter in the bamboo forest near Pond Khe Cam 1. The number of paravertebral scales is somewhat higher than in Nguyen et al. (2008) (53 vs. 48–51).

Eutropis longicaudatus (Hallowell, 1856)

EXAMINED MATERIAL. One adult male IEBR A.2010.13, collected by NQT, August 2001, 200–300 m asl.

MORPHOLOGICAL CHARACTERS. SVL 79.56 mm; supranasals in contact; frontonasal broader than long; postnasal single; prefrontals touching each other; lower eyelid scaly; supraoculars 4; supraciliaries 6; supralabials 7; infralabials 5; parietals separated; nuchals in 1 pair; tympanum deeply sunken; dorsal scales bicarinate; midbody scales in 27 rows; limbs overlapping when adpressed along the body; lamellae under toe IV 26–27; precloacal shields 4, enlarged. Colouration in alcohol: dorsal head and body brown; lateral sides dark brown to black; ventral surface cream (determination after Manthey & Grossmann, 1997; Ziegler, 2002; Bourret, 2009; Nguyen et al., 2011b).

DISTRIBUTION. This is one of the most common species in Vietnam. Elsewhere, the species has been reported from China, Taiwan, Laos, Thailand, Cambodia, and Malaysia (Nguyen et al., 2009).

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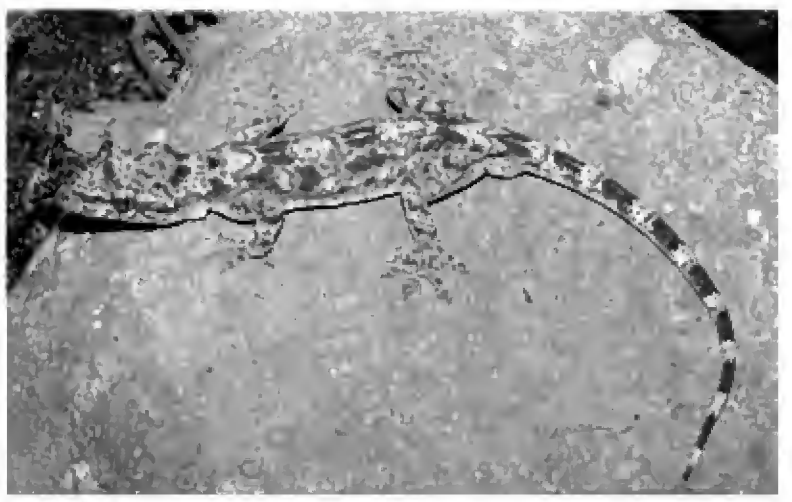

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Figure 45. *Acanthosaura lepidogaster*. Figure 46. *Draco maculatus*. Figure 47. *Physignathus cocincinus*. Figure 48. *Goniurosaurus lichtenfelderi*. Figure 49. *Hemidactylus frenatus*. Figure 50. *Gekko palmatus*. Figure 51. *Takydromus kuehnei.* Figure 52. *Shinisaurus crocodilurus*. Photos by T.Q. Nguyen, T. Ziegler and C.T. Pham.

REMARKS. The adult male was found in the morning in a plantation forest near Dong Thong Village.

Eutropis multifasciatus (Kuhl, 1820)

MORPHOLOGICAL CHARACTERS. The identification was based on direct observations and photographs (Fig. 54): head covered with large shields, prefrontals in broad contact; tympanum deeply sunken; supranasals present, separated from each other; lower eyelid scaly; one single postnasal; limbs well developed, dorsal scales tri-carinate; midbody scales in 30 rows; dark lateral band present (determination after Smith, 1935; Ziegler, 2002; Bourret, 2009).

DISTRIBUTION. This is a common species in Vietnam (Nguyen et al., 2009). Elsewhere, the species has been reported from India, throughout China, Indochina southwards to the Philippines and New Guinea (Nguyen et al., 2009).

REMARKS. One subadult specimen was observed in the evening of 8 June 2010 near the Dong Thong Ranger Station.

Plestiodon tamdaoensis (Bourret, 1937)

EXAMINED MATERIAL. One adult VNMN 1351, collected by TZ and NTT, June 2010; one adult female IEBR A.2010.06, collected by NQT, August 2001, ca. 300 m asl (Fig. 55).

MORPHOLOGICAL CHARACTERS. SVL male 120.2 mm, female 87.6 mm, tail of the male regenerated (TaL 108.7 mm), of the female lost; supranasals large, in contact with each other; postnasal single; postmentals 2; prefrontals in contact with each other; loreals 3; lower eyelid scaly; supraoculars 4; supraciliaries 8–9; frontoparietals in contact with each other; interparietal larger than frontoparietals; parietals separated; nuchals in 2 pairs; supralabials 8–9; infralabials 7; tympanum deeply sunken, with 3 small lobules on the anterior edge; dorsal scales smooth; midbody scales in 24 rows; paravertebral scales 42; lamellae under toe IV 19; precloacal shields 2, enlarged; limbs overlapping when adpressed along body. Colouration in alcohol: dorsal head and body brown; lateral band black-brown; ventral surface cream (determination after Hikida et al., 2001; Bourret, 2009).

DISTRIBUTION. In Vietnam, this species has been recorded from Ha Giang, Cao Bang, Bac Kan, Vinh Phuc, Bac Giang, Hai Duong, Hoa Binh, and Nghe An provinces. Elsewhere, the species is known from China (Nguyen et al., 2009).

REMARKS. Both specimens were found at night in the mixed secondary forest.

Sphenomorphus cryptotis Darevsky, Orlov et Ho, 2004

EXAMINED MATERIAL. Two adult males ZFMK 92833 and VNMN A.2013.16, collected by TZ and NTT, October 2009, ca. 500 m asl (Fig. 56).

MORPHOLOGICAL CHARACTERS. SVL 70.50–78.06 mm, TaL 127.67 mm; supranasals absent; rostral touching frontonasal; prefrontals in contact with each other; parietals in contact posteriorly; supraoculars 4; supralabials 7–8; infralabials 7; postmental undivided; primary temporal single; external ear present, without lobules, tympanum superficial; dorsals larger than laterals and ventrals; midbody scales in 34–36 rows; paravertebral scales 75; ventrals 80; limbs well developed, overlapping when adpressed along body; lamellae under toe IV 18–19. Colouration in life: dorsum and tail base bronze brown with a vertebral row of large black blotches; upper lateral zone with a dark grey stripe, in width of 4–5 scales, from behind eye to tail base, paler on distal tail; two rows of light spots on upper and lower margins of the dark stripe; lower lateral zone light grey (determination after Darevsky et al., 2004; Nguyen, 2011; Nguyen et al., 2011a).

DISTRIBUTION. This species is known only from Vietnam, in Lao Cai, Quang Ninh, Bac Giang, and Nghe An provinces (Nguyen et al., 2009; Nguyen, 2011).

REMARKS. Both specimens were found at night on leaves, ca. 0.2–0.5 m above the stream and on the rock in Suoi Tuyen I.

Sphenomorphus incognitus (Thompson, 1912)

EXAMINED MATERIAL. Two subadults TYT 62, 150, three adult females TYT 644, 675, 676, collected by TTT in May 2006; one adult male IEBR A.0823, two sudadults IEBR A.0825–A.0826 collected by NQT and NVS in August 2001; one subadult female IEBR 3637, two adult females IEBR 3687–3688, collected by NQT between 9 and

13 April 2008, 200–400 m asl; one subadult ZFMK 92834, collected by TZ and NTT, October 2009, ca. 350 m asl (Fig. 57).

MORPHOLOGICAL CHARACTERS. Size (SVL 79.6–103.9 mm, n = 6); prefrontals separated from each other; supralabials 7; primary temporals 2; external ear present, without lobules, tympanum deeply sunken; midbody scales in 36–44 rows; dorsal scales smooth, paravertebral scales 67–80, not widened; limbs well developed; subdigital lamellae under toe IV 19–24. Colouration in life: dorsum and tail base greyish brown or brown with irregular black dots; dorsolateral area with white spots; upper lateral zone with a black stripe, not clearly defined, in width of 3–4 scales, from behind eye to tail base, interrupted by light spots; lower lateral zone light grey with dark marbling or spots (determination after Nguyen et al., 2012).

DISTRIBUTION. *S. incognitus* was recorded for the first time from Vietnam by Nguyen et al. (2012). Elsewhere, the species is known from China and Taiwan (Nguyen et al., 2012).

REMARKS. *S. incognitus* inhabits the mixed forest of small wooden trees, bamboo, and shrub, at elevation between 200–400 m. Specimens were found both on the forest floor and in streams.

Sphenomorphus indicus (Gray, 1853)

EXAMINED MATERIAL. One adult VNMN 1329, collected by TZ and NTT, 26 June 2010, ca. 300 m asl (Fig. 58).

MORPHOLOGICAL CHARACTERS. SVL 75.91 mm, tail lost; supranasals absent; prefrontals in contact with each other; parietals slightly in contact; nuchals absent; lower eyelid scaly; supraoculars 4; supraciliaries 8; supralabials 7; infralabials 7; primary temporals 1/2; external ear present, with 1–3 very small lobules or without lobules, tympanum deeply sunk; postmental undivided; midbody scales in 36 rows; limbs overlapping when adpressed along body; lamellae under toe IV 17–18. Colouration in life: dorsum and tail base bronze brown with irregular black dots; light dorsolateral stripe present on neck and shoulder; upper lateral zone with a dark stripe, in width of 2–3 scales, from behind eye to tail base, paler on distal tail, light bars sometimes present on lower lateral zone; ventral surface whitish (determination after Smith, 1935; Manthey & Grossmann, 1997; Ziegler, 2002; Nguyen, 2011; Nguyen et al., 2011a).

DISTRIBUTION. *S. indicus* is a common species in Vietnam. However, this is the first record of the species from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, the species is known from India, Bhutan, China, Taiwan, Myanmar, Laos, Thailand, Cambodia, Malaysia, and Indonesia (Nguyen et al., 2009).

REMARKS. A single specimen was found in the evening on the forest ground near Suoi Tuyen I.

Sphenomorphus tonkinensis Nguyen, Schmitz, Nguyen, Orlov, Böhme et Ziegler, 2011

EXAMINED MATERIAL. One adult male VNMN 1331, collected by TZ and NTT, 26 June 2010, ca. 400 m asl (Fig. 59).

MORPHOLOGICAL CHARACTERS. SVL 42.82 mm, TaL 51.43 mm; head longer than wide; supranasals absent; prefrontals in contact with each other; supralabials 7; infralabials 6; nuchals absent; primary temporals 2; external ear present, without lobules, tympanum slightly sunken; limbs overlapping when adpressed along body; midbody scales in 34 rows; dorsal scales smooth; paravertebrals 74; lamellae under toe IV 15. Colouration in life: dorsum and tail base bronze brown with black, discontinuous vertebral line reaching to first third of tail; upper part of flanks with black bars, interrupted by small, light spots in the neck; tail orange brown; ventral surface cream (determination after Nguyen et al., 2011a).

DISTRIBUTION. In Vietnam, this species has been recorded from Vinh Phuc, Quang Ninh, and Hai Phong provinces. This is the first record of *S. tonkinensis* from Tay Yen Tu NR as well as from Bac Giang Province. Elsewhere, the species is known from China (Nguyen et al., 2011).

REMARKS. The specimen was found at night in forest near Suoi Tuyen II.

Tropidophorus hainanus Smith, 1923

EXAMINED MATERIAL. One adult male ZFMK 92835, collected by TZ and NTT, October 2009, ca. 400 m asl; one adult male VNMN 1343, collected by TZ and NTT, June 2010, 440 m asl (Fig. 60).

MORPHOLOGICAL CHARACTERS. SVL 37.77–42.31 mm (n = 2), TaL: 46.86 mm; head longer than wide; head shields striated; supranasals absent; frontonasal undivided; prefrontals separated from each other; tympanum superficial; supralabials 6–7; infralabials 5; postmental undivided; nuchals absent; limbs overlapping when adpressed along body; dorsals and laterals keeled; midbody scales in 30–32 rows; ventrals 43–44, cycloid; paravertebral scales 44; lamellae under toe IV 16–18; precloacal shields 2, enlarged. Colouration in life: dorsal head and body brown, with bright, narrow, transverse bars bordered with black, the first two V-shaped; flanks cream, upper part of flanks with large whitish dark bordered spots; ventral surface white; throat with dark longitudinal lines (determination after Bourret, 2009 and Nguyen et al., 2010b).

DISTRIBUTION. In Vietnam, this species has been recorded from Lai Chau, Lao Cai, and Ha Giang provinces southwards to Dak Lak and Dak Nong provinces. Elsewhere, the species is known from China (Nguyen et al., 2009).

REMARKS. One specimen (ZFMK 92835) was found at night on a rock in Suoi Tuyen I and another specimen (VNMN 1343) was collected on the forest ground near Ba Bep Pond in the late morning (11:40).

Tropidophorus sinicus Boettger, 1886

EXAMINED MATERIAL. One adult female VNMN A.2013.17 and one adult male ZFMK 92836, collected by TZ and NTT, October 2009, 400–600 m asl (Fig. 61).

MORPHOLOGICAL CHARACTERS. SVL male 53.12 mm, female 60.74 mm, TaL male 66.69 mm, female 76.24 mm; head longer than wide; head shields striated; supranasals absent; frontonasal divided; prefrontals in contact; loreal single; tympanum distinct, superficial; supralabials 5; infralabials 5; postmental divided; midbody scales in 32 rows; dorsal scales keeled; paravertebral scales 43–45; lamellae under toe IV 17–21. Colouration in life: dorsal head and body dark brown, with large, transverse pale yellow bars; flanks with smaller light spots; ventral surface white (determination after Bourret, 2009; Nguyen et al., 2010b; Nguyen, 2011).

DISTRIBUTION. In Vietnam, this species has been recorded from Cao Bang, Bac Kan, Lang Son, Bac Giang, Hai Duong, and Quang Ninh provinces. Elsewhere, the species is known from China (Nguyen et al., 2009).

REMARKS. Both specimens were found on rocks in Suoi Tuyen I.

SERPENTES
CALAMARIIDAE

Calamaria pavimentata Duméril et Bibron, 1854

EXAMINED MATERIAL. One juvenile VNMN 1349 (SVL 134.78 mm, TaL 10.33 mm), collected by TZ and NTT, June 2010, ca. 250 m asl (Fig. 62).

MORPHOLOGICAL CHARACTERS. Head not distinct from neck; internasals absent; rostral as wide as high, clearly visible from above; frontal longer than wide but shorter than parietals, approximately two times wider than supraocular; pupil round; loreal absent; preocular single; postocular single; temporals absent; supralabials 4, second and third touching the eye, fourth largest; infralabials 5, first touching mental; mental groove present; chin shields in 2 pairs, in contact medially; dorsal scales smooth, in 13:13:13 rows; ventrals 160; cloacal shield undivided; subcaudals 24, divided; tail with pointed tip. Colouration in life: dorsum brown, dark collar in nuchal region, outermost dorsal scale rows with dark line; neck with orange transverse band; ventral surface yellowish; tail with 2 yellow spots at base and 2 other ones close to the tip, ventral surface with a thin dark median line (determination after Smith, 1943; Ziegler et al., 2008b; Nguyen et al., 2009).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai and Cao Bang provinces southwards to Quang Nam and Lam Dong provinces. This is the first record of *C. pavimentata* from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, the species is known from China, Myanmar, Laos, Cambodia, Thailand, Malaysia, Indonesia, and Japan (Nguyen et al., 2009).

REMARKS. The specimen was found at night in the mixed forest of bamboo and small hardwood.

Calamaria septentrionalis Boulenger, 1890

EXAMINED MATERIAL. One adult male IEBR 3713 (SVL 287.36 mm, TaL 28.45 mm), collected

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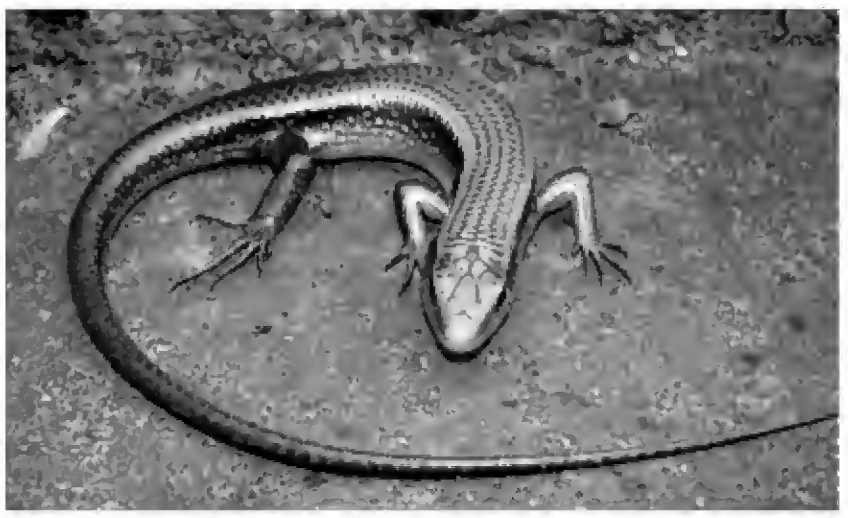

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Figure 53. *Ateuchosaurus chinensis*. Figure 54. *Eutropis multifasciatus*. Figure 55. *Plestiodon tamdaoensis*. Figure 56. *Sphenomorphus cryptotis*. Figure 57. *S. incognitus*. Figure 58. *S. indicus*. Figure 59. *S. tonkinensis*. Figure 60. *Tropidophorus hainanus*. Figure 61. *T. sinicus*. Photos by T. Ziegler, T.Q. Nguyen, and C.T. Pham.

by NQT, NTT and PTC, 18 June 2009, ca. 350 m asl (Fig. 63).

