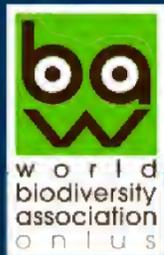


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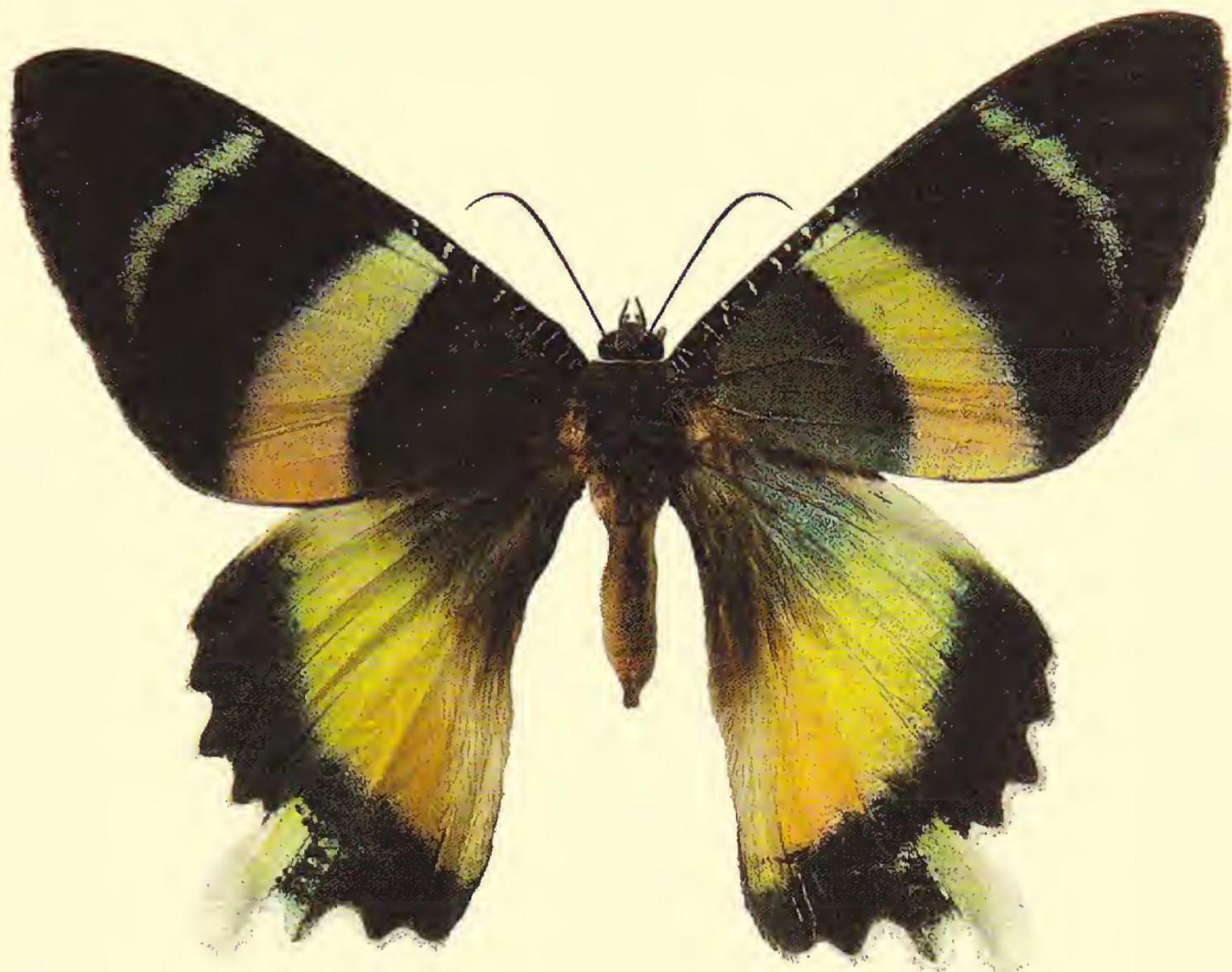
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FOR NATURALISTIC RESEARCH
AND ENVIRONMENTAL STUDIES



Alcides privitera Vinciguerra, 2006 - Sorong, Indonesia

The genus *Alcides* Hübner, [1822] (Lepidoptera Uraniidae). The Family Uraniidae contains some of the most beautiful moths known to lepidopterists. It includes four subfamilies (Auzeinae, Epipleminae, Microniinae and Uraniinae), some ninety genera and about seven hundred species. This is a tropical family which is found in Africa, the Americas, and the Indo-Australian region. Diurnal and nocturnal species are found within this family and the day-flying ones are usually vibrantly colored and covered with iridescent scales and tails which have led many to mistake them for butterflies. Several species are known to be migratory, but very little is known about the details of these migrations. One of these species was once considered by the French lepidopterist Jean Baptiste Antoine Dechauffor de Boisduval (1799-1879) as "... the most beautiful of the creation." The subfamily Uraniinae contains seven genera. Three of them include species of moderate size and with resemblance to those in the Microniinae, while the other four include large and strongly tailed species. Their hosts include plants belonging to the Euphorbiaceae and it appears that some of these moths are models for certain species of some butterfly families. Among the Uraniinae we find the swallow tail moths of the genus *Alcides* Hübner, which are brightly colored and probably distasteful to birds and other potential predators. *Alcides* is distributed in the Indo-Australian region and contains ten species. Most fly by day but some have also been reported with crepuscular activity. Their larvae feed on leaves of plants in the genera *Endospermum* and *Omphalea* which carry certain poisons that appear to protect the caterpillars, and eventually the adults, from predation. The caterpillars pupate in a sparse cocoon in crevices or between dead leaves. The imagoes are characterized by front wings of triangular shape with a large, curved band that starts in the Costal margin, crosses the discal area, and ends in the anal angle. A second, parallel, thinner band, is also observed in the apical angle of the wing and starts also in the costal margin (without touching it), and goes to the anal angle, but vanishes before reaching it. The colors in both bands are always iridescent green or blue. The hind wings have a wide band in the discal area, and when the wings are spread it looks like a continuation of the large band in the forewing. This band also presents iridescent colors. All species in the genus present short tails in the hind wings. The current systematic knowledge and taxonomy of the genus is incomplete and the status of some taxa remains uncertain. Even though ten species have been described so far, the systematics of the group is still somehow uncertain. They are known from localities in Indonesia, Papua New Guinea, and the Moluccas, New Hebrides and Solomon Islands. However, the only exception to this distribution, the species *Alcides metaurus* (Hopffer) [= *A. zodiaca* (Butler)], is endemic of Queensland, Northern Australia. The illustrated specimen is the Holotype of *Alcides privitera* Vinciguerra. This is a beautiful species somehow similar to *A. metaurus* but has been found in Sorong, Irian Jaya, Indonesia.

Description of a new species of *Amphidromus* Albers, 1850 from Sumba, Indonesia (Gastropoda Pulmonata Camaenidae)

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ABSTRACT

The camaenid *Amphidromus* (*Syndromus*) *iunior* n. sp. from an isolated forest in the east of Sumba island in the Indonesian archipelago is described. Its closest named relative is *Amphidromus* (*Syndromus*) *abbasi* Chan et Tan, 2010, and some conchological features are common for both species. However, the new species is smaller, with consistent differences in shell thickness, pattern and pigmentation.

KEY WORDS

Camaenidae; *Amphidromus iunior* n. sp.; Sumba; Indonesia.

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INTRODUCTION

The polyphyletic family Camaenidae Pilsbry, 1895 (Scott, 1996) is distributed in three distinct clades (Wade et al., 2007), geographically separated mainly by the Pacific Ocean. Synapomorphies amongst the members of the different clades are absent, and the family is characterized by the absence of vaginal accessory organs found in other members of the otherwise monophyletic Helicoidea Rafinesque, 1815 (Wade et al., 2006). According to molecular techniques employed by Wade et al. (2007), the Australasian fraction of this family was found to be synonymous with Bradybaenidae Pilsbry, 1934.

Amongst the most speciose genera in this Australasian clade is the arboreal *Amphidromus* Albers, 1850. Extending over a wide geographical area from India to Australia (Laidlaw & Solem, 1961; Solem, 1983), it is divided into two or three subgenera historically differentiated mostly through conchological characteristics. Of these, the subgenus *Syndromus* Pilsbry, 1900 (comprising the newly described species discussed herein) consists of animals with small shells (20-40 mm high, 10-25 mm wide) and a short epiphallic caecum, which according to Lok & Tan (2008) includes one dex-

tral, one enantiomorphic, and 44 sinistral taxa. New species have recently been assigned to this subgenus by Severns (2006), Dharma (2007) and Chan & Tan (2010), though Scucharit & Panha (2006) shed doubt on the taxon's monophyly. A new species of *Syndromus* collected on east Sumba is described herein.

ABBREVIATIONS. Depositories: BP = collection of Barna Páll-Gergely, Mosonmagyaróvár, Hungary; DC = collection of David P. Cilia, Santa Venera, Malta; FMNH = Field Museum of Natural History, Chicago, Illinois; HUI = Hebrew University of Jerusalem, Israel; JA = collection of John Abbas, Jakarta, Indonesia; MNHN = Muséum National d'histoire Naturelle, Paris, France; NHMUK = Natural History Museum, London, United Kingdom; NMNH = National Museum of Natural History, Mdina, Malta; TAU = Zoological Department of Tel Aviv University, Israel. Morphology and anatomy: D = diameter; H = height; H/D = height to diameter ratio; min. = minimum value; med. = median value; max. = maximum value.