MORPHOLOGICAL CHARACTERS. Head not distinct from neck; internasals absent; rostral as wide as high, barely visible from above; frontal longer than wide but shorter than parietals, 2.5 times wider than supraocular; pupil round; loreal absent; preocular single; postocular single; temporals absent; supralabials 4, second and third touching the eye, fourth largest; infralabials 5, first touching mental; mental groove present; chin shields in 2 pairs, in contact medially; dorsal scales smooth, in 13:13:13 rows; ventrals 157; cloacal shield undivided; subcaudals 17, divided; tail tapering with rounded end. Colouration in life: dorsum dark brown; outermost dorsal scale rows yellow, edged in black below; neck with two large orange blotches; ventral surface yellowish; ventral scales with dark outermost corners; tail with 2 yellow spots at base and 2 other ones close to the tip, ventral surface with a thin dark median stripe (determination after Smith, 1943; Ziegler et al., 2008b; Nguyen et al., 2009).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai and Ha Giang southwards to Ha Tinh and Quang Binh provinces. Elsewhere, the species is known from China (Nguyen et al., 2009).

REMARKS. The specimen was found at night in the bamboo forest near Mau Village.

COLUBRIDAE

Ahaetulla prasina (Boie, 1827)

This is a widespread species in Vietnam (Fig. 64). Elsewhere, the species is known from India throughout China and Indochina, southwards to Indonesia and the Philippines (Nguyen et al., 2009).

One specimen was seen during the day time in June 2010 in the bamboo forest near Mau Village. Species identification was based on photographs: Head very long, with a very long, pointed snout; canthus rostralis very sharp; pupil horizontal; body green, with interstitial white and black stripes (determination after Smith, 1943; Ziegler, 2002).

Cyclophiops multicinctus (Roux, 1907)

This is a widespread species in Vietnam (Fig. 65). However, this is the first record of *C. multicinctus* from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, the species is known from China and Laos (Nguyen et al., 2009).

One individual was seen at night in October 2009 in branches above a forest stream near Dong Ri Ranger Station. Identification was based on photographs: head and anterior part of body green, posterior part of body and tail brown with some pale black and white spots forming interrupted bars on body; ventral surface yellow (determination after Smith, 1943; Ziegler et al., 2007).

Lycodon futsingensis (Pope, 1928)

EXAMINED MATERIAL. One adult male IEBR A 2013.87, collected by TZ and NTT, October 2009, ca. 350 m asl; one adult male VNMN 1350, collected by TZ and NTT, June 2010, ca. 450 m asl (Fig. 66).

MORPHOLOGICAL CHARACTERS. SVL 512.52–527.51 mm (n = 2), TaL 145.02–147.76 mm (n = 2); head distinct from neck; snout long, prominent; pupil vertically elliptic; rostral large; internasals wider than long, not touching loreal and preocular; frontal hexagonal; parietals longer than wide; nasal divided; loreal single, not entering orbit; preocular single; postoculars 2; temporals 2+3; supralabials 8, third to fifth or fourth and fifth entering orbit; infralabials 8–9; mental groove present; dorsal scales smooth, in 17:17:15 rows; vertebrals not enlarged; ventrals 3–4 + 198–200, laterally distinctly angulated; cloacal shield undivided; subcaudals 76–81, divided. Colouration in life: back brownish grey to dark brown, with 23–24 light brown bands on body, 12 bands on tail; first band starting at ventrals 15–20; some bands in Y-shape, more distinct in posterior part of body; head grey with a lighter band, from eye to neck; belly cream, posterior part mottled; lower surface of tail dark brown (determination after Bourret, 1936; Vogel et al., 2009).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai and Cao Bang provinces southwards to Quang Binh and Da Nang provinces. Elsewhere, the species is known from China (Nguyen et al., 2009).

REMARKS. Both specimens were found at night in Suoi Tuyen I Stream. One was found on a root near the water and the other specimen was collected on a tree branch, about 2 m above the ground.

Lycodon meridionalis Bourret, 1936

EXAMINED MATERIAL. One adult female VNMN 1333, collected by TZ and NTT, 24 June 2010, ca. 360 m asl (Fig. 67).

MORPHOLOGICAL CHARACTERS. SVL 632.13 mm, TaL 164.23 mm; head distinct from neck; rostral twice as wide as high; internasals wider than long; prefrontals wider than long; frontal small, narrowing posteriorly, shorter than parietals; posterior nasal longer than anterior one; pupil vertically elliptic; loreal single, entering orbit at a point, not touching internasals; preocular single; postoculars 2; temporals 2+2/3; supralabials 8/9, third to fifth or fourth and fifth touching the eye; infralabials 9/10; chin shields in 2 pairs; mental groove present; dorsal scale rows 17:17:15; outer dorsal scale rows not keeled; vertebral scales not enlarged; ventrals 2+231ventrals; cloacal shield undivided; subcaudals 98, divided. Colouration in life: dorsum black, with 93 yellow transverse bands on body and 24 on tail; upper surface of head black with yellow sutures; flanks yellow with irregular black spots; ventral surface yellow; subcaudals dark brown to black with light sutures (determination after Bourret, 1936; Smith, 1943).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai and Ha Giang provinces southwards to Ninh Binh Province. Elsewhere, the species is known from China and Laos (Nguyen et al., 2009).

REMARKS. The specimen was found in the evening (ca. 19:00) on a branch, about 1.6 m above the water in Suoi Tuyen I Stream. Some other individuals were seen on branches about 1–2 m above the ground.

Oligodon chinensis (Günther, 1888)

EXAMINED MATERIAL. One adult male IEBR 3708, collected by NQT, NTT and PTC, 17 June 2009, ca. 300 m asl; one adult female VNMN 1352, collected by TZ and NTT, June 2010, ca. 250 m asl (Fig. 68).

MORPHOLOGICAL CHARACTERS. SVL male 460.2 mm, female 574.06 mm, TaL male 125.85 mm, female 103.87 mm; head indistinct from neck; internasals 2; prefrontals 2; frontal longer than its distance to tip of snout, as long as parietals; nasal divided or undivided; loreal single; preocular single; postoculars 2; suboculars absent; temporals 1+2; supralabials 8, fourth and fifth touching the eye; infralabials 8–9; mental groove present; dorsal scale rows 17:17:15; ventrals 1-2 + 173–182, slightly laterally angulated; cloacal shield undivided; subcaudals 52–63, divided. Colouration in life: dorsal surface brown to reddish brown with 11–13 distinct dark spots on body and 4 on tail; narrow, interrupted, black bands present between those spots; an inverse V-marking present behind head, distinct; dark spot on temporal region present or absent; belly white, with rectangular blotches (determination after Bourret, 1936; Smith, 1943; David et al., 2008).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai and Lang Son southwards to Gia Lai provinces. This is the first record of *O. chinensis* from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, the species is known from China (Nguyen et al., 2009).

REMARKS. Both specimens were found in the mixed secondary forest of small hardwood and bamboo. Another specimen was observed in the evening (20:30) near the stream close to Khe Cam Pond on 4 July 2010. Our specimens agreed with the descriptions of Bourret, (1936), Smith, (1943) and David et al. (2008), but showed some minor differences: dorsal dark spots cover only two instead of three vertebral scales and nasal of IEBR 3708 divided on one side and undivided on the other side.

Rhadinophis prasinus (Blyth, 1854)

EXAMINED MATERIAL. One adult male VNMN 1335, collected by TZ and NTT, 26 June 2010, ca. 400 m asl (Fig. 69).

MORPHOLOGICAL CHARACTERS. SVL 596.98 mm, TaL 230.71 mm; head distinct from neck; pupil round; internasals in contact with each other, wider than long but shorter than prefrontals; rostral wider than high; prefrontals 2; frontal longer than wide, as long as its distance to tip of snout, shorter than parietals, not touching preocular; loreal single; preocular single; postoculars 2; temporals 2+2/3; supralabials 9, fourth to sixth touching the eye; infralabials 8; mental groove present; dorsal scale rows 19:19:15; ventrals 6+196; cloacal shield di-

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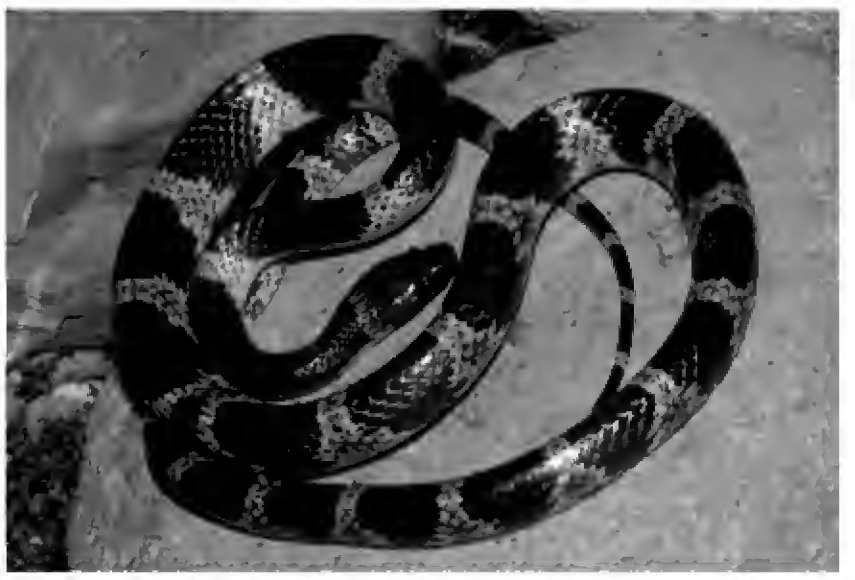

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Figure 62. *Calamaria pavimentata*. Figure 63. *C. septentrionalis*. Figure 64. *Ahaetulla prasina*. Figure 65. *Cyclophiops multicinctus*. Figure 66. *Lycodon futsingensis*. Figure 67. *L. meridionalis*. Figure 68. *Oligodon chinensis*. Photos by T.Q. Nguyen and T. Ziegler.

vided; subcaudals 111, divided. Colouration in life: dorsal surface entirely green; flanks yellowish green; interstitial skin black and white, more distinct in the anterior part of body; belly whitish-green (determination after Bourret, 1936; Smith, 1943; Manthey & Grossmann, 1997).

DISTRIBUTION. In Vietnam, this species has been known from Lao Cai, Bac Kan, Thai Nguyen, Vinh Phuc, Nghe An, Quang Binh, and Gia Lai provinces. This is the first record of *R. prasinus* from Tay Yen Tu NR as well as from Bac Giang Province. Elsewhere, the species is reported from India, China, Myanmar, Laos, Thailand, and Malaysia (Nguyen et al., 2009).

REMARKS. A single specimen was found in the evening (19:00) on a tree branch, approximately 1.60 m above the ground in Suoi Tuyen I. Our specimen differs from the descriptions of Bourret (1936) and Manthey & Grossmann (1997) in having three instead of two posttemporals on the left side.

Rhynchophis boulengeri (Mocquard, 1897)

EXAMINED MATERIAL. One adult male IEBR A.2013.88, collected by TZ and NTT, October 2009, ca. 350 m asl (Fig. 70).

MORPHOLOGICAL CHARACTERS. SVL 645.15 mm, TaL 252.28 mm; head long, distinct from neck; conical appendix present, covered by small scales on upper jaw, directing upwards, somewhat longer than its distance to eye; pupil round; nostril surrounded by 2 nasals; internasals half size of prefrontals; frontal broad anteriorly, shorter than parietals; loreal single, longer than high; preocular single, touching frontal; postoculars 2; temporals 2+2+3; supralabials 9, fourth to sixth touching eye; infralabials 10; dorsal scales smooth, in 19:19:15 rows; mental groove present; ventrals 221; cloacal shield divided; subcaudals 137, divided. Colouration in life: upper surface green; a black line running from nostril to the eye and continuing to neck; ventral surface light green; laterally angulated region of ventrals white (determination after Bourret, 1936; Pope, 1935; Smith, 1943).

DISTRIBUTION. In Vietnam, this species has been recorded from Son La, Thai Nguyen, Vinh Phuc, Hanoi, Quang Ninh, Hai Phong, and Ha Tinh provinces. This is the first record of *R. boulengeri* from Tay Yen Tu NR as well as from Bac Giang Province. Elsewhere, the species is known from China (Nguyen et al., 2009).

REMARKS. The adult male was found in the evening (19:00) on a tree branch, about 1.60 m above the ground at Suoi Tuyen I. A small bird was found in its stomach. The scale counts of IEBR A2013.88 are somewhat higher than in the description of Smith (1943) (221 ventrals instead of 207–216 and 137 subcaudals instead of 123–132).

Sibynophis chinensis (Günther, 1899)

EXAMINED MATERIAL. One adult male VNMN 1353, collected by TZ and NTT, May 2010, ca. 300 m asl (Fig. 71).

MORPHOLOGICAL CHARACTERS. SVL 367.25 mm, TaL 153.31 mm, tail tip broken; rostral wider than high; internasals 2, in contact with each other; prefrontals 2; parietals 2, touching upper postocular; pupil round; loreal single; preocular single, twice as high as loreal; postoculars 2; temporals 2+2; supralabials 9, fourth to sixth touching the eye; infralabials 9; mental groove present; chin shields in 2 pairs; dorsal scales smooth, in 17:17:17 rows; ventrals 164; cloacal shield divided; subcaudals 75, divided. Colouration in alcohol: dorsal head olive grey with two narrow black crossbars behind the eyes and another large one on neck; a dark stripe running from nostril to the eye and continuing to neck; ground colour of body and tail light reddish grey, dorsum with a vertebrally interrupted line of dark spots and two interrupted lines of light spots laterally; ventral surface yellowish-white, darker on ventral tail; each ventral with one dark spot on lateral edge and two dark spots in the center, these spots on subcaudals forming dark lines on ventral tail (determination after Pope, 1935; Bourret, 1936; Smith, 1943).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai, Cao Bang, Bac Kan, Vinh Phuc, Hoa Binh, Ninh Binh, Quang Tri, and Gia Lai provinces. This is the first record of *S. chinensis* from Tay Yen Tu Nature Reserve and from Bac Giang Province. Elsewhere, the species is known from China and Taiwan (Nguyen et al., 2009).

REMARKS. The single specimen was found on the forest floor. The specimen has fewer ventral scales than reported by Smith (1943) (164 instead of 168–183).

LAMPROPHIIDAE

Psammodynastes pulverulentus (Boie,1827)

Only one individual was seen at night in October 2009 on branches next to a forest trail about 1.5 m above the ground (Fig. 72).

MORPHOLOGICAL CHARACTERS. Identification was based on photographs: head elongated, in triangular shape; dorsal surface of head and neck brown with some dark stripes; dorsal body and tail brown with some light spots, edged in black (determination after Smith,1943; Ziegler et al., 2002).

DISTRIBUTION. Although *P. pulverulentus* is known almost from entire Southeastern Asia and from Vietnam (Nguyen et al., 2009), this is the first record of the species from Tay Yen Tu NR as well as from Bac Giang Province.

NATRICIDAE

Amphiesmoides ornaticeps (Werner, 1924)

EXAMINED MATERIAL. One subadult male VNMN 1355, collected by TZ and NTT, June 2010, ca. 200 m asl (Fig. 73).

MORPHOLOGICAL CHARACTERS. SVL 284.29 mm, TaL 139.01 mm; head distinct from neck; rostral hexagonal, wider than high; internasals 2, in contact, as long as prefrontals, narrowing anteriorly; prefrontals 2, touching loreal; frontal hexagonal, longer than wide; nostrils laterally; pupil round; loreal single, in contact with nasal; preocular single, postoculars 3; temporals 2+2/3; supralabials 9, fourth to sixth entering orbit; infralabials 8; mental groove present; dorsals strongly keeled, midbody scale rows 19; ventrals 2+160; cloacal shield divided; subcaudals 122, divided. Colouration in alcohol: upper surface of body and tail greyish brown, anterior part of body with white squarrish net; flanks cream, with some brown marbling; head light brown; eye bordered by two vertical white streaks, edged in black, posterior one large; ventral surface cream (determination after Pope, 1935; Nguyen et al., 2010a).

DISTRIBUTION. In Vietnam, this species has been recorded from Bac Giang, Hoa Binh, and Nghe An provinces. Elsewhere, the species is known from China (Nguyen et al., 2009).

Remarks.A single specimen was found on the forest floor near Mau Village. Another specimen was collected in a small stream in bamboo forest near Mau Village in April 2008.

Opisthotropis lateralis Boulenger, 1903

EXAMINED MATERIAL. One adult male ZFMK 93904, collected by TZ and NQT, 28 May 2009, 200 m asl (Fig. 74).

MORPHOLOGICAL CHARACTERS. SVL 407.06 mm, TaL 64.61 mm; rostral broader than high; internasals 2, as long as broad, in contact with each other; prefrontal single; frontal longer than wide, shorter than parietals, twice as broad as supraocular; nostrils directing upwards, in the upper part of single nasal; pupil round; loreal single, longer than high, not touching internasals; preoculars 2; postoculars 2; temporals 1+2; supralabials 10, sixth touching the eye; infralabials 9; mental groove present; dorsal scales smooth, in 17:17:17 rows; ventrals 2+184; cloacal shield divided; subcaudals 49, divided. Colouration in life: dorsal surface dark greyish brown, with 7 longitudinal lines on back; one black line on third dorsal scale row; 3 outer rows of dorsal scales orange; ventral surface yellowish white (determination after Pope, 1935; Bourret, 1936; David et al., 2011).

DISTRIBUTION. In Vietnam, this species has been recorded from Cao Bang, Lang Son, Vinh Phuc, Quang Ninh, Bac Giang, Hai Duong, and Hoa Binh provinces. Elsewhere, the species is known from China (Nguyen et al., 2009).

REMARKS. The specimen was found at night (21:00) in a small water pool in a stream near Vung Tron Ranger Station. The specimen matched the descriptions of Pope (1935), Bourret (1936) and David et al. (2011) but showed some differences: more ventral scales (2+184 instead of maximum 173), prefrontal entire instead of semi-divided, a longer total length (471.67 mm instead of maximum 437 mm), and a lower ratio of tail to total length (0.137 instead of 0.25).

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Figure 69. *Rhadinophis prasinus*. Figure 70. *Rhynchophis boulengeri*. Figure 71. *Sibynophis chinensis*. Figure 72. *Psammodynastes pulverulentus*. Figure 73. *Amphiesmoides ornaticeps*. Figure 74. *Opisthotropis lateralis*. Photos by T. Ziegler and T.Q. Nguyen.

Rhabdophis subminiatus (Schlegel, 1837)

Identification was based on photographs (Fig. 75): head distinct from neck; eye large, black; upper head bluish; neck with a black blotch, followed by a U-shaped yellow band; a black vertical stripe below the eye, directing backwards; anterior part of body reddish brown, posterior part yellowish brown, with numerous black or dark grey scales forming a regular pattern; tail brown; ventral surface cream (determination after Ziegler, 2002).

DISTRIBUTION. This is a common species in Vietnam. Elsewhere, the species is known from India throughout China and Indochina southwards to Indonesia (Nguyen et al., 2009).

REMARKS. Several individuals were seen during our survey in summer 2010. One was crawling on the ground in the bamboo forest and some were diving in ponds at the forest edge near Mau Village during day time.

Sinonatrix aequifasciata (Barbour, 1908)

EXAMINED MATERIAL. One adult female VNMN 1332, collected by TZ and NTT, 24 June 2010, ca. 400 m asl.

MORPHOLOGICAL CHARACTERS. SVL 360.48 mm, TaL 109.68 mm; head distinct from neck; rostral broader than high; internasals 2, in contact, twice as long as wide; prefrontals 2; frontal longer than wide, shorter than parietals; nostrils lateral; pupil round; loreal single, as long as high; preocular single; postoculars 2; subocular single; temporals 2+3; supralabials 9, fifth touching the eye; infralabials 9; mental groove present; dorsal scales keeled, in 19:19:17 rows; ventrals 5+141, no lateral edges; cloacal shield divided; subcaudals 75, divided. Colouration in life: head brownish above; back olive grey, with 18 black double-bands on body, 10 on tail; flanks with dark markings, in X-shape; ventral surface yellow, with some traces of the black bands (determination after Bourret, 1936; Vogel et al., 2004).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai, Ha Giang, Cao Bang, Lang Son, Vinh Phuc, Bac Giang, Nghe An, and Ha Tinh provinces. Elsewhere, the species is known from China (Nguyen et al., 2009).

REMARKS. The specimen was found in the evening (22:30), on a tree branch in Suoi Tuyen I. The specimen matched the descriptions of Bourret (1936) and Vogel et al. (2004) well, but showed two minor differences: only one subocular on the left side instead of two and 18 bands on body and 10 on tail instead of 20 and 12 bands, respectively.

Sinonatrix percarinata (Boulenger, 1899)

EXAMINED MATERIAL. One juvenile IEBR 3707 (SVL188.09 mm, TaL 62.05 mm), collected by NQT, NTT, PTC, June 2009, elevation ca. 400 m asl; one adult female VNMN 1357, collected by TZ and NTT, 3 June 2010, ca. 400 m asl (Fig. 76).

MORPHOLOGICAL CHARACTERS. SVL female 423.28 mm, TaL female 154.31 mm; head distinct from neck; rostral twice as wide as high; internasals 2, in contact, longer than wide; prefrontals 2; nostrils lateral; pupil round; nasal divided; loreal single; preocular single; postoculars 2–3; suboculars 1–2; temporals 2+3; supralabials 9, fourth and fifth touching the eye; infralabials 9–10; mental groove present; dorsal scales keeled, except for outermost rows, in 17/19:19:17 rows; ventrals 2–3 + 136/140; cloacal shield divided; subcaudals 72 or 75, divided. Colouration in life: dorsal head and back olive greyish; brown body with 28–31 transverse dark lozenge-shaped bands on back, dark bands continuing to belly, forming rings; tail with 13–20 black bands, similar to those on body; ventral surface yellow (determination after Pope, 1935; Bourret, 1936; Smith, 1943; Ziegler, 2002).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai and Ha Giang southwards to Gia Lai and Dong Nai provinces. Elsewhere, the species is known from India, China, Taiwan, Myanmar, Laos, and Thailand (Nguyen et al., 2009).

REMARKS. A juvenile was found in the evening and the female was found during the day time in Lai Am Pond.

PAREATIDAE

Pareas hamptoni (Boulenger, 1905)

EXAMINED MATERIAL. One adult male VNMN 1356, collected by TZ and NTT, 10 July 2010, ca. 400 m asl (Fig. 77).

MORPHOLOGICAL CHARACTERS. SVL 335.38 mm, TaL 113.05 mm; head distinct from neck; body strongly compressed; snout short; rostral not visible from above; internasals in contact, half of prefrontals; nostrils lateral; pupil vertically elliptic; prefrontals touching the eye; frontal shorter than parietals; loreal single, not touching the eye; preocular single, in triangle shape; eyes diameter greater than the distance from eye to tip of snout; postocular single; suboculars 2/3; temporals 2+3; supralabials 7, fourth and fifth touching the eye; infralabials 6/7; mental very small, mental groove absent; chin shields in 3 pairs; dorsals smooth, midbody scale rows 15, vertebral scales slightly enlarged; ventrals 186; cloacal shield undivided; subcaudals 84, divided. Colouration in life: dorsal surface reddish brown, with black bands on the interstitial skin; ventral surface yellow; upper head dark, with two parallel longitudinal stripes on neck, bordered in black (determination after Bourret, 1936; Smith, 1943; Cox, 1991).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai and Ha Giang southwards to Lam Dong and Dong Nai provinces. This is the first record of *P. hamptoni* from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, the species is known from China, Myanmar, Laos, and Cambodia (Nguyen et al., 2009).

REMARKS. Another adult male was seen in the evening (20:00) on a tree branch, 1.5 m above the ground near Ba Bep Stream.

Pareas margaritophorus (Jan, 1866)

EXAMINED MATERIAL. One adult female VNMN 1354, collected by TZ and NTT, 10 July 2010, ca. 400 m asl (Fig. 78).

MORPHOLOGICAL CHARACTERS. SVL 437.00 mm, TaL 83.95 mm; head distinct from neck; body not strongly compressed; eye moderate; internasals in contact, shorter than prefrontals; prefrontals in contact, entering orbit; frontal as long as wide, longer than its distance to tip of snout, shorter than parietals; loreal single; preocular absent; postocular single; supralabials 7, fourth and fifth entering orbit; infralabials 7; temporalia 2+2; mental groove absent; mental very small; chin shields in 3 pairs; dorsal scales smooth, midbody scale rows 15; paravertebral scales not enlarged; ventrals 150, without lateral edges; cloacal shield undivided; subcaudals 39, divided. Colouration in life: dorsum dark grey with transverse rows of spots, spot edged in white anteriorly and in black posteriorly; ventral surface white, with numerous brown spots (determination after Bourret, 1936; Smith, 1943; Manthey & Grossmann, 1997).

DISTRIBUTION. In Vietnam, this species has been recorded from Vinh Phuc and Hai Duong provinces southwards to Kien Giang Province. This is the first record of *P. margarithophorus* from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, the species is known from China, Myanmar, Laos, Thailand, Cambodia, Malaysia (Nguyen et al., 2009).

REMARKS. The female specimen was found at night (22:00) on the forest path near Ba Bep Stream.

TYPHLOPIDAE

Ramphotyphlops braminus (Daudin, 1803)

EXAMINED MATERIAL. One subadult VNMN 1336 (SVL 119.92 mm, TaL 2.76 mm), collected by TZ and NTT, June 2010, elevation ca. 300 m asl.

MORPHOLOGICAL CHARACTERS. Small sized, worm-like snake; nostril sourrounded by 2 nasals; preocular single, touching second and third supralabials; eye rudimental; mental groove present; ventrals as large as lateral scales; dorsal scales smooth, cycloid, in 20 rows; tail cylindrical. Colouration in alcohol: dorsal surface dark brown, ventral surface grey; lower side of head and cloacal region greyish white; throat with 3 white scales forming a line; tip of tail whitish (determination after Pope, 1935; Bourret, 1936; Smith, 1943; Manthey & Grossmann, 1997; Ziegler, 2002).

DISTRIBUTION. This is a widespread species in Vietnam. Elsewhere, the species is known from Sansibar, Tansania, Mosambique, Somalia, Camerun, Benin, Togo, Ivory Coast, Senegal, Gabun, Madagascar, Comores, Nosy Be, Mauritius, Iran, Pakistan, India, Sri Lanka, Nepal, Bangladesh, Bhutan, China, Myanmar, Laos, Thailand, Cambodia, Malaysia, Singapore, Indonesia, New Guinea, Philippines, Japan, Melanesia, Micronesia, Australia, New Caledonia, Solomon Islands, Vanuatu, Saudi Arabia, Guatemala, Mexico, USA, and Hawaii (Nguyen et al., 2009).

REMARKS. A single specimen was found on the forest floor between leaf litter.

XENODERMATIDAE

Achalinus rufescens Boulenger, 1888

EXAMINED MATERIAL. One adult female VNMN 1334, collected by TZ and NTT, 24 June 2010, 320–400 m asl (Fig. 79).

MORPHOLOGICAL CHARACTERS. SVL 424.37 mm, TaL 95.12 mm; head slender; suture between internasals twice as long as suture between prefrontals; frontal wider than long, half as long as parietals, 4 times wider than supraocular; parietals 2; loreal single, entering orbit; preocular and postocular absent; temporals 2+2, anterior upper one touching the eye; supralabials 6, fourth and fifth touching the eye, first very small, sixth very long; infralabials 5; mental wider than long; chin shields in 3 pairs; mental groove present; dorsal scales strongly keeled, tri-carinated, midbody scale rows 23; ventrals 63; cloacal shield undivided; subcaudals 5+152, undivided. Colouration in life: dorsal head and body light brown, iridescent; vertebral zone darker greyish brown; lips yellowish; ventral surface whitish-yellow (determination after Bourret, 1936; Pope, 1935; Smith, 1943; Ziegler, 2002).

DISTRIBUTION. In Vietnam, this species has been recorded from Lao Cai, Cao Bang, Bac Kan, Vinh Phuc, Hai Duong, and Ha Tinh provinces. This is the first record of *A. rufescens* from Tay Yen Tu NR and from Bac Giang Province. Elsewhere, the species is known from China (Nguyen et al., 2009).

REMARKS. The specimen was found at night (ca. 23:00) on a forest path near Suoi Tuyen I.

ELAPIDAE

Bungarus fasciatus (Schneider, 1801)

Identification was based on photographs (Fig. 80): triangular body with a prominent vertebral ridge along the back; tail tip blunt; body and tail alternately banded in black and yellow; a large black mark on nape, continued in a point on head to between the eyes, bordered on each side by yellow (determination after Smith, 1943).

DISTRIBUTION. This is a widespread species in Vietnam and in Asia (Nguyen et al., 2009).

REMARKS. One individual was seen crawling on the ground of the bamboo forest close to a pond during the night of 26 June 2010.

VIPERIDAE

Trimeresurus stejnegeri (Schmidt, 1925)

Identification was based on photographs (Fig. 81): head triangle-shaped; loreal pitches present; body green, with longitudinal parallel bicoloured (white and red) stripe on the outer edge of the ventrals (determination after Smith, 1943; Bain & Nguyen, 2004a).

DISTRIBUTION. This is a widespread species in northern and central Vietnam, from Lao Cai and Ha Giang provinces southwards to Quang Binh Province and Da Nang City. Elsewhere, the species is known from China, Taiwan, and Myanmar (Nguyen et al., 2009).

Natural history notes: Three individuals were sighted at night in the bushes and trees besides a forest stream and close to Khe Cam 1 Pond, in October 2009 and in May 2010.

DISCUSSION

Based on our field work during the period from 2008 to 2010, a total of 76 species were recorded from the Tay Yen Tu NR, comprising 36 species of amphibians and 40 species of reptiles. The families with the most diverse species richness are Ranidae (11 species), Rhacophoridae (9 species), Scincidae (10 species), and Colubridae (8 species) (Fig. 82). Because of the lack of convincing diagnostic characters, the identification of several amphibian species is still not clearly solved yet, for example *Leptobrachium* cf. *chapaense*, and *Hylarana* cf. *nigrovittata*, but also *Ichthyophis bannanicus* and *Limnonectes bannaensis* (see Gawor et al., 2009; Nguyen et al., 2009; McLeod, 2010; Nishikawa et al., 2012). Further studies based on additional voucher specimens and molecular comparisons are required to confirm the taxonomic placement of aforementioned species (or species complexes).

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Figure 75. *Rhabdophis subminiatus*. Figure 76. *Sinonatrix percarinata*. Figure 77. *Pareas hamptoni*. Figure 78. *P. margaritophorus*. Figure 79. *Achalinus rufescens*. Figure 80. *Bungarus fasciatus*. Figure 81. *Trimeresurus stejnegeri*. Photos by C.T. Pham, T. Ziegler, and T.Q. Nguyen.

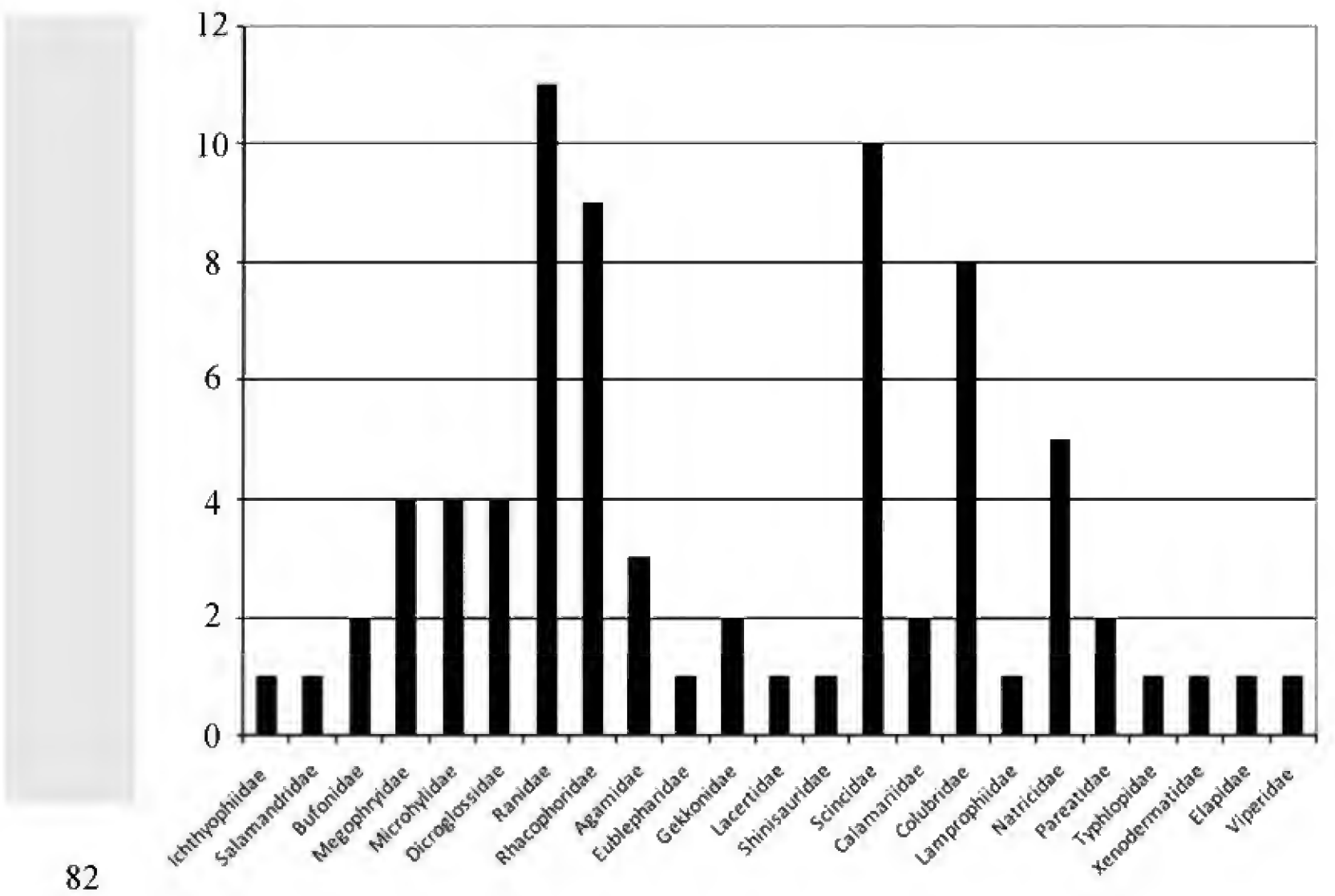

Figure 82. Species richness of amphibian and reptile families from Tay Yen Tu Nature Reserve (y-axis represents species numbers).