MATERIALS AND METHODS

The mean value of two readings for height (in-

cluding the reflected peristome), width (including the reflected peristome) and oblique apertural height for a random selection of 21 adult specimens was taken using a dial caliper of a resolution of 50 μ m. Results were rounded off to the nearest 0.1mm. Whorls were counted, including the nucleus. Statistical data was formulated and used together with peculiar morphological characteristics to differentiate the new species from similar ones, most significant of which is the geographically and phylogenetically close *A. abbasi* Chan et Tan, 2010. Topotypical adult shells of the latter were similarly measured and morphometrically compared to those of the new species. Systematics in the present paper follow Bouchet & Rocroi (2005).

SYSTEMATICS

Superfamily Helicoidea Rafinesque, 1815
 Family Camaenidae Pilsbry, 1895
 Subfamily Camaeninae Pilsbry, 1895
 Genus *Amphidromus* Albers, 1850
 Subgenus *Syndromus* Pilsbry, 1900
 Type species *Helix contraria* Müller, 1774

Amphidromus (Syndromus) iunior n. sp.

EXAMINED MATERIAL. Holotype: small forest close to Mangili village, east part of Sumba Island, East Nusa Tenggara, Indonesia (-10°05'32"N, 120°42'08"E), at an altitude of about 560 m above sea level, leg. JA: MNHN 23265. Paratypes (20 specimens): same data as holotype: DC RG217 (3); HUIJ 53490 (2); JA unreg. (3); MNHN 23266 (2); FMNH 328102 (2); TAU 75175 (1); NHMUK 20120044 (3); NMNH unreg. (2); BP unreg. (2).

DESCRIPTION OF HOLOTYPE (Figs. 1-6). Sinistral, conical, thin, smooth, glossy and translucent shell, 14 mm wide and 28 mm tall. Dull yellow base colour intensifying towards the ultimate whorl, with brown markings in the form of two well-defined subperipheral spiral striae, faint subordinate ones, and blurred spaced vertical columns featuring a reduction in their colour intensity and frequency towards the final whorl. These columns are interrupted halfway through by a perpendicularly crossing spiral band lacking in pigment, another of which is present just beneath the suture. Nucleus dark purple-brown, its colour descending and fading out along the apical whorl just above the suture,

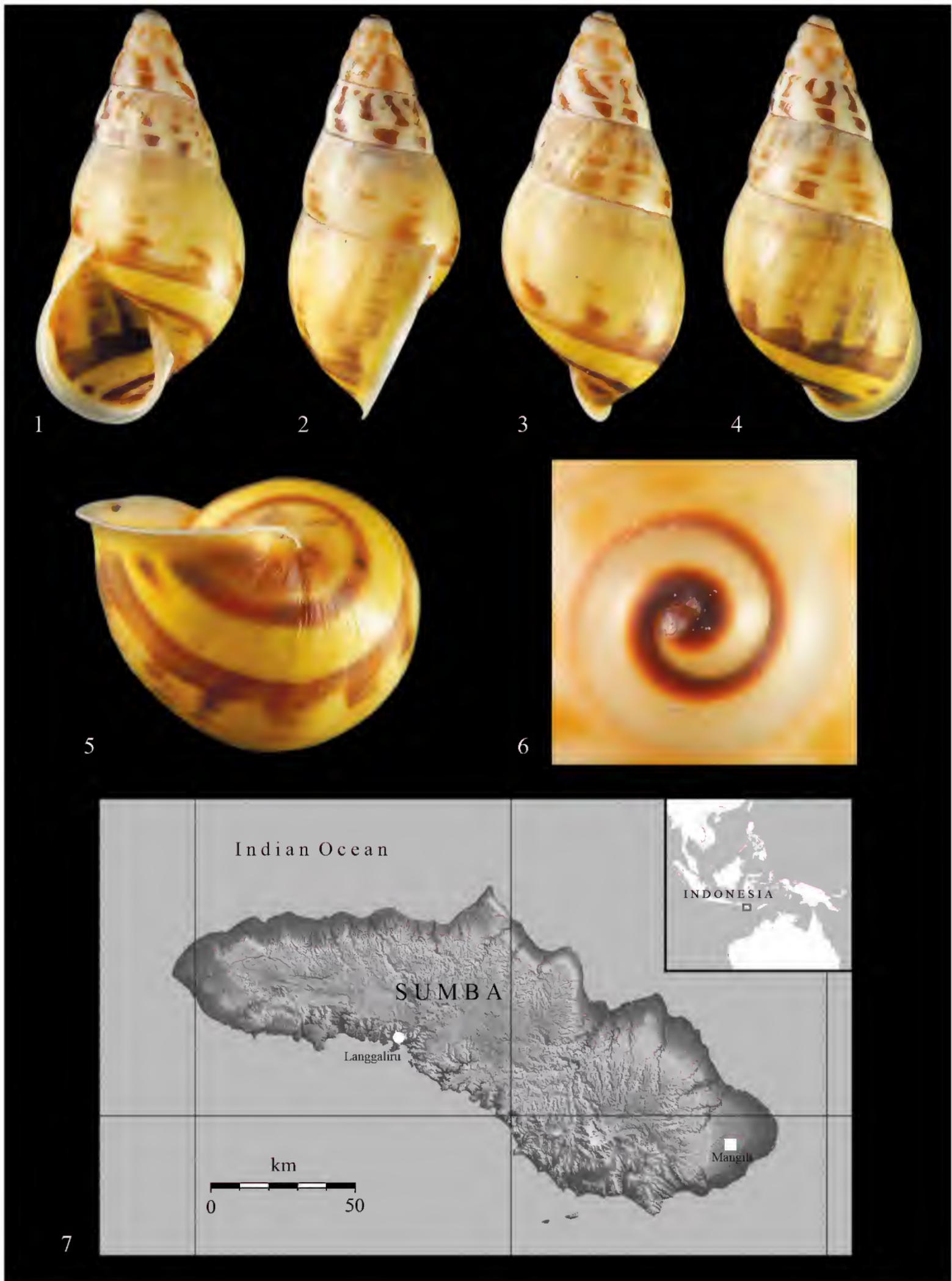
appearing in top view as a dark spiral over the pale base. The number of the moderately convex whorls is between six and seven, the final of which is smoothly rounded. Aperture is vertically elongated and teardrop-shaped, its height constituting about 40% of the shell's total. Peristome fragile and expanded, only thickened and reflected at its columellar side. The reflected segment is not completely fused to the base of the ultimate whorl, in most cases leaving an obliquely oriented pinhole umbilicus. Internal aspect glossy, with the brown markings showing through.

VARIABILITY. The width varies from 13 to 16 mm and the height from 23 to 34 mm (Figs. 8-22; Table 1). Whereas the subperipheral spiral striae are always present, very brief interruptions occasionally occur. Additional spiral striae may unusually take the form of parallel brown dashes that also coincide in a perpendicular direction, forming columns.

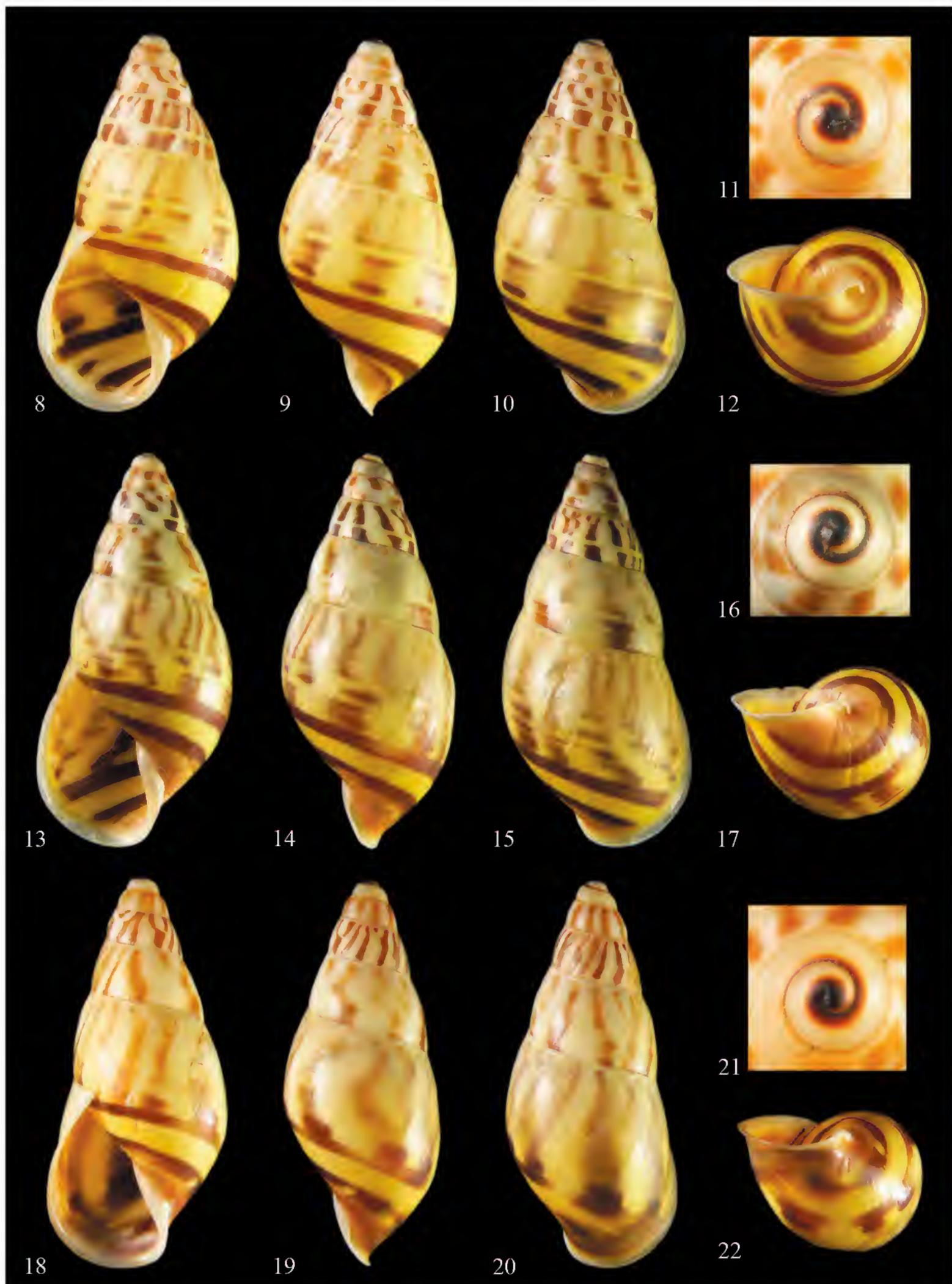
ETYMOLOGY. The species is named for the youngest son of John Abbas, who encountered this hitherto unrecorded species during one of his expeditions. Another species of *Amphidromus* named for John, *A. (S.) abbasi*, is closely related to this species, but is significantly larger, amongst other differences. The meaning of *iunior* therefore takes on another meaning, referring to the relative size of the snail (*iunior* is the comparative form of *iuvenis*, meaning young in Latin).

DISTRIBUTION. Only known from the type locality.

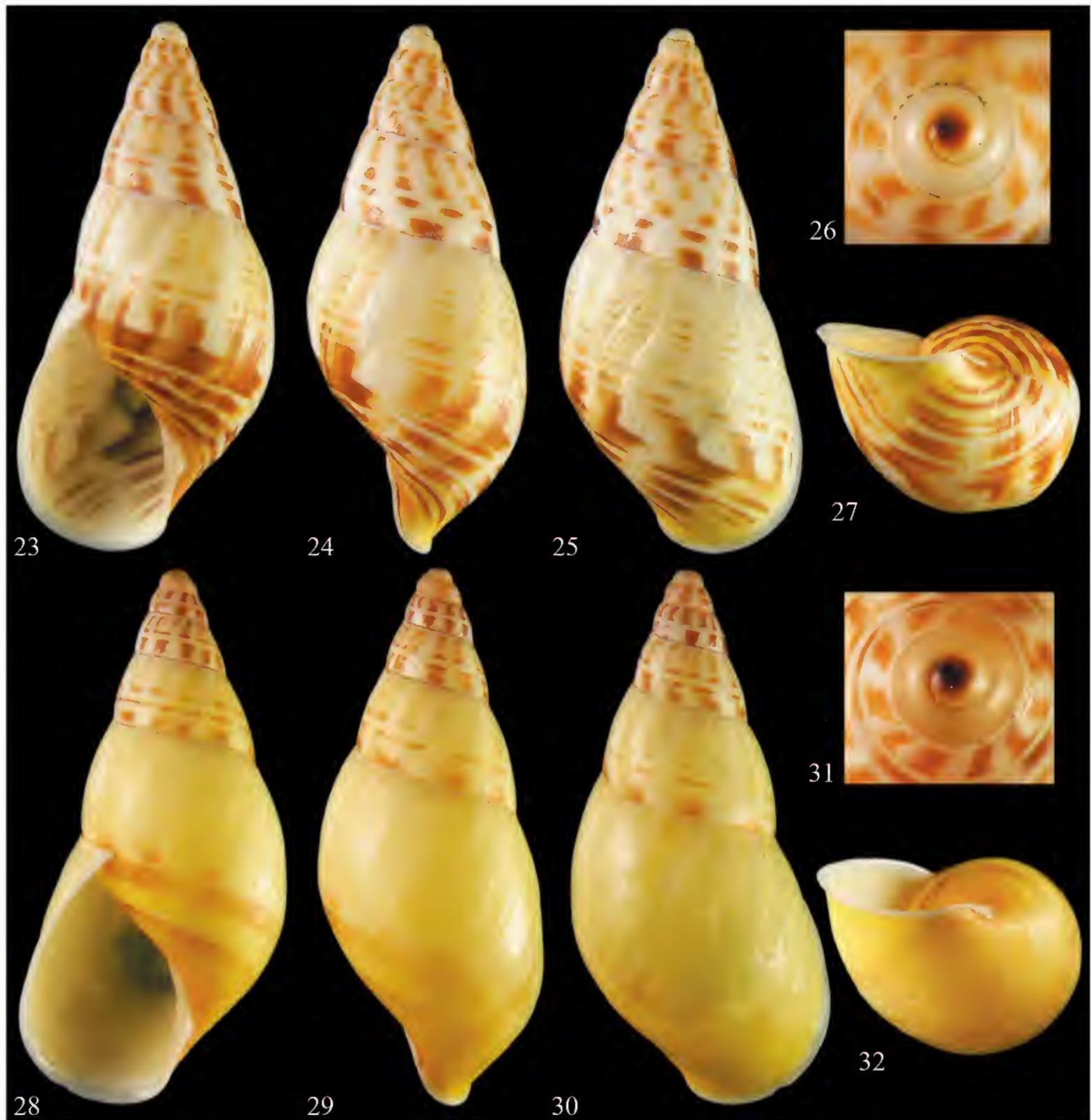
COMPARATIVE NOTES. Two *Syndromus* (sensu lato) lineages are represented on the volcanic island of Sumba (Laidlaw & Solem, 1961; Chan & Tan, 2008, 2010). One lineage is represented by the *A. (S.) latestrigatus* Schepman, 1892 complex, including *A. (S.) latestrigatus sumbaensis* Fulton, 1896 and *A. (S.) floresianus* Fulton, 1897. The other lineage has only recently been discovered, with the first species described being *A. (S.) abbasi* (see Chan & Tan, 2008: p. 9, figs. 1.1-1.6; 2010: p. 247, figs. 1A-C). The new species, a second addition to this latter lineage, is currently only known from a patch of forest close to Mangili in eastern Sumba which lies on a Pleistocene limestone platform, and as such it is reproductively separated from *A. abbasi*, which is located at Langgaliru, about 122km in a northwesterly direction, in another isolated forest patch, here on a late Cretaceous formation of sedimentary and volcanic origin (Lytwyn et al., 2001).



Figures 1-6. Shells of *Amphidromus iunior* n. sp., small forest close to Mangili village, east part of Sumba island, East Nusa Tenggara, Indonesia - holotype. Figure 7. Map of Sumba showing the type localities of *A. iunior* n. sp. (Mangili, marked with a white square) and of *A. abbasi* (Langgaliru, marked with a white circle). Inset map shows the Indonesian archipelago.



Figures 8-22. Shells of *Amphidromus iunior* n. sp., small forest close to Mangili village, east part of Sumba island, East Nusa Tenggara, Indonesia. Figs. 8-12: paratype (FMNH 328102). Figs. 13-17: paratype (NHMUK 20120044). Figs. 18-22: paratype (DC RG217).



Figures 23-32. Shells of *Amphidromus abbasi*, forest in Langgaliru, southwest part of Sumba island, East Nusa Tenggara, Indonesia (-09°45'44"N, 119°38'33"E) (DC RGA698).

	H (mm)				D (mm)				H/D
	mean	min.	med.	max.	mean	min.	med.	max.	
<i>A. iunior</i> n. sp. holotype	27.65	NA	NA	NA	14.25	NA	NA	NA	1.94
<i>A. iunior</i> n. sp. type series	27.70	23.30	27.65	33.80	14.31	12.65	14.25	15.75	1.93
<i>A. abbasi</i> topotype	37.78	35.60	38.00	39.50	18.86	18.00	18.95	19.65	2.01

Table 1. Condensed data for shell measurements of the type series of *A. iunior* n. sp. (21 specimens) and a topotypical sample of *A. abbasi* (6 specimens - DC R.GA698) for comparison. All measurements are in mm.

A number of morphological characteristics are valuable in differentiating between the two species. *A. abbasi* is larger, with its smallest specimens exceeding by about 2mm in width and in height the largest *A. iunior* n. sp. specimens encountered (Table 1). The degree of conchological intraspecific variability in *A. abbasi* significantly exceeds that of the *A. iunior* n. sp. population. It is also thicker-shelled, reaching a degree of opacity lacking in *A. iunior* n. sp. (Figs. 23-32). The two subperipheral brown spiral bands may be extremely faint or absent in *A. abbasi*, and considerable variation in base colour occurs in the topotypic population, with a spectrum ranging from pink to yellow-brown, whereas this is never the case for *A. iunior* n. sp. The columnar markings in the former are frequently resolved to a series of dashes, in the latter they are generally fused and continuous, apart from the one main perpendicular interruption through which the yellowish base colour appears. The peristome of *A. abbasi* is more strongly reinforced and its degree of fusion at the columellar side is rarely incomplete; in *A. iunior* n. sp., the umbilical zone is always narrowly perforated (closed in *A. abbasi*). Pigmentation of the nucleus, a feature of significant diagnostic value amongst Nusa Tenggara *Syndromus*, according to Goldberg & Severns (1997), is always restricted to a spot in *A. abbasi*, varying between pinkish and brown, while in *A. iunior* n. sp. it is always dark, descending and diminishing gradually along the first whorl in proximity of the suture.