Thirty of the recorded species (or 39.5% of the total species number) are new records for Tay Yen Tu Nature Reserve as well as for Bac Giang Province. Remarkably, five of the recorded species are currently known only from Vietnam, namely *Tylototriton vietnamensis*, *Quasipaa acanthophora*, *Odorrana bacboensis*, *O. yentuensis*, and *Goniurosaurus lichtenfelderi*. The high level of species diversity and endemism of the herpetofauna underscores the biodiversity conservation potential of the Tay Yen Tu NR. Although this nature reserve harbors a considerable number of endemic and rare species, its biodiversity is heavily threatened by habitat degradation and over harvesting associated with wildlife trade (Nguyen, 2011). To preserve the unique biodiversity of Yen Tu Mountain (see also Ha et al., 2010), we must not only continue with research, in particular the ecological requirements of the local flora and fauna, but also the protection of the habitat must be improved. Only by doing so, we can guarantee the long-term survival of the unique lowland forest system and its in part endemic diversity.

ACKNOWLEDGEMENTS

We thank the directorate of the Tay Yen Tu Nature Reserve, Forest Protection Department of Bac Giang and Quang Ninh provinces for support of our field work and issuing relevant permits. V.L. Hecht and C.T. Pham are grateful to M. Bernardes and D. Karbe (Cologne), T.T. Tran (Vinh Phuc) for their assistance in the field. For the loan of specimens, we are grateful to C.X. Le and T.H. Tran (Hanoi), W. Böhme and D. Rödder (Bonn). We thank E. Sterling (New York) and K. Koy (Berkeley) for providing the map. Field surveys in Yen Tu Mountains were partially funded by the European Association of Zoos and Aquaria

(EAZA), World Association of Zoos and Aquariums (WAZA), Nagao Natural Environment Foundation, Japan (Small-scale research grant programme for T.T. Nguyen), Vietnam Academy of Science and Technology (Small grant for young researchers for C. T. Pham), and Cologne Zoo. Internship of C.T. Pham in Germany was funded by the Deutsche Foschungsgemeinschaft (DFG) - International Collaboration Grant (BO 1907/ 11-1). Research of T.Q. Nguyen in Germany is funded by the Alexander von Humboldt Foundation (VIE 1143441).

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Biodiversity Journal, 2013, 4 (4): 553-556

First record of *Hierophis gemonensis* (Laurenti, 1768) (Reptilia Serpentes Colubridae) in the Aegean island of Tsougriá, Northern Sporades, Greece

Mauro Grano[1*], Cristina Cattaneo[2] & Augusto Cattaneo[3]

[1] Via Valcenischia 24 – 00141 Roma, Italy; e-mail: elaphe58@yahoo.it
[2] Via Eleonora d'Arborea 12 – 00162 Roma, Italy; e-mail: cristina.cattaneo76@libero.it
[3] Via Cola di Rienzo 162 – 00192 Roma, Italy; e-mail: augustocattaneo@hotmail.com
[*]Corresponding author

ABSTRACT The presence of *Hierophis gemonensis* (Laurenti, 1768) (Reptilia Serpentes Colubridae) in Tsougriá, a small island of the Northern Sporades, Greece, is here recorded for the first time.

KEY WORDS Aegean islands; Balkan whip snake; *Hierophis gemonensis*; Northern Sporades; Tsougriá.

Received 05.11.2013; accepted 02.12.2013; printed 30.12.2013

INTRODUCTION

The Balkan whip snake, *Hierophis gemonensis* (Laurenti, 1768) (Reptilia Serpentes Colubridae), is widespread along the coastal areas of Slovenia, Croatia, Bosnia-Erzegovina, Montenegro, Albania and Greece (Vanni et al., 2011). The basic colour is silver gray to dark green with some spots only on one third of the body, tending to regular stripes on the tail. Melanistic specimens are also known (Dimitropoulos, 1986; Schimmenti & Fabris, 2000). The total length is usually less than 130 cm, with males larger than females (Vanni et al., 2011).

Regarding the Aegean islands, this species has an irregular distribution, therefore its presence in this area can be defined discontinuous (Clark, 1989). *H. gemonensis* has been found on these islands:

Northern Sporades
- Aspróniso (= Aspro): Buchholz & Schultze-Westrum, 1964; Kock, 1979.

Euboea: Werner, 1933; Kock, 1979.
Argo-Saronic islands
- Aegina: Werner, 1937; Wettstein, 1953; Kock, 1979; Clark, 1989.
- Psili: Clark, 1973, 1989; Kock, 1979.
- Tolon: Clark, 1973, 1989; Kock, 1979.
- Stavronissos, Dhokos, Trikkeri (archipelago of Hydra): Clark, 1989.

Kythera: Boulenger, 1893; Kock, 1979.
Crete: Boettger, 1888; Sowig, 1985.
Cretan islets
- Gramvoussa: Wettstein, 1953; Kock, 1979.
- Gavdos: Wettstein, 1953; Kock, 1979.
- Gianyssada: Wettstein, 1953; Kock, 1979.
- Dia: Raulin, 1869; Kock, 1979.
- Theodori: Wettstein, 1953.

Karpathos: Broggi, 1994.

The population of the island of Gyaros (Cyclades), previously assigned to *H.* (*Coluber*) *gemonensis* (Mertens, 1968), and successively considered an endemic species, *H. gyarosensis* (Mertens, 1968), by Schätti (1988) and Böhme (1993), is actually referred to *H. viridiflavus carbonarius* (Bonaparte, 1833) (Utiger & Schätti, 2004), on the bases of molecular and, in part, morphological data (the structure of the hemipenis is different). The western whip snake on Gyaros was introduced casually on the island in historical times.

In fact, the values of the ventral lepidosis (194-205), colour pattern (dark and without spots ventrally) and the geographical location of the island surrounded by other islands inhabited by *Dolichophis caspius* (Gmelin, 1789), as well, would led to assign the ophidic population of Gyaros to *D. caspius*. Moreover, despite as stated by Schätti (1988), the melanoticism is present in the micro insular Aegean populations of *D. caspius* (see Alonissos and, perhaps, Patmos) (Cattaneo, 1998, 2008; Broggi, 2010).

Study area

Tsougriá is a small island off the SE coast of Skiathos (longitude: 23°29'58.63"E; latitude 39°07'20.17"N). (Fig. 1) The area of 1.14 km² and the altitude 90 m a.s.l. This small island, just like Skiathos and other nearby islets (except for Aspróniso, that consists of limestone), are composed of igneous and metamorphic rocks (Ferentinos, 1972). Two small pounds occur on the island behind the dunes of brackish water surrounded by a belt of *Juncus acutus* L.; during our visit to the island only one still contained water. Tsougriá is currently uninhabited, but there was human presence in the past. This is testified by the presence of small valleys in the western part of the island exploited for the cultivation of olive trees. These old olive trees are now mixed with a shrub vegetation consisting of *Erica manipuliflora* Salisb., *Cistus creticus* L. and *Dittrichia viscosa* (L.) Greuter. The rest of the island is covered by woodlands of *Pinus halepensis* Mill. (with undergrowth of *Erica arborea* L. and *Pistacia lentiscus* L.) alternated with stretches of dense and intricate maquis where predominant elements are *Pistacia lentiscus*, *Quercus coccifera* L., *Phillyrea latifolia* L., *Olea europaea* subsp. *oleaster* Hoffmg. et Link. Remains of two rural buildings and information obtained from the inhabitants of Skiathos, indicate that the anthropic use of the island occurred until the 1970s of the last century. As sign of the activities carried out in the island, remain two groups of buildings actually crumbling. The first was used for processing oil, the other one was a farm with lodge on the upper floor and stalls on the lower one. The area in front of the farm provided a well for fresh water and some tanks for watering the animals.

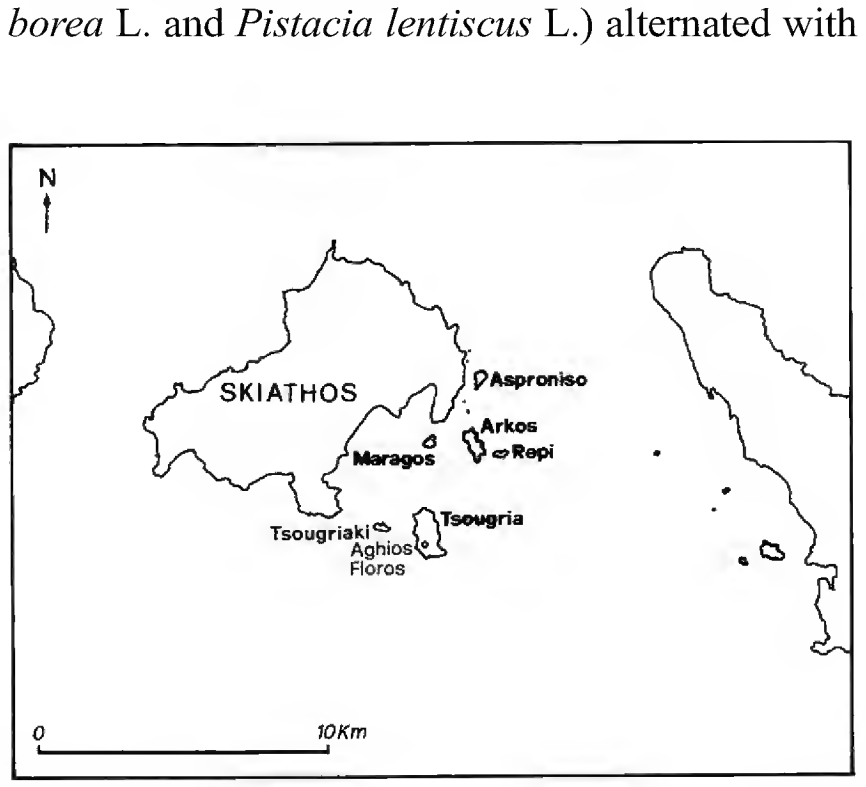

Figure 1. Study area.

RESULTS AND CONCLUSIONS

Six records of *H. gemonensis* were found in the island of Tsougriá in August 2013: four pieces of exuvia, one carcass and a live specimen. Two of the four pieces of exuvia were rather dark. The live specimen was a young adult of 60 cm total length (tail 19 cm). It was found in front of the farm, under an iron sheets set in the shade, near a dry stone wall (Fig. 2) The soil covered by the sheet was wet despite the dry spell. Colour and pattern were typical of the species (Figs. 3, 4)

At Tsougriá were also found *Hemidactylus turcicus* Linnaeus, 1758 and *Lacerta trilineata* Bedriaga, 1878. *H. turcicus* has been frequently observed under wooden tables and iron sheet near the two groups of buildings and around the little Church of Aghios Floros. *L. trilineata* instead, has been observed within the rushes. In this island, as indeed in Skiathos, the Northern Sporades lizard, *Podarcis erhardii ruthveni* (Werner, 1930), is absent (Wettstein, 1953; Gruber & Schultze-Westrum, 1971; Cattaneo, 1997). Only Bergman (1995) observed specimen of *P. erhardii* in Skiathos, nearby the main town where it was probably introduced by boats that connect Skiathos to nearby islands. But this record has not been confirmed. On the other hand is documented its occurrence in the other surrounding islets, such as Repi, Aspróniso, Tsougriáki, Arkos, Maragós. In both Skiathos and Tsougriá *P. erhardii* is lacking, but *L. trilineata* occurs (Gruber & Schultze-Westrum, 1971). This has raised many questions among herpetologists leading to more or less plausible hypotheses. It was assumed that *P. erhardii* forming part

Figure 2. Tsougriá island: the place of discovery of the *Hierophis gemonensis*.
Figures 3, 4. *Hierophis gemonensis* from Tsougriá island.

in the pabulum of *L. trilineata* (Gruber & Schultze-Westrum, 1971), would have suffered a selective pressure by the latter species with the result of an extinction on both above mentioned islands and possibility of existence only in the surrounding islets, where *L. trilineata* is absent. However it seems not confirmed by the case of Arkonissi, a small island which is also part of Skiathos archipelago, where the two species are sympatric (however in the absence of ophidic saurophagous species).

The same could regard *H. gemonensis*. The plausible competitive interaction with *Malpolon monspessulanus* Hermann, 1804 also present at Skiathos (Buchholz & Schultze-Westrum, 1964; Cattaneo, 1997) could be a relevant factor in the distribution of *H. gemonensis* in the Northern Sporades (as well as in the islands of the Argo-Saronic archipelago: Clark, 1989). In fact, the exclusive presence of *H. gemonensis* in Aspróniso and Tsougriá, could be a consequence of the selective pressure operated by *M. monspessulanus*, that would allow the Balkan whip snake to survive only in these two small islands surrounding Skiathos. Considering the ophiophagy and the aggressive behavior of this large snake, it could have played an important role to obstacle the coexistence between the two species. Also in the Argo-Saronic islands usually these two snakes are not sympatric (Clark, 1989). The first report of *H. gemonensis* for the Northern Sporades is related to one specimen found in the island of Aspróniso, very close to Skiathos (Buchholz & Schultze-Westrum, 1964). In this paper is given the first record for the island of Tsougriá and the second for the Northern Sporades archipelago and

confirmed the occurrence on some of the small islands around Skiathos of this species, whose relict presence on the main island could possibly be detected in the future (in 1994 the third author frequently sighted in Skiathos snakes perhaps attributable to this species).

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Biodiversity Journal, 2013, 4 (4): 557-564

Trend of a population of Wild Rabbit *Oryctolagus cuniculus* (Linnaeus, 1758) in relation to Domestic Sheep *Ovis aries aries* (Linnaeus, 1758) grazing within a small insular protected area

Agatino Maurizio Siracusa* & Ettore Petralia

Department of Biological, Geological and Environmental Sciences - Section of Animal Biology, University of Catania, via Androne 81 - 95124 Catania, Italy
*Corresponding author: amsira@unict.it

ABSTRACT The wild rabbit *Oryctolagus cuniculus* (Linnaeus, 1758) (Mammalia Leporidae) if present at high density can cause significant damages to crops and natural vegetation. The aim of this study, carried out from 2002 to 2008 in the Natural Reserve "Complesso Immacolatelle e Micio Conti", in the foothills of Mount Etna, was to investigate the relationship between the wild rabbit and the presence of grazing domestic sheep *Ovis aries aries* (Linnaeus, 1758) (Mammalia Bovidae), considering also the possible synergistic effect of these two herbivores on the natural vegetation in a small protected area. Precipitation during the month of September correlated statistically significantly with the density of rabbits. A comparison between the density values obtained during the period under study did not show statistically significant differences with the exception of 2006 and 2007 when, within the area, was present a flock of sheep (200–250 individuals), free to graze in the reserve. The abundance of rabbits in 2002–2005 and 2008 is equal to 6.97% more than the expected value; in the absence of the grazing sheep flock (2006–2007) instead the population assumed density values significantly higher than expected. Since grazing of rabbits, especially in summer, is critical for the subsequent composition of herbaceous vegetation, for the purposes of conservation and protection of natural or semi natural environments, especially with a small extension, it is desirable to properly assess and manage the presence of the wild rabbit, especially in areas where it is not original, for the effects it may have on plant communities and populations of arthropods, and to control sheep grazing as well to contain the caused damages.

KEY WORDS *Oryctolagus cuniculus*; *Ovis aries aries*; over grazing; small protected area.

Received 28.11.2013; accepted 22.12.2013; printed 30.12.2013

INTRODUCTION

The wild rabbit *Oryctolagus cuniculus* (Linnaeus, 1758) (Mammalia Leporidae) is considered to be endemic of the Iberian Peninsula (Dobson M., 1998; Alves et al., 2008; Amori et al., 2008) and since the Neolithic is widespread in the rest of the Mediterranean (Hardy et al., 1994; Ferrand & Branco, 2007; Alves et al., 2008; Amori et al., 2008). It has demonstrated to be a successful colonizer, since is currently present in at least 150 islands around the Mediterranean Basin (Masseti & De Marinis, 2008). It is a nocturnal and strongly gregarious animal, which can live in colonies the size of which is proportional to the availability of food. In Sicily is naturalized and widely distributed, although non-uniformly and with very variable density (Amori et al., 1996; AA.VV., 2008). Individuals present in this

area show intermediate size within the range of variability known for populations of Spain (Andalusia) and France (Camargue) (Siracusa et al., 2007; Lo Valvo et al., 2008); it is supposed that the current biometric characteristics of the species are the result of immissions for the purpose of restocking with strains of different origins (Lo Valvo et al., 2008).