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REFERENCES

- Bouchet P. & Rocroi J.-P., 2005. Classification and nomenclator of gastropod families. *Malacologia*, 47: 1-397.
- Chan S.Y. & Tan S.K., 2008. On a new species of *Amphidromus* (*Syndromus*) (Gastropoda: Pulmonata: Camaenidae) from Sumba Island, Indonesia. *Occasional Molluscan Papers*, 1: 6-10.
- Chan S.Y. & Tan S.K., 2010. On two new species of *Amphidromus* (Gastropoda: Camaenidae) from the Lesser Sunda Islands, Indonesia. *The Raffles Bulletin of Zoology*, 58: 245-249.
- Dharma B., 2007. Report on fossil *Amphidromus* and description of new species and subspecies of recent and fossil *Amphidromus* from Indonesia (Gastropoda, Pulmonata: Camaenidae). *Schriften zur Malakozoologie*, 23: 45-78 + pls. 9-14.
- Goldberg R.L. & Severns M., 1997. Isolation and evolution of the *Amphidromus* in Nusa Tenggara. *American Conchologist*, 25: 3-7.
- Laidlaw F.F. & Solem A., 1961. The land snail genus *Amphidromus*: a synoptic catalogue. *Fieldiana (Zoology)*, 41: 507-677.
- Lok A.F.S.L. & Tan S.K., 2008. A review of the Singapore status of the green tree snail, *Amphidromus atricallosus perakensis* Fulton, 1901 and its biology. *Nature in Singapore*, 1: 225-230.
- Lytwyn J., Rutherford E., Burke K. & Xia C. 2001. The geochemistry of volcanic, plutonic and turbiditic rocks from Sumba, Indonesia. *Journal of Asian Earth Sciences*, 19: 481-500.
- Scott B., 1996. Phylogenetic relationships of the Camaenidae (Pulmonata: Stylommatophora: Helicoidea). *Journal of Molluscan Studies*, 62: 65-74.
- Severns M., 2006. A new species and a new subspecies of *Amphidromus* from Atauro Island, East Timor (Gastropoda, Pulmonata, Camaenidae). *Basteria*, 70: 23-28.
- Solem A., 1983. First record of *Amphidromus* from Australia, with anatomical notes on several species (Mollusca: Pulmonata: Camaenidae). *Records of the Australian Museum*, 35: 153-166.
- Sutcharit C. & Panha S., 2006. Taxonomic review of the tree snail *Amphidromus* Albers, 1850 (Pulmonata: Camaenidae) in Thailand and adjacent areas: Subgenus *Amphidromus*. *Journal of Molluscan Studies*, 72: 1-30.
- Wade C.M., Hudelot C., Davison A., Naggs F. & Mordan P.B., 2007. Molecular phylogeny of the helicoid land snails (Pulmonata: Stylommatophora: Helicoidea), with special emphasis on the Camaenidae. *Journal of Molluscan Studies*, 73: 411-415.
- Wade C.M., Mordan P.B. & Naggs F., 2006. Evolutionary relationships among the Pulmonate land snails and slugs (Pulmonata, Stylommatophora). *Biological Journal of the Linnean Society*, 87: 593-610.

Reproductive cycle of the European anchovy *Engraulis encrasicolus* (Linnaeus, 1758) (Clupeiformes Engraulidae) in the gulf of Skikda (Algerian East coasts)

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ABSTRACT

A study on the sexual cycle of the European anchovy, the pelagic fish *Engraulis encrasicolus* (Linnaeus, 1758) (Clupeiformes Engraulidae), was carried out in Algerian East coasts over a year (July 2008-June 2009). Annual sex-ratio (SR) showed that females dominate with an average male sex-ratio of 39.35%. The European anchovy spawning period ranges from April to October with peaks in the warmest months, strictly dependent on temperature. The gonado-somatic index was updated monthly which allowed us to divide the entire cycle into four successive phases: (i) a phase of slow maturation which occurs between the end of winter and the beginning of spring; (ii) a phase of significant sexual activity; (iii) a phase of emission of the sexual products which corresponds to the warmest months; and, finally, (iv) a phase of sexual rest occurring in the coldest months. Monthly variation of either hepato-somatic index or mesenteric fat reserves informed us about the origin of the energetic deposits, particularly important for the development of the gonads. In both sexes, the first sexual maturity is reached at a fish total length (Lt) of 12.5 cm.

KEY WORDS

Algerian East-coasts; *Engraulis encrasicolus*; reproduction; sex-ratio; first sexual maturity.

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INTRODUCTION

Reproduction and sexual behaviour of the European anchovy *Engraulis encrasicolus* (Linnaeus, 1758) (Clupeiformes Engraulidae) were the subject of many studies focusing on the connection between these items and food behaviour, plumpness of fishes and ecological factors in natural populations of this species (Fage, 1911, 1920; Dorel, 1986; Hemida, 1987; Whitehead et al., 1988; Djabali & Hamida, 1989; Pertierra, 1992; Prouzet & Metuzals-Sebedio, 1994; E.R.H., 1996; Kara, 2001; Mezedjri & Tahar,

2005, 2006; Kada et al., 2009). This work brings new information on the reproduction of *E. encrasicolus* in the Gulf of Stora, Skikda (Algerian East coasts). Sex-ratio, gonado-somatic and hepato-somatic indexes, adiposity and size at first sexual maturity were studied. Obtained results were compared with those reported in literature for several Mediterranean areas.

MATERIALS AND METHODS

The study was carried out on fishes caught by means of sliding seines in the Gulf of Stora (Alge-

ria) during one year, from July 2008 to June 2009. Just with the unloading, a sample of 1 kg at minimum was taken at the port of Stora, monthly. On each fish a series of measures were made (Table 1) including length, by using an ichthyometer with meadows millimetre; total and eviscerated weights, by means of a balance with an accuracy of 0.01 g; and gonadic and hepatic weights to the nearest 0.0001 g.

Determination of maturity stages was carried out according to the method recommended by the ERH team (E.R.H., 1996), in particular, by taking into account the degree of fattening of each specimen according to an empirical four degree-scale which is a derivative of the scale of Nikolsky (1963). In literature there is a divergence on the formula for the sex-ratio. In our work we used the formula which gives sex-ratio as a percentage of males by the following relation: $SR = (Males\ Number / Total\ Number) \times 100$. Then, the chi-squared (χ^2) test was used to evaluate the variation of the observed values of the sex-ratio compared to the theoretical proportion of 50% (Dagnélie, 2006). We supposed as hypothesis H_0 : sex-ratio = 50% and tested this hypothesis by calculating the value of χ^2_{obs} by the formula:

$$\chi^2 = (m^2 / F) + (f^2 / F) - n$$

where, m: number of males; f: number of females; $n = m + f$; $F = n/2$. When $\chi^2_{obs} \geq \chi^2_{1-\alpha}$ at 1 degree of freedom we rejected the hypothesis H_0 at the level $\alpha = 0.05$. Please note that this test is valid only for number of males or females higher than 5 (Dagnélie, 2006). The gonado-somatic index (GSI)

is an index expressed in percentage. It is calculated starting from the relationship between the weight of the gonads (Wgon) and the eviscerated weight of fish (We). We preferred to use the weight of emptied specimens in the place of the total weight to eliminate the variations due to the repletion state of the stomach. The GSI is calculated for each individual according to the following formula (Kara, 1997): $GSI = (Wgon / We) \times 100$. GSI values reflect changes in gonads weight during the reproductive cycle, thus making us possible to monitor their maturation (Barnabé, 1976). The hepato-somatic index (HSI) is expressed in percentage as well. This relationship links the hepatic weight (Whep) and the eviscerated weight (We) according to the following formula (Kara, 1997): $HSI = (Whep / We) \times 100$. Its changes are connected to the variations of hepatic weight during the reproductive cycle. Monthly variations of adiposity (Adip), i.e. the mesenteric fat, were followed during the entire period (July 2008-June 2009). All the specimens caught during the reproduction period (from April to October) were distributed, according to their size, in classes of sizes with an interval of 0.5 cm. Then, we took in consideration the frequency of the mature individuals in relation to the total number of specimens belonging to each class. Size at first sexual maturity is determined as the size of 50% of the mature individuals (Barnabé, 1976; Kara, 1997). This parameter is calculated separately for each sex, and then the two sexes are compared. All calculations have been executed with the software MINITAB for analysis and statistical treatment of the data, version 16 for Windows (2010).

N°	CODE	DESCRIPTION
1	Lt	Total length
2	Wt	Total Weight
3	We	Eviscerated Weight
4	Wgon	Gonadic Weight
5	Whep	Hepatic Weight
6	Adip	Adiposity
7	Sex	Identification of sex and stage of maturity

Table 1. Measures made on fishes for the reproduction survey.

RESULTS AND DISCUSSION

Sex-ratio

On a whole of 803 examined individuals, we observed 316 males and 487 females with an average male sex-ratio of 39.35% ($\chi^2 = 36.41$; $P \leq 0.001$). Monthly variations of sex-ratio are shown in Table 2. Broadly speaking, the sex-ratio was always in favour of females (with a male SR ranging from 18.42% to 35.62%, $0 \leq P \leq 0.05$) except during September, when we noted a value of sex-ratio in favour of males (SR=71.96%, $P \leq 0.001$). SR values assessed in October 2008 and March 2009 (56.30% and 40%,

respectively) were not statistically significant. Females remained dominant for 7 months, particularly during the warmest ones (from April to August), when the anchovies come closer to the Algerian coasts, where they are captured easily. This leads us to say that the Gulf of Stora may be considered as a zone of spawning of the European anchovy.

Month	No. of males	No. of females	Sex-ratio	χ^2 obs
Jul-08	14	62	18.4211	30.31579 ***
Aug	50	100	33.3333	16.66667 ***
Sep	77	30	71.9626	20.64486 ***
Oct	67	52	56.3025	1.89076 ns
Nov	-	-	-	-
Dec	-	-	-	-
Jan-09	12	26	31.5789	5.15789 *
Feb	25	86	22.5225	33.52252 ***
Mar	32	48	40	3.2 ns
Apr	26	47	35.6164	6.04109 *
May	9	30	23.0769	11.30769 ***
Jun	4	6	40	0.4 ns
Total	316	487	39.3524	36.41469 ***

Table 2. Monthly variations of male sex-ratio for *Engraulis encrasicolus* from the gulf of Stora between July 2008 and June 2009. $p > \alpha = 0,05$: (ns) not significant, $p \leq \alpha = 0,05$: (*) significant, $p \leq \alpha = 0,001$: (***) very highly significant.

Gonado-somatic index

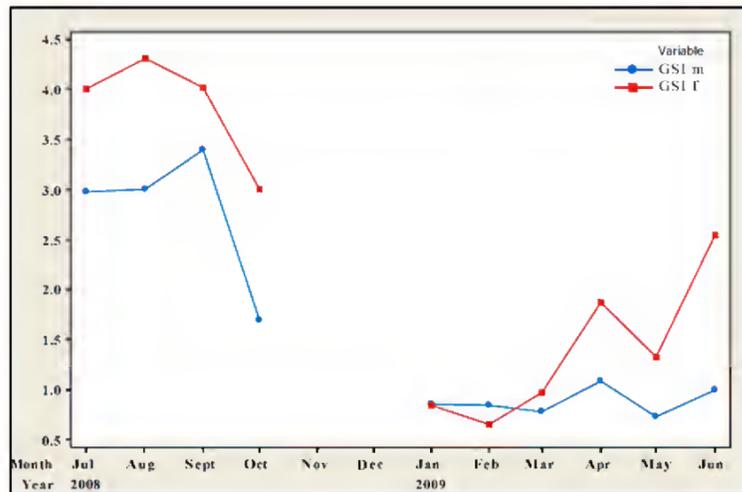
Graphically, monthly fluctuations of gonado-somatic index (GSI) values of *E. encrasicolus* are shown in figure 1. For females, GSI showed the highest values in summer with a maximum in August (GSI=4.31%), decreased at the beginning of autumn, the lowest values being recorded in winter with a minimum in February (0.65%), and then gradually and notably increased in spring. Males exhibited more or less a similar trend, with the maximum value recorded in September (3.39%) and the least in January (0.86%). Noteworthy, the increase in GSI values through the spring period

(March-June) was less marked than in females. Monthly variations of the gonado-somatic index revealed that the reproduction period of the anchovy in our area spreads between April and October. This is in line with Whitehead et al. (1988) who affirm that the peak of spawning generally coincides with the warmest months, the limits of the spawning season being dependent on the temperature. Plotting the evolution of GSI values showed that the reproductive cycle of *E. encrasicolus* is characterized by four successive phases: (i) a phase of slow maturation which starts in March and continues until June; (ii) a phase of significant and intense sexual activity which occurs during the warm-est months (from June to September); (iii) a phase of decline starting in September during which the testicles and the ovaries gradually lose their mass; and finally (iv) a phase of rest, coinciding with the coldest months (from December to February), when fishes become sexually inactive.

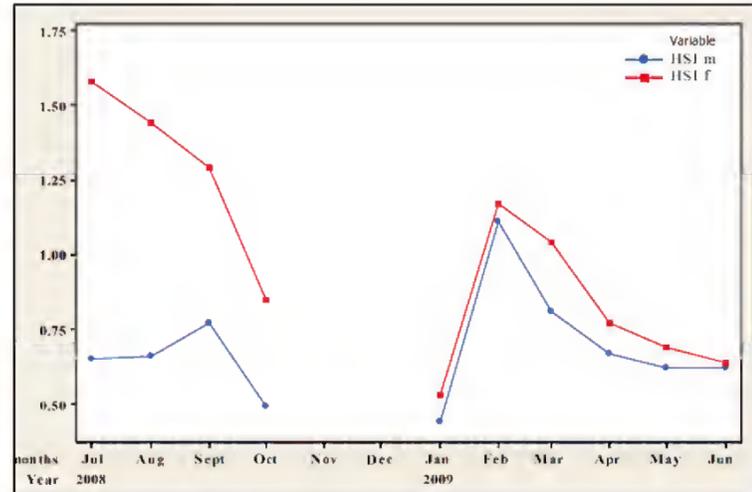
These findings once again support the hypothesis that temperature exerts a strong influence on the sexual cycle of the European anchovy, with high temperatures leading to spawning and low temperatures preventing sexual activity (Whitehead et al., 1988; Djabali & Hamida, 1989).

Hepato-somatic index

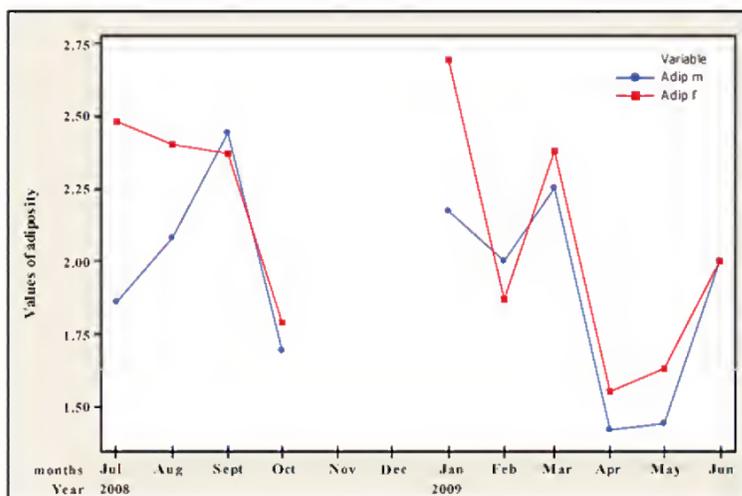
For the hepato-somatic index (Fig. 2) we observed, in females, a maximum in July (HSI=1.58%) and, then, a clear reduction up to October (0.85%), with the lowest values in January (0.53%) when it dramatically increased to reach a maximum in February (1.17%). After that, HSI gradually decreased up to June (0.64%). In males we observed the same trend, although absolute values were slightly lower than in females. HSI, compared with GSI, was less marked. During the reproduction period HSI values decreased probably due to the consumption of fat deposits, reaching a peak in winter (at the end of February) which suggests a possible storage of reserves in the liver during the sexual rest, followed by the reduction of HSI from March on, when sexual maturity begins. It is interesting to note that, especially for females, HSI and GSI values did not always show complementary trends, thus suggesting that energy reserves used to allow the development of the gonads may not be accumulated exclusively in the liver.



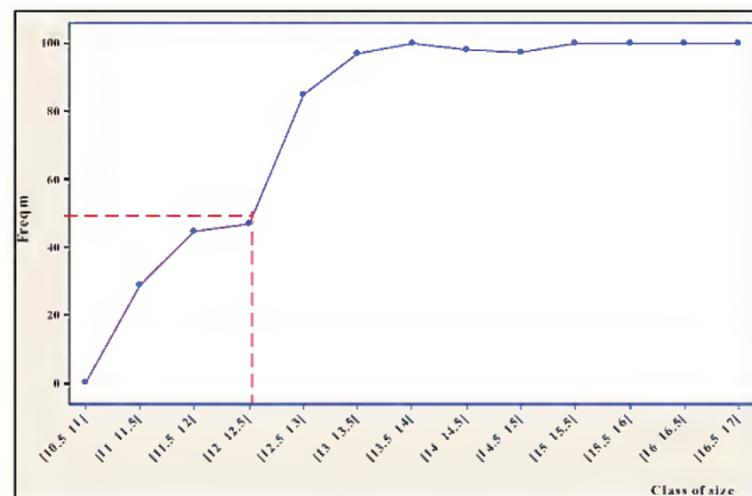
1



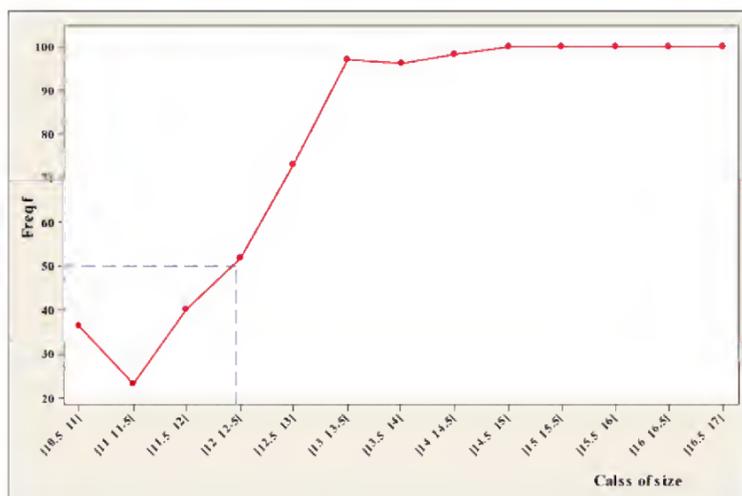
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3



4



5

Djabali & Hamida (1989) during a study on the European anchovy, carried out between 1983 and 1984, concluded that the liver didn't have any role in the maturation process of the sexual products; this implies that the two parameters (GSI and HSI) should be studied together.