In Southern Spain ecosystems it is a key species; it participates in determining the community structure of predators and scavengers, as well in supporting their populations density (Delibes & Hiraldo, 1981; Ferrer & Negro, 2004; Delibes-Mateos et al., 2007). Besides it plays a strong influence on the habitat of other species ("ecosystem engineers") by consuming vegetation, dispersing the seeds, spreading latrines and digging burrows (Delibes-Mateos et al., 2008; Delibes-Mateos et al., 2009; Gálvez-Bravo et al. 2009). It has a significant role even outside the areas of origin; being prey for many vertebrates, it maintains, at low density of grazing, a greater plant diversity and sustains a better quality of habitat for some species of invertebrates (Norbury, 1996; Wray, 2006). In contrast if present at high density can cause significant damage to crops and natural vegetation. In the Iberian Peninsula the wild rabbit is in decline from early '50s (Ward., 2005; Williams et al., 2007), and currently the state of conservation in this region, based on the IUCN criteria, is assessed as "Vulnerable" (Virgós et al., 2007). According to Smith & Boyer (2008; IUCN, 2013), the species is globally evaluated as near threatened (NT). For these reasons, it is necessary to manage the wild rabbit through scientific criteria to maintain auto-sustainable populations and prevent (or intervene in the case of) significant damage to the economy or to the natural heritage.

The aim of the present study was to investigate the relationship between wild rabbit and domestic sheep *Ovis aries aries* (Linnaeus, 1758) (Mammalia Bovidae), considering also the possible synergistic effect of these two grazing herbivores on the annual development of natural vegetation in a small protected area.

MATERIALS AND METHODS

Study area

The study area is the Natural Reserve "Complesso Immacolatelle e Micio Conti", an area in the foothills of Mount Etna. It is included within the SIC ITA070008 ("Complesso Grotte Immacolatelle, Micio Conti e boschi limitrofi") and covers about 70 hectares; it is divided into a Zone A of absolute restriction and a Zone B where the fruition is permitted (Fig. 1).

In the area habitats are affected by agro-pastoral activities, which determined the degradation of the original vegetation. The tree cover consists of *Quercus virgiliana* (Ten.), *Quercus amplifolia* Gus., which are accompanied by *Celtis australis* L.; there are also several individuals of *Olea europea* L., remains of an ancient cultivation. The herbaceous vegetation that colonizes the most degraded areas has several species typical of arid and uncultivated lands as *Hyparrhenia hirta* (L.), *Carlina corymbosa* L., *Lobularia marittima* (L.), *Dittrichia graveolens* (L.) Greuter, *Micrometria graeca* (L.), *Mandragora autumnalis* Bertol and the endemic *Helitropium bocconei* Guss. Finally, the crags are covered with plant species characteristic of the Mediterranean maquis including *Euphorbia dendroides* L. associated with various other sclerophyllous such as *Olea oleaster* (Hoffmg. et Lk.), *Pistacia therebintus* L., *Rhamnus alaternus* L. and liana species as *Smilax aspera* L., *Asparagus acutifolius* L. and *A. albus* L.

Monitoring survey design

For counting rabbits was applied the method proposed by Taylor & Williams (1956), used for similar studies in the Doñana National Park (Spain) (Moreno & Villafuerte, 1992) and in several protected areas of Sicily (Caruso & Siracusa, 2001; Siracusa et al., 2004; Siracusa et al., 2005; Siracusa et al., 2007). This methodology consists in counting the number of excrement in fixed detection stations scattered randomly in the study area. The data may provide information on population size and numerical trends over time (Meriggi, 1991). This method has been confirmed successful for the good correlation between the number of excrements and the density of animals (Wood, 1988; Palomares, 2001). To obtain an estimation of the density of animals (D) in an area of identified surface, knowing the number of excrements deposited daily by the animal (r) and the period of time in which these have been deposited (t), we applied the formula of Eberhardt & Van Etten (1956):

$$D = d/rt$$

where d is the mean density of excrement for sam-

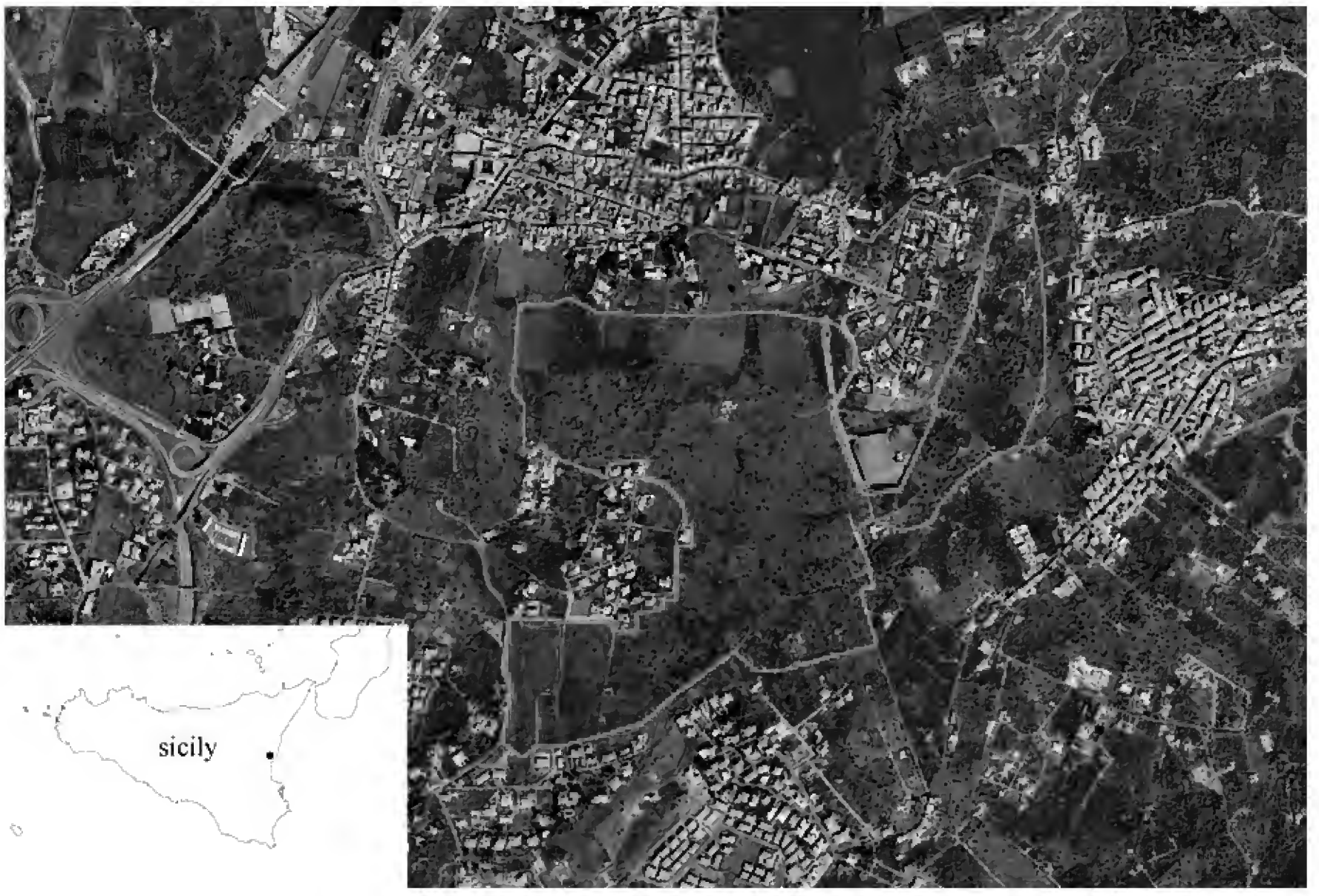

Figure 1. View from above of the study area; red line represents the boundaries of the Reserve.

pling station. Due to the lack of experimental data for Sicily, r was considered equal to 350, the value reported by Moreno & Villafuerte (1992) for the Mediterranean environments, value however not far from those found in the UK and Australia (Lockley in Pages, 1980; Wood, 1988). The parameter (t) is instead the number of days between the cleaning of stations and counting.

The number of stations (n = 30), with circular shape and large 1.54 m^2, was chosen in function of the abundance of excrement (> 30 escr./1.54 m^2) found at the site subjected to investigation. This value was defined based on asymptotic functions of the ratio number of plots-mean value of excrement found. The number of pellets per station also showed an aggregate distribution (variance considerably higher than the average); extreme values found tend to alter the average because the distribution of data appeared irregular (Fowler & Cohen, 1993).

Between 2002 and 2008 we calculated the annual density of the rabbit population in the Reserve through monthly surveys of the population (see also Siracusa et al., 2005). At the same time have been measured some meteorological parameters (mean annual temperature, mean annual precipitation, total precipitation and annual total precipitation for each month of the year) in order to verify a possible influence of these on the annual density of wild rabbits. The correlations were made both considering the values of the same year and those of the previous year in order to identify a possible delayed influence of these parameters.

In the course of the study was estimated as well (by direct counting) the number of grazing sheep present, with the purpose to verify for any interference with the population of wild rabbit, also to assess the amount of grazing pressure of both sheep and rabbits. Was also calculated an expected value of density (spec./ha) of wild rabbit, combining the number of species of Poacae present and the altitude above sea level using 9 different sample areas by the technique of Multiple Regression. For the comparison between the abundance of rabbits in different years under investigation was used instead the χ^2 test. For the correlation

between variables (meteorological parameters and density) was used the Spearman rank correlation coefficient (rs).

Statistical analyses were performed using the software STATISTICA 5.0.

RESULTS

The annual average density of wild rabbits was found to be 44.79± 27.34 (s.d.) ind./ha, with a minimum value of 25.6 ind./ha in 2005 and a maximum value of 94.6 ind./ha in 2007 (Fig. 2).

The value of density can be predicted by the number of species of Poacae and the altitude above sea level (R^2= 0.822; $F_{2,6}$ = 13.881; P < 0.006), where both variables resulted as predictive (p <0.003) (Fig. 3).

The expected value of density is equal to 36.3 (± 95.0 % 51.1–21.5) ind./ha. None of the climatic variables correlated statistically significantly with the density of the species, with the exception of the significant negative correlation between the density of rabbits and the annual amount of precipitation during the month of September (r_s=- 0.929; n=7; p=0.002).

The comparison between the density values obtained does not show statistically significant differences during the years 2002, 2003, 2004, 2005 and 2008 (χ^2=2.74, df=4, p < 0.60). However, there are differences with the abundance values observed in 2006 and 2007 (χ^2=19.51, df=2, P=0.000). Noteworthy, during the all period, with the exception of 2006 and 2007, within the area was present a flock of sheep (200–250 individuals) free to graze in the reserve.

DISCUSSION

In Sicily, the main factors that seem to affect the density of this species are the extension of abandoned ex-cultivated areas (and / or uncultivated areas) (Caruso & Siracusa, 2001; Siracusa et al., 2007), the altitude above sea level and the number of species of Poacae (Caruso & Siracusa, 2001; Siracusa et al., 2007).

It's rather less probable that the wild rabbit is generally subject to limitation by the community of predators (Trout & Tittensor, 1989; Moreno & Villafuerte, 1992; Trout et al., 2000; Caruso & Siracusa, 2001; Siracusa et al., 2004; Siracusa et al., 2007). Habitat fragmentation is also considered one of the causes of the decline of local populations of wild rabbit (Virgós et al., 2003); the site is not isolated from the surrounding areas and the degree of fragmentation of the territory, for the presence of the wild rabbit, can be considered of small entity with the opportunity for individuals to disperse and maintain normal phenomenon of immigration/emigration.

In another area with Mediterranean climate, predominantly semiarid, in the NE of Spain, Calvete et al. (2004) found a positive correlation between

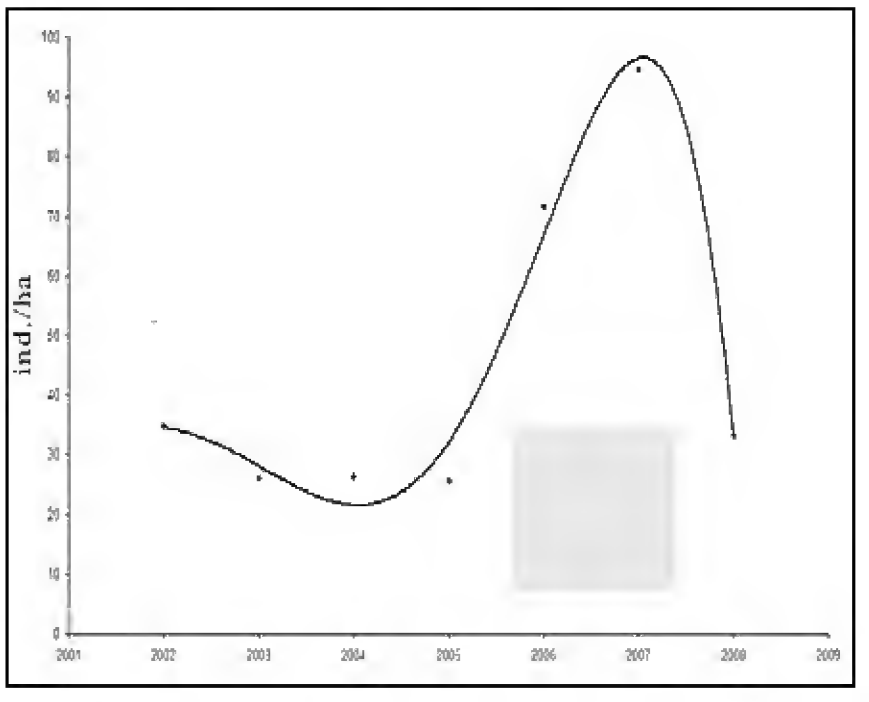

Figure 1. Annual trend of wild rabbit abundance observed during the years 2002-2008 within the Reserve "Immacolatelle-Micio Conti"

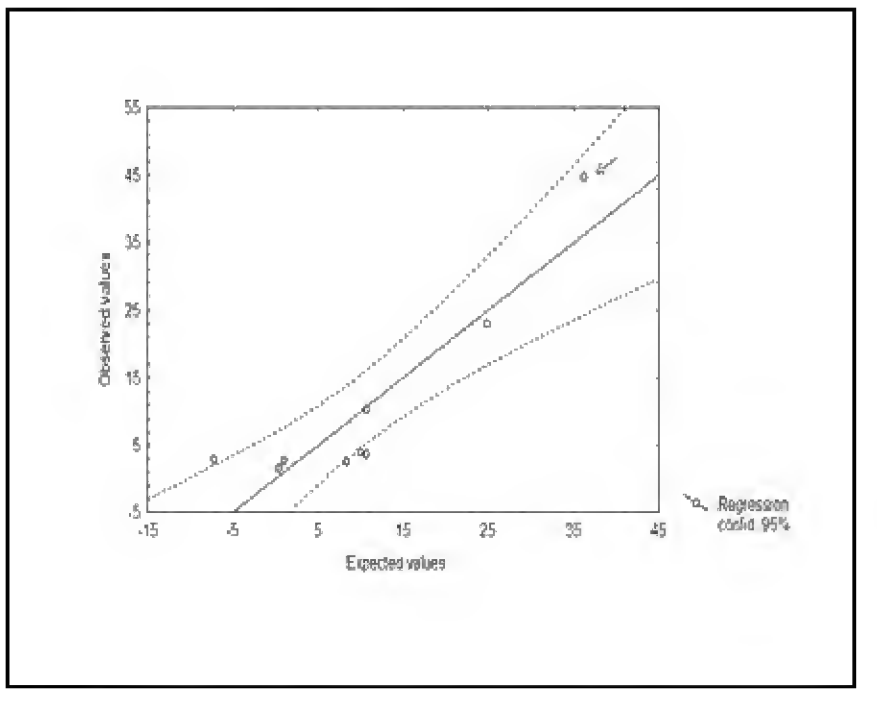

Figure 2. Expected and observed values of wild rabbit density at nine different sites in the Etna area (the arrow indicates the Reserve "Immacolatelle-Micio Conti").

the annual mean temperature, the average of rainfall in the months of February and May, and abundance of rabbits in different sites, while the average rainfall for the months of September and November correlated negatively.

In this protected area of Mount Etna the total rainfall for the month of September is negatively correlated with the density per year. It is possible that heavy rainfall in early autumn can determine an increase of winter mortality due to various factors such as greater difficulty in thermoregulation, excessive soil moisture with limited plant growth resulting in food shortages and delays in beginning of the breeding season (Calvete et al., 2004). Meteorological events, concentrated in a few days can also have negative effects on rabbit populations, especially in open areas (Palomares, 2003).

The abundance of rabbits in 2002–2005 and 2008 (29.30 ± 4.48 ind./ha) is equal to 6.97% more than the expected value. In the absence of the grazing sheep flock (2006–2007) instead the population assumed density values (83.1 ind./ha) significantly higher than expected (23.8 ind./ha); under these conditions the grazing of rabbits, especially in late summer, resulted in high proportions. Generally speaking, the remarkable grazing of rabbits in the summer is critical as fundamental for the subsequent composition of herbaceous vegetation in the following spring (Myers & Poole, 1963). To this it should be also added the grazing activity of sheep.

As an indication, if one considers 390.9 gr the food ingested daily by a rabbit (Meakin et al., 2002) for its metabolic needs, the annual demand per hectare of the population is on average 17.5 kg of vegetables. It should also be estimated that a sheep consumes the equivalent of 10–16 rabbits (Myers et al., 1994).