Adiposity

Changes in mesenteric deposits in *E. encrasi-*

Figure 1. Monthly variations of GSI in *Engraulis encrasicolus* from the gulf of Stora.

Figure 2. Monthly variations of the HSI for *E. encrasicolus* from the gulf of Stora.

Figure 3. Monthly variations of adiposity for *E. encrasicolus* from the gulf of Stora.

Figure 4. Size at first sexual maturity in females of *E. encrasicolus* from the gulf of Stora.

Figure 5. Size at first sexual maturity in males of *E. encrasicolus* from the gulf of Stora.

colus are shown in figure 3. The maximum values were recorded in September (males) and January (females) while, in both sexes, the lowest ones were in April.

Taking into account that the highest values were observed in winter (during the sexual rest) and the lowest ones in the warmest months, these findings confirm the hypothesis, maintained by Djabali & Hamida (1989), that gonadic reserves may originate mainly from mesenteric fat deposits.

Size at first sexual maturity

The size at the first sexual maturity (Lt) is roughly the same for both sexes and corresponds to 12.5 cm (Figs. 4, 5). As can be seen, our data are in line with most of the Lt values available for *E. encrasicolus* populations in the Mediterranean (Table 3), suggesting that, in the areas analysed, there are not big differences in environmental factors, particularly water temperatures, population density and food availability, while Lt = 6.5 cm reported for the lagoon of Nador (Morocco) might be possibly due to disturbing issues including high fishing pressures.

In conclusion, the present study not only gave information on any biological aspects of *Engraulis encrasicolus* from the gulf of Skikda (Algerian East-coasts), which up to now were deficient, but also contributed to provide a preliminary base for monitoring the changes in biological indexes connected to the reproduction cycle of this species in order to ensure its sustainable management in the Mediterranean area.

Lt (cm)	Sex	Locality	Author
13.0	Males	Gulf of Biscay	Dorel, 1986
13.0	Females	Gulf of Biscay	Dorel, 1986
11.2	Males	Bay of Algiers	Djabali & Hamida, 1989
11.6	Females	Bay of Algiers	Djabali & Hamida, 1989
11.5	Indefinite	Coast of Catalonia	Pertierra, 1992
12.5	Both sexes	Gulf of Stora (Skikda)	Mezedjri & Tahar, 2005; 2006
12.5	Both sexes	Gulf of Stora (Skikda)	present paper
06.5	Both sexes	the lagoon of Nador (Morocco)	Kada et al., 2009

Table 3. Size at first sexual maturity of *Engraulis encrasicolus* in some regions of the Mediterranean Sea.

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REFERENCES

- Barnabé G., 1976. Contribution à la connaissance de la biologie du loup *Dicentrarchus labrax* (L.) (Poisson Séranidé) de la région de Sète. Thèse d'état, Université des Sciences et Techniques du, Montpellier, 426 pp.
- Dagnélie P., 2006. Statistique théorique et appliquée. Tome 2: Inférences statistique à une et à deux dimensions. De Boeck, Bruxelles, 659 pp.
- Djabali F. & Hamida F., 1989. Reproduction de l'anchois (*Engraulis encrasicolus*, Linné 1758) de la région d'Alger. Bulletin de l'institut des sciences de la mer et de l'aménagement du littoral ISMAL. Pelagos, 7: 11-14.
- Dorel D., 1986. Poissons de l'Atlantique nord-est relations taille-poids. Institut Français de Recherche pour l'Exploitation de la Mer. IFREMER, Nantes, 165 pp.
- E.R.H., 1996. Evaluation de la ressource halieutique. Ministère des pêches et des ressources halieutiques. Rapp. Campagne, 40 pp.
- Fage L., 1911. Recherches sur la biologie de l'anchois (*Engraulis encrasicolus* Linné): races-âge-migrations. Annales de l'Institut océanographique Monaco, 2: 1-40.
- Fage L., 1920. Engraulidae, Clupeidae. Report on the Danish Oceanographical Expeditions 1908-1919 to the Mediterranean and adjacent seas, Vol. 2, 140 pp.
- Hemida F., 1987. Contribution à l'étude de l'anchois *Engraulis encrasicolus* (Linné, 1758) dans la région d'Alger. Biologie et exploitation. Thèse de magistère, USTHB.
- Kada O., Abdellaoui S., Ramdani M. & Nachit D., 2009. Contribution à l'identification et à la caractérisation biologique et dynamique de l'anchois de la lagune de Nador (Maroc). Bulletin de l'Institut Scientifique, Rabat, section Sciences de la Vie, 31: 91-98.
- Kara M.H., 1997. Cycle sexuel et fécondité du loup *Dicentrarchus labrax* (poisson Moronidé) du golfe d'Annaba. Cahiers de Biologie Marine, 38: 161-168.
- Kara M.H., 2001. Biologie, dynamique et évaluation des ressources halieutiques côtières du littoral Est-algérien. Projet de recherche: Ministère de l'Enseignement Supérieur et de la Recherche scientifique.
- Mezedjri L. & Tahar A., 2005. Reproduction de l'anchois Européen dans le golfe de Skikda, Algérie : Actes du Sixième Congrès Maghrébin des Sciences de la Mer Monastir, Tunisie (18-22 décembre 2005). Abstract book.
- Mezedjri L. & Tahar A., 2006. Reproduction de l'anchois Européen *Engraulis encrasicolus* dans le golfe de Stora, Skikda. 8ème conférence internationale des limnologues d'expression française « CILEF 2006 ». Hammamet, Tunisie. Abstract book.
- Minitab 16 Statistical Software (2010). [Computer software]. State College, PA: Minitab, Inc. (www.minitab.com).

- Nikolsky G.V., 1963. The ecology of fishes. Academic Press. London, 352 pp.
- Pertierra J.P., 1992. Fisheries biology of the anchovy (*Engraulis encrasicolus*) in the Catalan coast. Ph.D. Thesis, Universitat Politècnica de Catalunya, Spain.
- Prouzet P. & Metzals-Sebedio K.I., 1994. Population structure and reproductive biology. Stock discrimination studies using morphometric and genetic data. In: Cendrero O. (Ed.), Improvement of Stock Assessment by direct Methods, Its Application to the Anchovy (*Engraulis encrasicolus*) in the Bay of Biscay. Final Report. Projet DG XIV EU, ref MA. 2. 495.
- Whitehead P.J.P., Nelson G.J. & Wongratana T., 1988. FAO species catalogue Vol. 7. Clupeoid fishes of the world. An annotated and illustrated catalogue of the herrings, sardines, pilchards, sprats, shads, anchovies and wolf-herrings. Part 2. Engraulididae. FAO Fisheries Synopsis, 7: 305-579.

***Amauta hodeei* (Oberthür, 1881) and its subspecies (Lepidoptera Castniidae), with comments on the life and times of Brother Apolinar María**

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ABSTRACT

In 1948, a fire destroyed the La Salle Museum in Bogotá, Colombia, which was built with a great effort by the La Salle religious teaching congregation, but with the particular and decisive input of Brother Apolinar María. He became a champion of the study of the natural history of Colombia and through the museum, he established numerous connections with scientists and naturalists worldwide. Some rare Castniidae were among the numerous specimens of the fauna he traded with museums around the world. General information about Brother Apolinar María, the La Salle Museum, and the subspecies of *Amauta hodeei* (Castniidae) are provided here in an attempt to improve and stimulate the interest in such a remarkable naturalist and some rare and almost unknown species of the South American Fauna. One of these ssp. (*A. hodeei kruegeri*) is reported from Ecuador, thus increasing knowledge about its geographical distribution.

KEY WORDS

Museo La Salle Bogotá; Castniidae; *Amauta hodeei hodeei*; *Amauta hodeei kruegeri*.

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INTRODUCTION

Massive riots followed the assassination of political leader and presidential candidate Jorge Eliécer Gaitán (1903-1948) in Bogotá, Colombia, on April 9, 1948. The 10 hour riot resulted in a fire that left thousands of dead and injured, and much of downtown Bogotá was destroyed by the effects of a widespread fire (Alape, 1994). The Museum of Natural History La Salle was among those buildings that disappeared because of the fire (Figs. 2, 3). It originally contained samples of over 73,000 specimens of several groups, and by 1930, some 37,706

of those specimens were insects (Salazar, 1999). The success of this museum was mainly the product of the efforts of Nicolás Seiller (1867-1949), better known as Brother Apolinar María (Figs. 1, 4) (Vélez & Salazar, 1991; Salazar, 1999; Diaz Meza et al., 2006). The museum and its annex library were consumed by the fire and, as a result, Apolinar María entered a deep state of depression and died in December, 1949 (Salazar, 1999).

Seiller was born in Alsace, France, in 1867. Some time later, he went to Reims, where he eventually joined the religious Brotherhood of La Salle.