In addition, the density values occurred in 2006 and 2007 are high when compared with other areas of Mount Etna (Siracusa et al., 2004). An excessive presence of rabbits, because of overgrazing, may adversely affect the normal evolution in the succession of the vegetation (Zeevalking & Fresco in Begon et al., 1986) determining a reduction of plants diversity and sometimes even causing the extinction of some species. The most important factors that cause these changes are the selection by the rabbit of some species and parts of plants, especially during the critical period of vegetative growth, and the mechanical destruction of the soil surface; both of these factors facilitate, in competition, some species than others (Myers & Pool, 1963).

Herbivores influence the species richness of plants in many terrestrial ecosystems by affecting their structure, composition and function; the number of plant species is also closely linked to the size of the area (AA.VV. in Albon et al., 2007; Olofsson et al., 2008). Grazing and deposition of excrements of rabbits creates spatial heterogeneity in vegetation and soil resources.

An overexploitation of vegetation, due to an excessive number of rabbits, tends so to reduce the heterogeneity and structural complexity of plant communities with indirect effects on populations of arthropods (both phytophagous and predators - 'intermediate disturbance hypothesis'), in particular on the abundance of many species with consequent negative effects on functionality of the ecosystem considered (compare for example Moss & Hassal, 2006).

It should be also taken into consideration the high impact of sheep, due to their behaviour that tends to be aggregative and with limited displacements, with consequent action of disturbance in limited areas. Among the effects of the removal of sheep there are significant changes in the composition and structure of vegetation, with clear repercussions on populations of wild herbivores (Hope et al., 1996). Are also documented the effects of sheep grazing on the arthropod communities through changes in the composition and structure of vegetation heterogeneity (Dennis, 2003).

Wild rabbits and sheep, as well as other domestic ruminants are herbivorous grazers that often feed on the same plant species; for this reason among them there is a strong competition for food (Dawson & Ellis, 1979; Soriguer, 1983).

CONCLUSIONS

The relationship wild rabbit-vegetation-habitat has been studied thoroughly both in the area where the species is native and where it has been introduced (see for example Copson & Whinam, 1998; Moller et al., 1997; Norbury & Norbury, 1996; Zeevalking & Fresco, 1977; Denyer et al., 2007 and their references). A moderate grazing is considered positive for vegetation, contributing to increase diversity; the disappearance of the rabbit in

some areas has in fact led to the development of dominant plant species with consequent effects on plant communities (such as decrease or disappearance of the most sensitive species and reduction of biological diversity).

For the purposes of conservation and protection of natural or semi natural environments (especially with small extension) it is desirable to properly assess and manage the presence of the wild rabbit, especially in areas where it is not original, and to control as well sheep grazing in order to contain the caused damages.

ACKNOWLEDGEMENTS

We wish to thank the staff of the Natural Reserve "Complesso Immacolatelle e Micio Conti", especially Dr. Salvo Cartarrasa and Dr. Silvia Giuffrida who made possible the realization of this study.

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Remarks on the genus *Sphecodes* Latreille, 1804, *pinguiculus* Pérez, 1903 species-group (Hymenoptera Apidae) from Italy: a reply to the article of Schwarz & Gusenleitner (2012)

Vittorio Nobile[1*] & Giuseppe Fabrizio Turrisi[2]

[1]Via Psaumida, 17, lotto 25 - 97100, Ragusa, Italy; e-mail: nobilevittorio@tin.it
[2]via Cristoforo Colombo 8 - 95030, Pedara, Catania, Italy; e-mail: turrisifabrizio@yahoo.it
[*]Corresponding author

ABSTRACT The present paper is a reply to the article by Schwarz & Gusenleitner (2012) and deals with the taxonomy of the genus *Sphecodes* Latreille, 1804, *pinguiculus* Pérez, 1903 species-group. Particularly, this study, after a critical revision of the morphological characters used to the identification of the species of the genus *Sphecodes* from Italy, confirms the results of Nobile & Turrisi (2004) and allows the revalidation of all species which they described; therefore are considered valid species the following taxa: *S. campadellii* Nobile et Turrisi, 2004, *S. combai* Nobile et Turrisi, 2004, *S. banaszaki* Nobile et Turrisi, 2004, *S. marcellinoi* Nobile et Turrisi, 2004, *S. walteri* Nobile et Turrisi, 2004, *S. iosephi* Nobile et Turrisi, 2004, *S. tomarchioi* Nobile et Turrisi, 2004.

KEY WORDS *Sphecodes*; *pinguiculus* species-group; taxonomic discussion; species revalidated.

Received 15.12.2013; accepted 27.12.2013; printed 30.12.2013

INTRODUCTION

The identification of the species of the cleptoparasitic genus *Sphecodes* Latreille, 1804 is somewhat problematic (Meyer, 1919; Bogusch & Straka, 2012) and, to facilitate the identification, several Authors have been recognized the usefulness of the morphology of the antennomeres. Whereas the females have the antennomeres normally shaped, instead the males have mostly antennomeres ventrally gibbous. In more detail, the gibbous process is always placed distally on antennomere, whereas proximally, beginning from the base, it is present a variously shaped and more or less deep notch (anular, half-moon like, etc.) covered by short, bristly and white setae, which form sensillar plates. At low magnification, these sensillar plates resemble white spots, defined differently by several Authors: "reticulatio subtilis grisea" (Thomson, 1872); "graaktigt rotfalt" (Aurivillius, 1903); "svobepletter" (Jørgensen, 1921); "pilose facets" (Mitchell, 1960); "flagellar sensilla" (Ågren & Svensson, 1982); "Haarfleck" (Hagens, 1882; Meyer, 1919; Blüthgen, 1923; Warncke, 1992); "white setae" (Nobile & Turrisi, 2004); "felt-like pubescence" (Bogusch & Straka, 2012). It is noteworthy that on each antennomere, it exists a complementarities, e.g. if the notched area is relatively small, conversely, the gibbous area is wider, and vice versa. These peculiar morphological features of antennomeres are constant within a species but show distinct patterns among different *Sphecodes* species, thus providing good characters for identification, as confirmed by careful investigation of antennae of eleven Swedish *Sphecodes* species carried out by Ågren & Svensson (1982), who pointed out as following indicated:

a) on antenna of both males and females there are about ten diverse types of sensillar structures;

b) some sensilla are erect, hair-like, short and white (e.g., sensilla trichodea, etc.), whereas, some other are flattened, not evidently protruding above cuticle (e.g., sensilla placodea, etc.);

c) in the males, on the ventral surface of flagellomeres, the erected sensilla (Haarfleck, etc.) are placed basally, covering the notched area, whereas, the flattened sensilla cover the distal, gibbous area of the same flagellomeres;

d) in the females, the differently shaped sensilla are mixed up, covering uniformly the flagellomeres.

Based solely on the morphology of the male antenna of some *Sphecodes*-species, Ågren & Svensson (1982) provided a key for their identification. Utilizing these antennal characters, as well as other ones, Warncke (1992) provided a key to the male of the West Palaearctic *Sphecodes*-species. However, in the species belonging to the *S. pinguiculus* species-group, the antennal flagellum of males, at least beginning from the third flagellomere, is uniformly covered by sensilla thus, without the characteristic sequence of notch-gibbous areas. Nobile & Turrisi (2004) have been recorded *S. pinguiculus* and additionally have described seven new Italian species of *Sphecodes*, having a similar antennal morphology of the former species. Based on antennal morphology and other commonly shared features, Nobile & Turrisi (2004) proposed the institution of the *S. pinguiculus* species-group, providing a comprehensive key to species. Recently, these newly described species have been synonymised by Schwarz & Gusenleitner (2012), on the basis of the examination of type material.

In the present paper, the distinctive characters of the seven species of *Sphecodes* described by Nobile & Turrisi (2004) are confirmed and pointed out, demonstrating the inconsistency of the synonymies by Schwarz & Gusenleitner (2012) and thus confirming the validity of these species.

MATERIALS AND METHODS

The present paper is based on primary type material of the seven species described by Nobile & Turrisi (2004), preserved in the collection of Zoologische Staatssammlung München (Germany).

RESULTS

In the following, we point out the results of the reexamination of each species of the *S. pinguiculus* species-group described by Nobile & Turrisi (2004), which confirm their validity.

Sphecodes banaszaki Nobile et Turrisi, 2004

Sphecodes banaszaki, Nobile & Turrisi, 2004. Entomofauna, 25 (8): 120 (Italia).
Sphecodes marginatus, Schwarz & Gusenleitner, 2012. Entomofauna, 33 (8): 74.

From the comparison between *S. marginatus* Hagens, 1882 and *S. banaszaki* Nobile et Turrisi, 2004 (the latter retained synonym of *S. marginatus* by Schwarz & Gusenleitner, 2012), and the descriptions provided by Hagens (1882) and Meyer (1919), as well as the identification keys provided by Warncke (1992) and Bogusch & Straka (2012), it is possible to point out many remarkable differences between the two considered species, the most important being:

- *S. banaszaki* has the flagellomeres, excluding the basal two, uniformly covered by sensilla on the ventral surface (Haarfleck, sensilla), without the characteristic sequence of alternate notch and gibbous areas, as also pointed out by the same Schwarz & Gusenleitner (2012: fig. 1); conversely, in *S. marginatus*, each flagellomere, excluding the basal three, bears a basal white spot of sensilla alternate with an evident and well protruded distal gibbous area, as also clearly showed by Bogusch & Straka (2012: fig. 122);
- the male genital capsule of *S. banaszaki* has the membranous area of the gonostylus wide and quadrangular shaped (Nobile & Turrisi, 2004: fig. 3; Schwarz & Gusenleitner, 2012: figs. 7a–d), thus, quite different from *S. marginatus*, which has a less wide and triangular shaped membranous area (Hagens, 1882: fig. 18; Warncke, 1992: fig. 32; Bogusch & Straka, 2012: figs. 165, 166). Moreover, the apex of the sclerifed part of the gonostylus of *S. banaszaki* is more robust and more developed than *S. marginatus*.

These strong differences between *S. banaszaki* and *S. marginatus*, affecting important features of head and metasoma, and clearly not running within intraspecific variation, have been overlooked by Schwarz & Gusenleitner (2012); moreover, while *S.*

banaszaki belongs to the *S. pinguiculus* species-group, *S. marginatus* belongs to the *S. miniatus* Hagens, 1882 species-group (Bogusch & Straka, 2012).

S. banaszaki is deeply different from *S. marginatus*, and taking also into account the differences with the other species of the same group, *S. banaszaki* Nobile et Turrisi, 2004 is valid species.

Sphecodes campadellii Nobile et Turrisi, 2004

Sphecodes campadellii, Nobile & Turrisi, 2004. Entomofauna, 25 (8): 118 (Italia).
Sphecodes geoffrellus, Schwarz & Gusenleitner, 2012. Entomofauna, 33 (8): 74.

From the comparison between *S. geoffrellus* (Kirby, 1802) and *S. campadellii* (the latter retained synonym of *S. geoffrellus* by Schwarz & Gusenleitner, 2012) and the descriptions provided by Hagens (1882) and Meyer (1919), as well as the identification keys provided by Warncke (1992) and Bogusch & Straka (2012), it is possible to point out many remarkable differences between the two considered species, the most important being:

- *S. campadellii* has flagellomeres, excluding the basal two, uniformly covered by sensilla on the ventral surface (Haarfleck, etc.), without the characteristic sequence of alternate notch and gibbous areas (similarly to that presented by Schwarz & Gusenleitner, 2012: fig. 1); instead *S. geoffrellus* has each of the median flagellomeres covered for at most 3/4 of the surface by a white spot of sensilla alternate with evident gibbous areas.

Moreover, *S. campadellii* belongs to the *S. pinguiculus* species-group, whereas *S. geoffrellus* belongs to a different group.

S. campadellii is deeply different from *S. geoffrellus*, and taking also into account the differences with the other species of the same group, *S. campadellii* Nobile et Turrisi, 2004 is valid species.

Sphecodes combai Nobile et Turrisi, 2004

Sphecodes combai, Nobile & Turrisi, 2004. Entomofauna, 25 (8): 119 (Italia).
Sphecodes marginatus, Schwarz & Gusenleitner, 2012. Entomofauna, 33 (8): 75.

From the comparison between *S. marginatus* and *S. combai* (the latter retained synonym of *S. marginatus* by Schwarz & Gusenleitner 2012) and the descriptions by Hagens (1882) and Meyer (1919), as well as the identification keys provided by Warncke (1992) and Bogusch & Straka (2012), it is possible to point out many remarkable differences between the two considered species, the most important being:

- *S. combai* has flagellomeres, excluding the basal two, uniformly covered by sensilla on the ventral surface (Haarfleck, etc.), without the characteristic sequence of alternate notch and gibbous areas (similarly to that presented by Schwarz & Gusenleitner, 2012: fig. 1); instead, in *S. marginatus*, each flagellomere, excluding the basal three, bears a basal white spot of sensilla alternate with an evident and well protruded distal gibbous area, as also clearly showed by Bogusch & Straka (2012: fig. 122);
- *S. combai* has the first metasomal tergite polished and shiny, due to the absence of microsculpture, with fine, superficial and scattered punctures (distance between punctures 1.0-3.0x puncture diameter); instead *S. banaszaki* (= *S. marginatus* ?) has the first metasomal tergite dull, due to the presence of microsculpture, with coarse, deep and dense punctures (distance between punctures 1.0-1.5x puncture diameter) (Nobile & Turrisi, 2004; Schwarz & Gusenleitner, 2012: fig. 4).

These strong differences between *S. combai* and *S. marginatus*, affecting important features of head and metasoma and clearly not running within intraspecific variation, have been overlooked by Schwarz & Gusenleitner (2012); moreover, while *S. combai* belongs to the *S. pinguiculus* species-group, *S. marginatus* belongs to the *S. miniatus* species-group (Bogusch & Straka, 2012).

S. combai is deeply different from *S. marginatus*, and taking also into account the differences with the other species of the same group, *S. combai* Nobile et Turrisi, 2004 is valid species.

Sphecodes marcellinoi Nobile et Turrisi, 2004

Sphecodes marcellinoi, Nobile & Turrisi, 2004. Entomofauna, 25 (8): 121 (Italia).
Sphecodes marginatus, Schwarz & Gusenleitner, 2012. Entomofauna, 33 (8): 75.

From the comparison between *S. marginatus* and *S. marcellinoi* (the latter retained synonym of *S. marginatus* by Schwarz & Gusenleitner, 2012)

and the descriptions provided by Hagens (1882) and Meyer (1919), as well as the identification keys provided by Warncke (1992) and Bogusch & Straka (2012), it is possible to point out many remarkable differences between the two considered species, the most important being:

• *S. marcellinoi* has flagellomeres, excluding the basal two, uniformly covered by sensilla on the ventral surface (Haarfleck, etc.), without the characteristic sequence of alternate notch and gibbous areas (similarly to that presented by Schwarz & Gusenleitner, 2012: fig. 1); instead, in *S. marginatus*, each flagellomere, excluding the basal three, bears a basal white spot of sensilla alternate with an evident and well protruded distal gibbous area, as also clearly showed by Bogusch & Straka (2012: fig. 122);

• *S. marcellinoi* has a slightly arcuate clypeus, nearly straight; conversely, *S. walteri* (= *S. marginatus* ?) has a strongly arcuate clypeus;

• *S. marcellinoi* has fine, superficial and scattered punctuation on frons (distance between punctures about 2.0x puncture diameter); instead *S. banaszaki* (= *S. marginatus* ?) has coarse, deep and dense punctuation on frons (distance between punctures less than puncture diameter) (Nobile & Turrisi, 2004; Schwarz & Gusenleitner, 2012: fig. 2).

These strong differences between *S. marcellinoi* and *S. marginatus*, affecting important features of head and metasoma, clearly not running within intraspecific variation, have been overlooked by Schwarz & Gusenleitner (2012); moreover, while *S. marcellinoi* belongs to the *S. pinguiculus* species-group, *S. marginatus* belongs to the *S. miniatus* species-group (Bogusch & Straka, 2012).

S. marcellinoi is deeply different from *S. marginatus*, and taking also into account the differences with the other species of the same group, *S. marcellinoi* Nobile et Turrisi, 2004 is valid species.

Sphecodes walteri Nobile et Turrisi, 2004

Sphecodes walteri, Nobile & Turrisi, 2004. Entomofauna 25, (8): 122 (Italia).
Sphecodes marginatus, Schwarz & Gusenleitner, 2012. Entomofauna, 33 (8): 75.

From the comparison between *S. marginatus* Hagens, 1882 and *S. walteri* (the latter retained synonym of *S. marginatus* by Schwarz & Gusenleitner, 2012) and the descriptions provided by Hagens (1882) and Meyer (1919), as well as the identification keys provided by Warncke (1992) and Bogusch & Straka (2012), it is possible to point out many remarkable differences between the two considered species, the most important being:

• *S. walteri*, has flagellomeres, excluding the basal two, uniformly covered by sensilla on the ventral surface (Haarfleck, etc.), without the characteristic sequence of alternate notch and gibbous areas (similarly to that presented by Schwarz & Gusenleitner, 2012: fig. 1); instead in *S. marginatus*, each flagellomere, excluding the basal three, bears a basal white spot of sensilla alternate with an evident and well protruded distal gibbous area, as also clearly showed by Bogusch & Straka (2012: fig. 122);

• *S. walteri* has the clypeus strongly arcuate; instead, *S. marcellinoi* (= *S. marginatus* ?) has the clypeus slightly arcuate, nearly straight;

• *S. walteri* has irregular, coarse, deep and moderately dense punctuation on frons (distance between punctures 1.0–2.0x puncture diameter); instead *S. marcellinoi* (= *S. marginatus* ?) has nearly regular, fine, superficial and scattered punctuation on frons (distance between punctures about 2.0x puncture diameter).

These strong differences between *S. walteri* and *S. marginatus*, affecting important features of the head and clearly not running within intraspecific variation, have been overlooked by Schwarz & Gusenleitner (2012); moreover, while *S. walteri* belongs to the *S. pinguiculus* species-group, *S. marginatus* belongs to the *S. miniatus* species-group (Bogusch & Straka, 2012).

S. walteri is deeply different from *S. marginatus*, and taking also into account the differences with the other species of the same group, *S. walteri* Nobile et Turrisi, 2004 is valid species.

Sphecodes iosephi Nobile et Turrisi, 2004

Sphecodes iosephi, Nobile & Turrisi, 2004. Entomofauna, 25 (8): 123 (Italia).
Sphecodes marginatus, Schwarz & Gusenleitner, 2012. Entomofauna, 33 (8): 75.

From the comparison between *S. marginatus* and *S. iosephi* (the latter retained synonym of *S. marginatus* by Schwarz & Gusenleitner, 2012) and the descriptions provided by Hagens (1882) and Meyer (1919), as well as the identification keys pro-

vided by Warncke (1992) and Bogusch & Straka (2012), it is possible to point out many remarkable differences between the two considered species, the most important being:

- *S. iosephi* has flagellomeres, excluding the basal two, uniformly covered by sensilla on the ventral surface (Haarfleck, etc.), without the characteristic sequence of alternate notch and gibbous areas (similarly to that presented by Schwarz & Gusenleitner, 2012: fig. 1); instead, in *S. marginatus*, each flagellomere, excluding the basal three, bears a basal white spot of sensilla alternate with an evident and well protruded distal gibbous area, as also clearly showed by Bogusch & Straka (2012: fig. 122);
- *S. iosephi* has irregular, coarse, deep and very dense punctuation on frons (distance between punctures about equal to puncture diameter); moreover, the vertex is punctate-carinulate, with punctuation coarse, deep and dense; instead, in *S. marcellinoi* (= *S. marginatus* ?) the frons and vertex have punctuation, with nearly regular, fine, superficial and scattered punctuation (distance between punctures about 2.0x puncture diameter);
- in *S. iosephi* the first metasomal tergite bears fine, superficial and scattered punctuation (distance between punctures 1.0-3.0x puncture diameter); instead *S. banaszaki* (= *S. marginatus* ?), has the first metasomal tergite bearing coarse, deep and dense punctures (distance between punctures 1.0–1.5x puncture diameter) (Nobile & Turrisi, 2004; Schwarz & Gusenleitner, 2012: fig. 4);
- *S. iosephi* has a stout genital capsule and the sclerified part of the gonostylus extends very slightly beyond the membranous part (Nobile & Turrisi, 2004: fig. 6; Schwarz & Gusenleitner, 2012: figs. 10a-10d); instead *S. banaszaki* (= *S. marginatus* ?) has the sclerified part of the gonostylus well extended beyond the membranous part (Nobile & Turrisi, 2004: fig. 3; Schwarz & Gusenleitner, 2012: figs. 7a–7d).

These strong differences between *S. iosephi* and *S. marginatus*, affecting important features of head and metasoma, clearly not running within intraspecific variation, have been overlooked by Schwarz & Gusenleitner (2012); moreover, while *S. iosephi* belongs to the *S. pinguiculus* species-group, *S. marginatus* belongs to the *S. miniatus* species-group (Bogusch & Straka, 2012).

S. iosephi is deeply different from *S. marginatus*, and taking also into account the differences with the other species of the same group, *S. iosephi* Nobile et Turrisi, 2004 is valid species.

Sphecodes tomarchioi Nobile et Turrisi 2004

Sphecodes tomarchioi, Nobile & Turrisi, 2004. Entomofauna, 25 (8): 124 (Italia).
Sphecodes marginatus, Schwarz & Gusenleitner, 2012. Entomofauna, 33 (8): 76.

From the comparison between *S. marginatus* and *S. tomarchioi* (the latter retained synonym of *S. marginatus* by Schwarz & Gusenleitner, 2012) and the descriptions provided by Hagens (1882) and Meyer (1919), as well as the identification keys provided by Warncke (1992) and Bogusch & Straka (2012), it is possible to point out many remarkable differences between the two considered species, the most important being:

- *S. tomarchioi* has flagellomeres, excluding the basal two, uniformly covered by sensilla on the ventral surface (Haarfleck, etc.), without the characteristic sequence of alternate notch and gibbous areas (similarly to that presented by Schwarz & Gusenleitner, 2012: fig. 1); instead, in *S. marginatus*, each flagellomere, excluding the basal three, bears a basal white spot of sensilla alternate with an evident and well protruded distal gibbous area, as also clearly showed by Bogusch & Straka (2012: fig. 122);
- *S. tomarchioi* has irregular, coarse, deep and very dense punctuation on frons and vertex (distance between punctures less than puncture diameter); instead *S. marcellinoi* (= *S. marginatus* ?) has frons and vertex bearing nearly regular, fine, superficial and scattered punctuation (distance between punctures about 2.0x puncture diameter);
- *S. tomarchioi* has the first metasomal tergite bearing fine, superficial and scattered punctuation (distance between punctures 2.0–3.0x puncture diameter); instead *S. banaszaki* (= *S. marginatus* ?) has the first metasomal tergite with coarse, deep and dense punctures (distance between punctures 1.0-1.5x puncture diameter) (Nobile & Turrisi 2004; Schwarz & Gusenleitner, 2012: fig. 4);
- the genital capsule of *S. tomarchioi* (Nobile & Turrisi, 2004: fig. 7; Schwarz & Gusenleitner, 2012: figs. 11a–11d) is significantly differentiated from that of *S. marginatus*, due to the presence of a long, slender and strongly curved toward inner distal process of the sclerified part of gonostylus; instead,

in *S. marginatus* this process is absent, with the distal sclerified part of gonostylus stouter and straight toward apex (Hagens, 1882: fig. 18; Warncke, 1992: fig. 32; Bogusch & Straka, 2012: figs. 165, 166).

These strong differences between *S. tomarchioi* and *S. marginatus*, affecting important features of head and metasoma, clearly not running within intraspecific variation, have been overlooked by Schwarz & Gusenleitner (2012); moreover, while *S. tomarchioi* belongs to the *S. pinguiculus* species-group, *S. marginatus* belongs to the *S. miniatus* species-group (Bogusch & Straka, 2012).

S. tomarchioi is deeply different from *S. marginatus*, and taking also into account the differences with the other species of the same group, *S. tomarchioi* Nobile et Turrisi, 2004 is valid species.

CONCLUSIONS

Schwarz & Gusenleitner (2012) studied and compared the type specimens of all the seven species described by Nobile & Turrisi (2004), taking into account the dimensions of the body, the features of genital capsule and, in some cases, the distal part of the antenna. Schwarz & Gusenleitner (2012) criticized the bad preparation of the genital capsules, as well as the drawings provided by Nobile & Turrisi (2004); moreover, they retained some specimens, namely those belonging to *S. walteri* and *S. iosephi*, too early collected, thus with cuticle of some parts, useful for identification, too soft (the last flagellomeres and some detail of the genital capsule). With regard to the drawings provided by Nobile & Turrisi (2004), we reject the statement by Schwarz & Gusenleitner (2012), because if a strict comparison is made between these drawings and the photographs provided by Schwarz & Gusenleitner (2012) and Bogusch & Straka (2012), it is possible to ascertain not only the substantial adherence of the features showed in the drawings with the photographs, but also the usefulness of these features for identification of the species, and clearly appears the paradox of having a species, namely *S. marginatus* (sensu Schwarz & Gusenleitner, 2012), including the additional six taxa described by Nobile & Turrisi (2004), too variable and definitely without clear diagnostic features, thus introducing an inacceptable taxonomic treatment of the species concept within *S. pinguiculus* species-group.

ACKNOWLEDGMENTS

We would to thank Schwarz M. and Gusenleitner F. for giving us the opportunity to point out the validity of the species described in Nobile & Turrisi (2004) especially through the usefulness of the antenna morphology. Thanks also to Schmidt S. (Zoologische Staatssammlung München, Germany) for allowing the examination of the type material.

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Biodiversity Journal, 2013, 4 (4): 571-580

On the presence of *Dreissena polymorpha* Pallas, 1771 and *Sinanodonta woodiana woodiana* (Lea, 1834) in Sicily (Bivalvia)

Maria Stella Colomba[1*], Fabio Liberto[2], Agatino Reitano[3], Rosario Grasso[4], Davide Di Franco[5] & Ignazio Sparacio[6]

[1]Università di Urbino "Carlo Bo", Dipartimento di Scienze Biomolecolari, via Maggetti 22 (loc. Sasso) - 61029 Urbino (PU), Italy
[2]Strada Provinciale Cefalù - Gibilmanna, 93 - 90015 Cefalù, Palermo, Italy; e-mail: fabioliberto@alice.it
[3]Via Gravina, 77 - 95030 Tremestieri Etneo, Catania, Italy; e-mail: tinohawk@yahoo.it
[4]Dipartimento di Scienze Biologiche, Geologiche ed Ambientali, Università degli Studi di Catania, Via Androne, 81 - 95124 Catania, Italy; e-mail: rosagra@unict.it
[5]Via S. Maria dei Monti 38/D - 95030, Gravina, Catania, Italy; email: davide_di_franco@hotmail.it
[6]Via E. Notarbartolo 54 int. 13 - 90145 Palermo, Italy; e-mail: isparacio@inwind.it
[*]Corresponding author: mariastella.colomba@uniurb.it

ABSTRACT In this paper we report on the presence of two non-native and invasive species of bivalve mollusks in Sicily: *Sinanodonta woodiana woodiana* (Lea, 1834) (Bivalvia Unionidae) native to East Asia and *Dreissena polymorpha* (Pallas, 1771) (Bivalvia Dreissenidae) native to the Ponto-Caspian area, with a particular focus on how the presence of these alien species can lead to imbalances in the delicate equilibrium of Sicilian freshwater invertebrates and, above all, does threaten the existence of *Unio elongatus gargottae* Philippi, 1836 an island's native bivalve suffering from strong rarefaction.

KEY WORDS invasive species; bivalve mollusks; aquatic biotopes; Sicily.

Received 28.11.2013; accepted 20.12.2013; printed 30.12.2013

INTRODUCTION

The problem of non-native and invasive species, and particularly those who have settled in the Euro-Mediterranean area, has become in recent years extremely interesting in relation to the large number of species that have been reported.

All habitats and all groups of animals and plants are affected by this phenomenon and the impact on native ecosystems is almost always devastating (Bogan, 1993; Lydeard et al., 2004).

The sicilian aquatic biotopes are not an exception, with an increasing colonization by allochthonous organisms observed both in historical times that during the last few decades, for the freshwater mollusks:

- *Haitia acuta* (Draparnaud, 1805): Cianfanelli et al., 2007)
- *Radix auricularia* (Linnaeus, 1758): Liberto et al., 2010
- *Corbicula fluminea* (Müller, 1774): Mienis, 1991
- *Anodonta* sp.: Zettler & Richard, 2003
- *Potamopyrgus antipodarum* (J.E. Gray, 1843): Zettler & Richard, 2003; Bodon et al. 2005; Cianfanelli et al., 2007
- *Melanoides tuberculatus* (O.F. Müller, 1774): Reitano et al., 2007
- *Helisoma duryi* (Wetherby, 1879): Manganelli et al. 1995; Reitano et al., 2007
- *Ferrissia fragilis* (Tryon, 1863): Marrone et al., 2011.

Recently, some observations have indicated to us the presence in Sicily of *Sinanodonta woodiana woodiana* (Lea, 1834) (Bivalvia Unionidae) (personal observations; Distefano, 2013; Firrito, 2013) one of the most invasive aquatic macroinvertebrate species. Subsequent research carried out in the field allowed to highlight the presence of another allochthonous: *Dreissena polymorpha* (Pallas, 1771) (Bivalvia Dreissenidae).

ACRONYMS. The materials used for this study are deposited in the following private collections: R. Grasso collection, Dipartimento di Scienze Biologiche, Geologiche ed Ambientali, Università degli Studi di Catania, Italy (CGR); S. Giglio collection, Cefalù, Italy (CGS); F. Liberto collection, Cefalù, Italy (CL); A. Reitano collection, Tremestieri Etneo, Italy (CR); I. Sparacio collection, Palermo, Italy (CS).

MATERIALS AND METHODS

All specimens were collected by sight directly in the field. Photographs were taken with a digital camera. Voucher specimens were stored in collections indicated below. Toponyms (place-names) are reported following the Portale Cartografico Nazionale (PCN, http://www.pcn.minambiente.it /PCN/), Map IGM 1:25000. Taxonomical references are based on the checklist of "Fauna Europaea", version 2.0 (Araujo 2009a, 2009b) available at: http://www.faunaeur.org.

RESULTS

BIVALVIA
DREISSENIDAE

Dreissena polymorpha Pallas, 1771
Zebra mussel

EXAMINED MATERIAL. Italy, Sicily, Ragusa, Lago di Santa Rosalia, 385 m, 36°59'19"N 14°46'47"E, 29.IX.2012, 3 specimens with soft tissues (CR) (Figs. 1, 2).

DESCRIPTION. Mytiliform bivalve (25–35 mm in size) with relatively flattened ventral margins, roundend dorsal margins and pointed umbo. Brownish-yellowish in color with dark and light coloured zigzag banding. Viewed from the inside, the shell has a large septum to which the anterior adductor and retractor muscles are attached (Killeen et al., 2004) (Figs. 3–7).

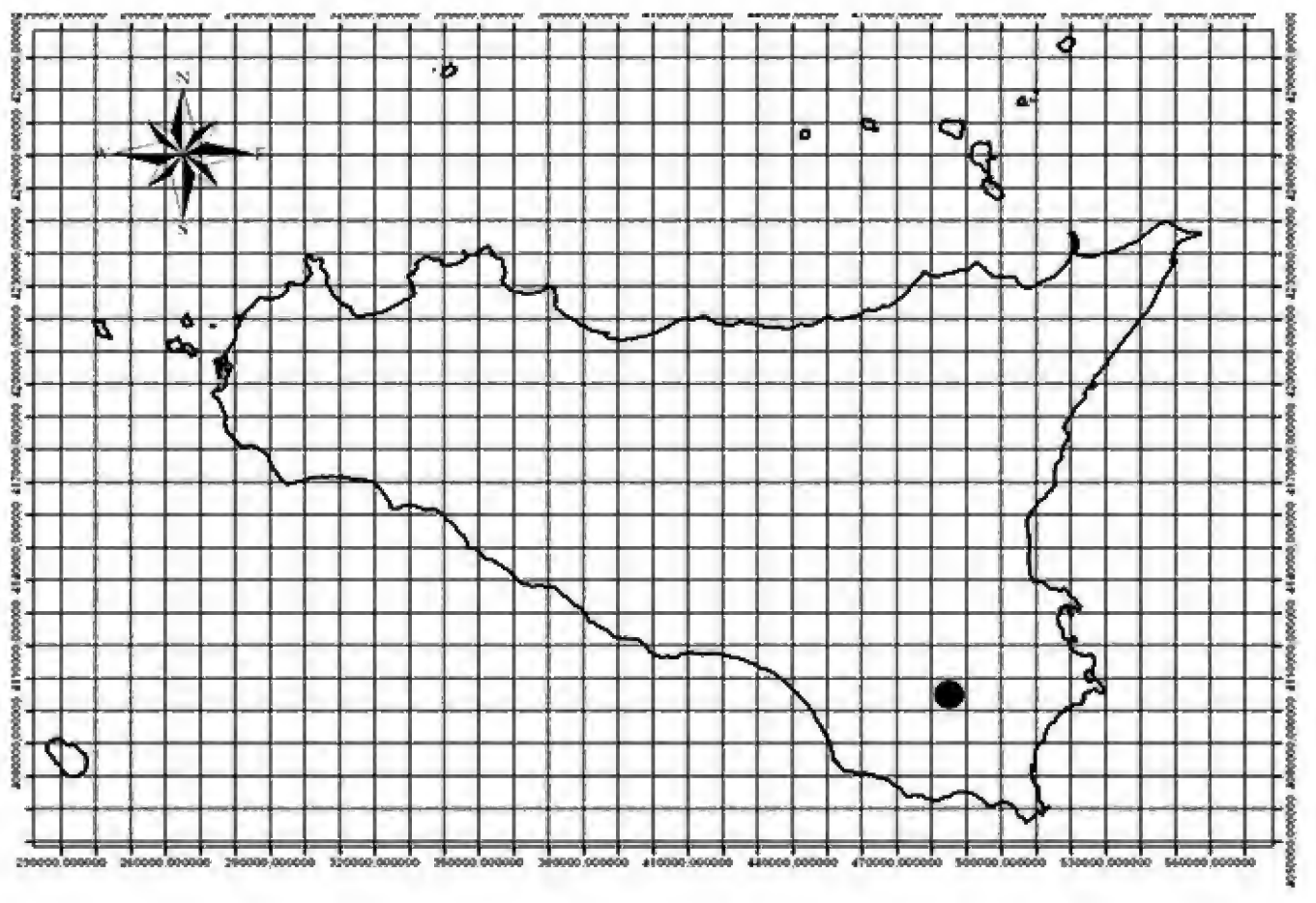


Figure 1. Current geographic distribution of *Dreissena polymorpha* and *Sinanodonta woodiana* in Sicily. Dot: Ragusa, Lago di Santa Rosalia.