As customary in the brotherhood, he changed his name to Apolinar María and was then sent to Colombia, where he arrived in 1904 (Lamas, 1979). Thanks to his interest in the natural sciences, he founded the Natural History Society of La Salle Institute in Bogotá, in 1912 (Lamas, 1979). With the help of other brothers and local amateur naturalists, he also built the museum that would eventually contain the largest collection of Lepidoptera in Colombia (Lamas, 1979; Salazar, 1999). Most importantly, he emphasized the need of knowing and sharing in-

formation with scientists around the world, and with this vision, he sent countless Colombian specimens to several institutions and private American and European collections in an effort to trade, but also obtain the appropriate identification of his adopted country's fauna and flora (Lamas, 1979; Rodríguez, 2002; Freile & Córdova, 2008). Together, with colleagues and pupils, he published numerous papers on Lepidoptera, described many new taxa, and made observations on Colombian natural history (Lamas, 1979, 2013).



Figure 1. Brother Apolinar María examining specimens inside the Natural History Museum, La Salle, Bogotá (Picture borrowed from Díaz Meza et al. 2006). Figure 2. La Salle Museum being devoured by the flames, 1948. Figure 3. La Salle Museum after the flames were controlled, 1948. Figure 4. Nicollas Seiller, best known as Brother Apolinar María (1867-1949).

Through the Museum he established communications with scientists and naturalists around the world, including renowned entomologists such as Charles Oberthür (1845-1924), Paul Dognin (1856-1931), Eugène Louis Bouvier (1856-1944), Harrison Gray Dyar jr. (1866-1929), Anton H. Fassl (1876-1922), William Schaus (1858-1942), Johannes Karl Röber (1861-1942), Arnold Schültze (1875-1948), and Romualdo Ferreira D'Almeida (1891-1969) (Lamas 1979; Salazar, 1999; Vélez & Salazar, 1991; Julián Salazar, pers. comm.).

Apolinar María is considered one of the most relevant and recognized Colombian naturalists and the precursor of the studies of Lepidoptera in the country (Salazar 1999; Rodríguez, 2002). Aside from the collecting he and other brothers from his congregation did while travelling to different Colombian locations, he hired people to collect fauna and flora specimens, mainly from Muzo, Boyacá, along the forests that border Río Magdalena and other effluents, like Río Carare, as well as Villavencio, Meta (Apolinar María, 1915; Julián Salazar, pers. comm., 2012).

He published some of his findings, including the descriptions of several new species, in various journals and newsletters (Lamas, 1979; 2013). In Lepidoptera, he mainly published about butterflies, however he also wrote several papers or notes with information about moths (Salazar, 1999; Lamas, 2013). Among those works, he wrote about some Castniidae found in Colombia (Apolinar María, 1915, 1945). Brother Apolinar María recognized and made brief comments about ten species and several subspecies in the Castniidae collected in Colombia and deposited at Bogota's La Salle Museum (Apolinar María, 1915, 1945; Salazar, 1999).

Among the over 31 taxa belonging to 21 species of Castniidae found in Colombia (Hernández-Baz et al., 2012), some belong to the genus *Amauta* Houlbert, 1918. According to Lamas (1995) it contains four species: *A. ambatensis* (Houlbert, 1918), *A. cacica* (Herrich-Schäffer, [1854]), *A. hodeei* (Oberthür, 1881), and *A. papilionaris* (Walker, [1865]). They are all species of medium to large dimensions, with triangular forewings, commonly dark brown to black, with some white/cream and orange markings in both wings and they are sexually dimorphic (Miller, 1986). The genus is distributed from Guatemala, through Central America and down to South America, where specimens have

been found in Colombia, Peru, Ecuador, Bolivia and Brazil (Miller, 1986, 1995; Lamas, 1995). Unfortunately, the known information on the several species in the genus is still fragmentary and scarce, and data found in several insect Museums is far from adequate (Miller, 1986; Miller & Sourakov, 2009).

Even though we have been able to study Castniidae specimens from many museums worldwide, we could locate only few of *Amauta hodeei*. Among the known specimens of both subspecies (*A. hodeei hodeei* and *A. hodeei kruegeri*), including those mentioned in the literature, a few were collected by Brother Apolinar María (or his group of collectors). Both subspecies are known to occur in Colombia; however, a specimen of *A. hodeei kruegeri* collected in Ecuador is reported herein, thus expanding its known distribution.

Specimens examined are in the following collections: AMNH = American Museum of Natural History, New York, USA; MGCLB = McGuire Center for Lepidoptera & Biodiversity, (Allyn Museum Collection), Gainesville, Florida, USA; MHN-UC = Natural History Museum, University of Caldas, Manizales, Colombia; MHNP = Natural History Museum, Paris, France; NMNH-SI = National Museum of Natural History, Smithsonian Institution, Washington D.C., USA; GPC = G. Penati Collection, Milan, Italy; RVC = Roberto Vinci-guerra Collection, Palermo, Italy.

COMMENTS ON THE TWO KNOWN SSP. OF *AMAUTA HODEEI* (OBERTHÜR, 1881)

Amauta hodeei hodeei (Oberthür, 1881)

This subspecies was originally described (as *Castnia hodeei*) by Oberthür (1881) from material collected in the Colombian region along Santa Rosa and the Carare river. Years later, Schaus (1896) described *Castnia corrupta* from Colombia, while Oberthür (1925) illustrates a species he names *C. apollinaris* [nomen nudum (Lamas, 1995)] based on a male specimen collected in Colombia, and compares and discusses similarities and differences with the species *C. corrupta*. That same year, Knop (1925) describes *C. amazona* from Bogotá, Colombia. Those species have been established as synonyms of *hodeei hodeei* (Lamas, 1995).

Unfortunately, this is a rare taxon and almost nothing is known about its biology and ecology. In fact, very few specimens are known from insect collections worldwide. Joicey & Talbot (1925) mentioned that they received three specimens (two males and a female) sent by Brother Apolinar María which were originally collected in Muzo and Villavicencio. González & Salazar (2003) also reported a male and a female from Guamoco and Cauca Valley (Caucaval).

EXAMINED MATERIAL (with notes). COLOMBIA: 1 male, 1 female, Bogotá, 1931, Coll. Fr. Apolinaire Marie (MHNP) [even though the labels (Fig. 10) clearly state that this material was collected in Bogotá, they were most certainly collected in the Muzo region where Brother Apolinar María had peasants hired to collect specimens. Since the La Salle Museum was located in Bogotá, most Institutions that received material from Apolinar María, commonly assumed that “Bogotá” was the collec-