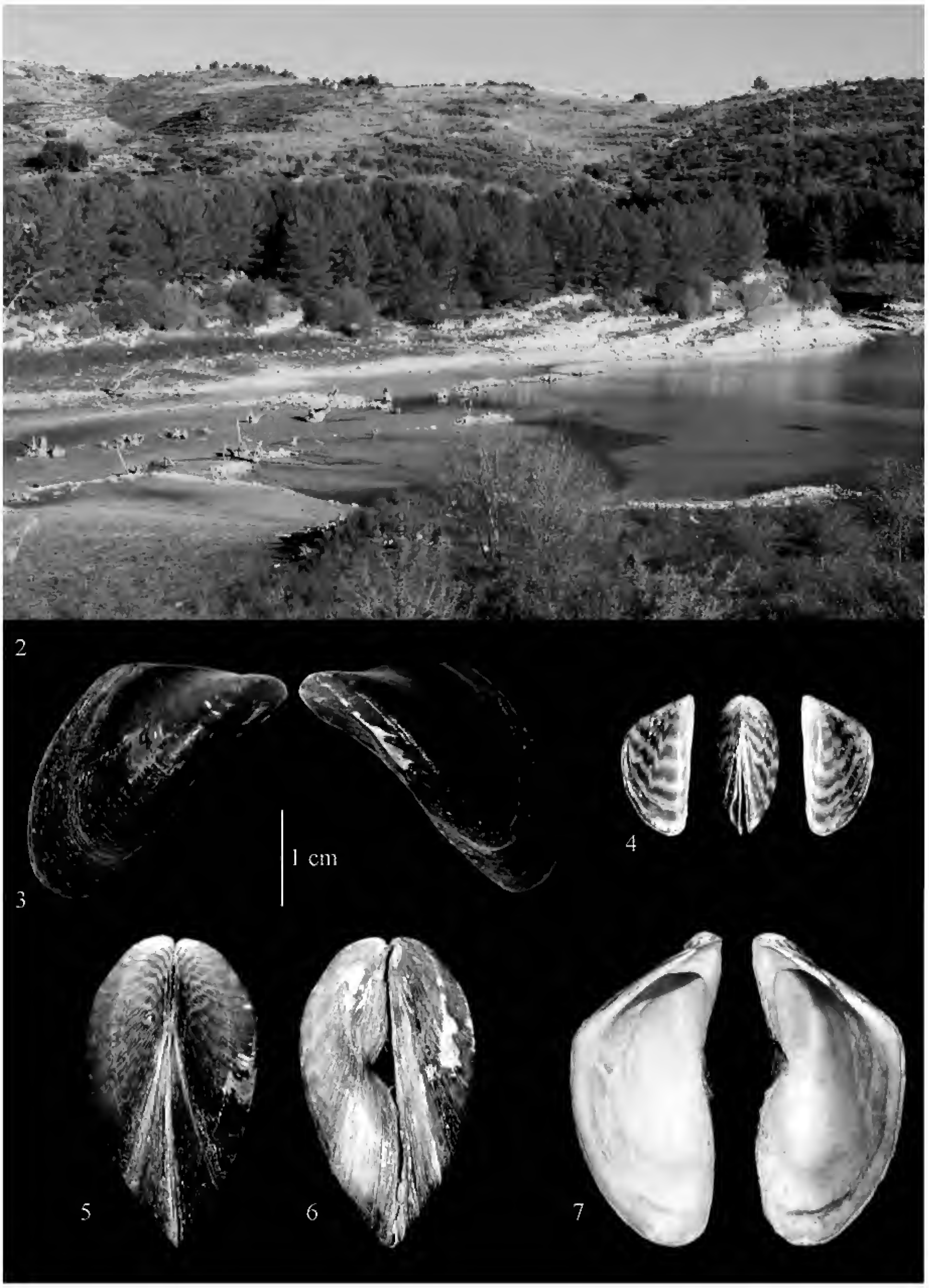


Figure 2. Sicily, Ragusa: Lago di Santa Rosalia. Figures 3–7. *Dreissena polymorpha* from Sicily, Lago di Santa Rosalia.

DISTRIBUTION AND BIOLOGY. *D. polymorpha* is native to the Ponto-Caspian Region of Eastern Europe. Its invasion history dates back to the late 18th century in Russia and during the 19th century the species spread out in most of inner water systems of central and western Europe (Kinzelbach, 1992; Strayer & Smith,1993; Minchin et al., 2002); it has been reported also in Spain, in the southern part of the Ebro river (Araujo & Halcon, 2001; Araujo et al., 2004) and in Northern Ireland (Millane et al., 2008). In 1988, it first appeared in the Great Lakes of North America and rapidly spread along the Mississippi River (Strayer, 1991; Strayer et al., 1994; Strayer & Smith, 1996; Strayer et al., 1998; May et al., 2006). It was found for the first time in Italy in 1969 in Lake Garda (Giusti & Oppini, 1973; Franchini, 1976). Subsequently, *D. polymorpha* has been reported for several lakes of Northern Italy (Bianchi et al., 1974; Camusso et al., 2001; Morpurgo & Thaler, 2002; Dalfreddo & Maiolini, 2003, Roncaglio & Borsani, 2005) and central Italy (Spilinga et al., 2000; Bodon et al., 2005; Lori & Cianfanelli, 2006).

D. polymorpha is characterized by a high fecundity, ranging from about 30,000 to 40,000 eggs/female per year. Veliger larvae lead a planktonic life for, usually, 8-10 days, then settle and attach to the bottom by byssal filaments. The average life span is 3-6 years. Adults anchored to the substratum can reach a high density, in the order of thousands per square meter. Hence, filtrating capacity of zebra mussels usually cause severe damages at both local and system-levels, including changes in species composition and density of native benthic invertebrates; decreases in phytoplankton and zooplankton densities, in chlorophyll concentration and suspended matter; increase in water transparency with a consequent growth of macrophytes (Mackie et al., 1991; Therriault et al., 2013).

REMARKS. In September 2013 a population of *D. polymorpha* was found in the artificial Lake Santa Rosalia (Ragusa, Sicily, Italy), which is the first record of *D. polymorpha* in Sicily. Water discharge due to introduction of fish was probably the main vector that made it possible the spread of *D. polymorpha* in the lake. As noted, the species seems to be successfully established in the lake basin with large aggregations (druses) and it is likely that a future further increase in its spreading rate and diffusion will occur leading these organisms to colonize the basin of Irminio river and other basins. Indeed, Lake Santa Rosalia is connected to Scicli by a 16 km aqueduct and two other pipelines will be built to connect the Lake to Marina di Ragusa and Santa Croce Camerina (Ragusa), which might behave as highways for the diffusion of the species.

According to the Global Invasive Species Database of IUCN (2006) *D. polymorpha* is one of the 100 World's Worst Invasive Alien Species, and its negative impacts on the ecosystem and especially its economical damage are well known.

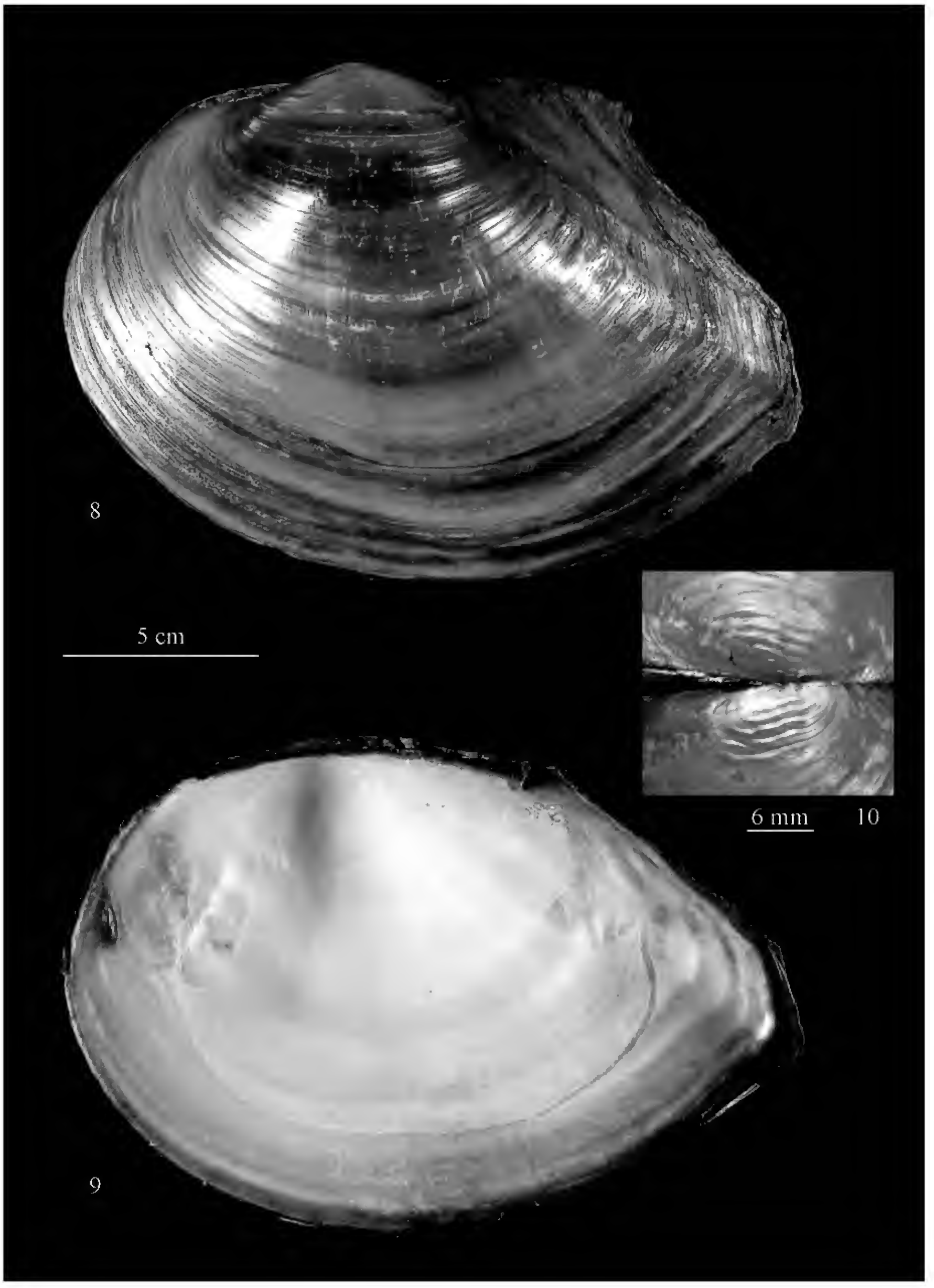
UNIONIDAE

Sinanodonta woodiana woodiana (Lea, 1834)
Chinese pond mussel

EXAMINED MATERIAL. Italy, Sicily, Ragusa, Lago di Santa Rosalia, 36°59'13"N 14°46'50"E, 385 m, 21.VII.2012, 1 specimen (CGR); Italy, Sicily, Ragusa, Lago di Santa Rosalia, 36°59'19"N 14°46'47"E, 385 m, 29.IX.2012, 4 specimens (CR); idem, legit Reitano A., 3 specimens (CL); idem, legit Reitano A., 3 specimens (CGS); idem, legit Reitano A., 3 specimens (CS) (Figs. 8–10).

DESCRIPTION. From a morphological standpoint, *S. woodiana* collected in Sicily show typical characters of the species: wide shell (maximum length ca. 300 mm), with deeply rounded ventral margin, surface irregularly rippled to corrugated, umbonal rugae prominent widely spaced, subconcentric or slightly transverse ripples without prominent nodules, posterior pedal retractor scar very narrow; hinge without teeth. The size of some specimens exceed 190 mm in length.

DISTRIBUTION AND BIOLOGY. *S. woodiana* is a species of East Asia (Baba, 2000) that has recently been reported as being invasive worldwide. The expansion of *S. woodiana*'s range began in the second half of the twentieth century. To date, *S. woodiana* can be found in the Indonesian islands (Djajasasmita, 1982), Central America (Watters, 1997), Europe (Hungary: Petró, 1984; Romania: Sárkány-Kiss, 1986; France: Girardi & Ledoux, 1989; Slovakia: Košel, 1995; Czech Republic: Beran, 1997; Austria: Reischutz, 1998; Poland: Bohme, 1998; Ukraine: Yurishinets & Korniushin, 2001; Germany: Glöer & Zettler, 2005; Serbia:



Figures 8–10. *Sinanodonta woodiana woodiana* from Sicily, Lago di Santa Rosalia.

Paunovic et al., 2006; Montenegro: Tomović et al., 2013; see also Sárkány-Kiss et al., 2000; Kraszewski, 2007; Douda et al., 2012), and North America (Benson, 2011).

It was first reported in Italy in 1996 (Manganelli et al., 1998), and in about 15 years it formed colonies in many Italian regions: Emilia-Romagna and Latium (Manganelli et al., 1998; Fabbri & Landi, 1999; Lodde et al., 2005a; 2005b; Albano, 2006), Tuscany and Veneto (Niero, 2003; Lori & Cianfanelli, 2006), Marche, Piedmont, Umbria and Lumbardy (Solustri & Nardi, 2006), and Campania (De Vico et al., 2007); in Sicily, *Anodonta* sp. was recorded by Zettler & Richard (2003) and, recently, the presence of *S. woodiana* was reported in some web pages from Ragusa, Lago di Santa Rosalia (Distefano, 2013; Firrito, 2013).

S.woodiana larvae, like all Unionidae (Castagnolo et al., 1980; Aldridge & McIvor, 2003), go throught an obligatory parasitic stage (known as glochidium); glochidia larvae parasitize, by clinging with a kind of hook, the fins or gills of fish for several days to weeks; afterwards they detach from the host and fall to the bottom where mature and start to conduct a free life. The great success of *S. woodiana* has been attributed to the worldwide introduction for commercial purposes of its sympatric fish hosts (mainly carp species from East Asia) (Watters, 1997). *S. woodiana* is a broad generalist, and it may parasitize even on novel native hosts (Kiss,1995; Watters, 1997; Sárkány-Kiss et al., 2000; Douda et al., 2012), in addition both juveniles and adults of *S. woodiana* can successfully cope with a wide range of environmental conditions. Thermal conditions, water flow and substrate characteristics mostly determine the distribution and density of *S. woodiana* (Kraszewski & Zdanowski, 2007). According to Demayo et al. (2012), this species prefers habitats with higher temperatures (the optimal thermal conditions vary within 10 and 35ºC).

REMARKS. The presence of *S. woodiana* in Lake Santa Rosalia, an artificial basin for irrigation built in 1980 on Irminio river (Ragusa, South-eastern Sicily), may have been caused by the introduction of several species of fish from farms to promote sport fishing. The discovery in 2012 of specimens larger than 190 mm, aged more than 8 years, allows us to hypothesize that the entrance of *S. woodiana* in the lake took place at least 10 years ago.

According to the Global Invasive Species Database of IUCN (2006), *S. woodiana* is one of the 100 World's Worst Invasive Alien Species.

DISCUSSION AND CONCLUSIONS

Generally, the introduction of alien species in a given territory produces nearly always negative effects on the presence and population dynamics of native species. Particularly, the filtrating capacity of *D. polymorpha* and *S. woodiana* may affect organic matter pathways within the sediment and the water column with serious consequences for the surrounding ecosystem (Vaughn & Hakenkamp, 2001; Kraszewski & Zdanowski, 2007).

In Sicily, the increase in population density of these species and the diffusion to other lakes and rivers can be expected to produce a negative impact on native sedentary benthic invertebrates. For example, native unionid mussels may be threatened by competition for food, space and hosts, as has already been observed in other Italian regions (Fabbri & Landi, 1999; Niero, 2003).

In Sicily, the presence of the genus *Unio* Philipson, 1788, the only major bivalve native to the island is particularly critical. According to Bodon et al. (2005) and Prie et al. (2012) two species of *Unio* are present in Italy, *Unio pictorum* in the Isonzo Basin and *Unio elongatus* (Pfeiffer, 1825) in the rest of the Italian territory, including Sicily (the latter previously reported also as *U. mancus* Lamarck, 1819). *Unio* populations from Sicily are considered by Zettler & Richard (2003) and Araujo (2009a) as belonging to the endemic subspecies *U. elongatus gargottae* Philippi, 1836.

In the second half of the nineteenth century, many taxa were described or reported for the genus *Unio* in major rivers and lakes of Sicily (see for example: Philippi, 1836- 1844; Benoit, 1875, 1882; Monterosato, 1896; Castagnolo et al., 2002).

During the twentieth century the records of *Unio* in Sicily were rare (Naselli-Flores et al., 1996; personal observations), thus indicating a dramatic decline in the distribution and abundance of *Unio* populations mainly caused by pollution and improper wetland management (drainage, channel alterations, water intake, cementification of riverbanks, or total destruction of habitats). However, some observations in the field have allowed

to testify the presence of *U. elongatus gargottae* in a few basins of western Sicily with small but stable populations monitored successfully since 2003 to 2007. Now, this survival strategy of the native *Unio* could be threatened by the presence and strong invasiveness of *S. woodiana*.

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