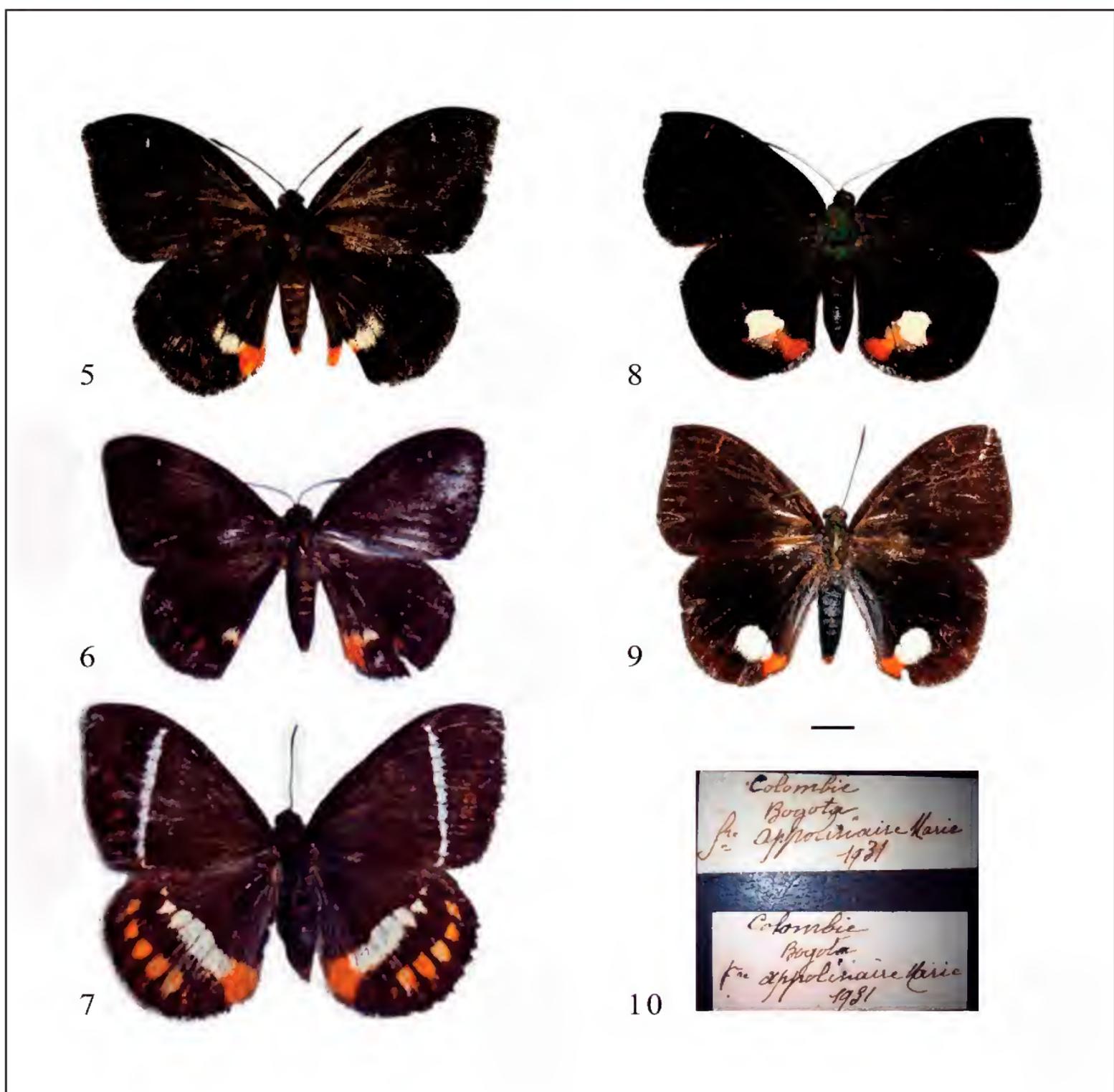


Figure 5. *Amauta hodeei hodeei*, male, Bogotá, Colombia (MHNP). Figure 6. Idem, male, Guamoco Colombia (AMNH). Figure 7. Idem, female, Cauca Valley, Colombia (AMNH). Figure 8. *A. hodeei kruegeri*, Esmeraldas, Ecuador (RVC). Figure 9. Idem, Río Calima, Colombia (MGCLB). Figure 10. Labels of two *A. hodeei hodeei* specimens collected or sent by Brother Apolinar María (MHNP). Scale (for figures 5-9): 10 mm.

ting locality]; 1 male?, Muzo, Boyacá, [the occidental sector with influence of the middle area of the Magdalena River], Coll. Apolinar María [reported in Apolinar María (1945). This specimen was surely lost in the Museum's fire]; 1 male, Campo Santo, Bogota, 1922, Coll. L. Pfeiffer (NMNH-SI) [this is the type specimen of *Castnia corrupta* described by Schaus (1896) and now considered a synonym of *A. hodeei hodeei* (Lamas, 1995)]; 1 female, Colombia, Boyacá, Coll. ? (NMNH-SI); 1 male, Guamoco, Coll. F. Johnson (AMNH); 1 female, Caucaval [Cauca Valley], Coll. F. Johnson (AMNH); 1 male, Santa Rosa-Carare, Coll. Oberthür [mentioned in Oberthür (1881) and Houlbert (1918)].

Amauta hodeei kruegeri (Niepelt, 1927)

Only males are known of this rare subspecies, and they differ from the nominate subspecies because of its darker, blackish, background color, and also because of the very distinctive white and orange markings in the hind wings (Figs. 5-9). Niepelt (1927) described it (as *Castnia krügeri*) based on a male collected in "West Colombia." We have been able to examine four specimens, all males, from four different collections. The forewings are devoid of any markings except for a small light amber band in the sub-apical region. They are larger than the sub-apical creamy spot observed in males of the nominate subspecies (Figs. 5, 6, 8, 9). A large, creamy-white spot can be observed in the tormal region of the hind wing. The spot turns orange at the edge of the wing. Such markings are clearly noticeable, better defined, and larger in the four studied specimens than in the similar (but smaller and faddier) markings found in males of the nominate species (Figs. 5, 6, 8, 9).

EXAMINED MATERIAL. COLOMBIA: 1 male, Rio Dagua, W. Colombia, ex coll. H. Gerstner (GPC); 1 male, Río Calima, VII, [19]84, Allyn Museum Acc. 1991-13, Allyn Museum Photo No. 850827-15/16, Slide No. M-7132, male append. Jacqueline Y. Miller (MGCLB); 1 male, Valle, Queremal - Km 55, 9-IV-85, Leg. J.A Salazar (MHN-UC). ECUADOR: 2 males, Esmeraldas, (RVC).

All specimens known to us (and listed above) of *A. hodeei hodeei* were collected east of the Western Cordillera while those of *A. hodeei kruegeri* were collected on the western slope of the Western Cordillera in Colombia, and closer to the coast and west

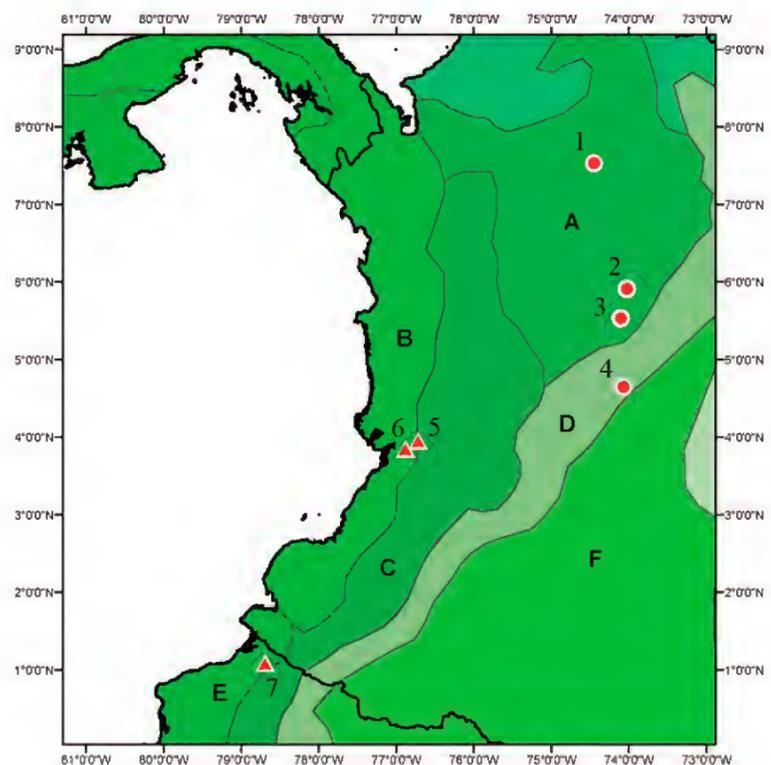


Figure 11. Map showing localities and ecological regions where specimens of *Amauta hodeei* ssp. have been collected in Colombia and Ecuador. *A. hodeei hodeei*: A1: Magdalena, Guamocó; A2: Magdalena, Santa Rosa and Carare; A3: Magdalena, Muzo; D4: Páramo, Bogotá; *A. hodeei kruegeri*: B6: Chocó, Río Dagua; C5: Cauca, Río Calima; E7: East Ecuador, Durango; F: Napo.

of the Ecuadorian Western Cordillera (Fig. 11). The Western Cordillera of Colombia continues along the Western Cordillera of Ecuador and they seem to be a geographic barrier that clearly separates the populations of both subspecies. The populations of both ssp. appear to be highly dispersed along their geographic range, but the low number of specimens known and the lack of knowledge about their biology and ecology prevent us from providing any information about their conservation status.

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Our friend and colleague Roberto Vinciguerra passed away shortly after this manuscript was submitted to BJ for consideration. We (JMG & SDR) will like to dedicate this work to his memory.

REFERENCES

- Alape A., 1994. El Bogotazo: memorias del Olvido. Abril 9 de 1948. Planeta, Colombia, 653 pp.
- Apolinar María, 1915. Miscelánea. Capturas interesantes. Boletín de la Sociedad de Ciencias Naturales del Instituto La Salle, 3: 141-144.
- Apolinar María, 1945. Miscelánea entomológica. I-Algo sobre castnidos colombianos. Revista de la Academia Colombiana de Ciencias Experimentales, Físicas & Naturales, 6: 322.
- Díaz Meza C.J., Jiménez J.R. & Turriago D., 2006. Historicidad, Saber y Pedagogía, Una Mirada al Modelo Pedagógico Lasallista en Colombia 1915-1935. Universidad de La Salle, Bogotá, Colombia. 170 pp.
- Freile J.F. & Córdoba S., 2008. Historia de la ornitología en la región andina: el ejemplo de Colombia y Ecuador. Ornitología Neotropical, 19 (suppl.): 381-389.
- González J.M. & Salazar J.A., 2003. Adición a la lista de cástnidos (Lepidoptera: Castniidae: Castniinae) conocidos de Colombia. Boletín Científico del Museo de Historia Natural, Universidad de Caldas, Manizales, 7: 47-56.
- Houlbert C., 1918. Révision monographique de la sous-famille des Castniinae. Etudes de Lépidopterologie Comparée, 15: 1-730.
- Joicey J.J. & Talbot G., 1925. Notes on some Lepidoptera, with descriptions of new forms. Annals and Magazine of Natural History, (9)16 (96): 633-653.
- Knop T., 1925. *Castnia amazona* nov. spec. und *Papilio androgeus* (Cr.) nov. var. *fassli*. Entomologische Zeitschrift, 39: 42-43.
- Lamas G., 1979. Brother Apolinar María (1867-1949) and his contributions to Colombian lepidopterology. Journal of the Lepidopterists Society, 33: 65-67.
- Lamas G., 1995. A critical review of J. Y. Miller's checklist of the Neotropical Castniidae (Lepidoptera). Revista Peruana de Entomología, 37: 73-87.
- Lamas G., 2013. Bibliography of Butterflies. An Annotated Bibliography of the Neotropical Butterflies and Skippers (Lepidoptera: Papilionoidea and Hesperioidea). Revised Electronic edition, 672 pp.
- Miller J.Y., 1986. The Taxonomy, Phylogeny, and Zoogeography of the Neotropical Castniinae (Lepidoptera: Castnioidea: Castniidae). Ph.D. Thesis. University of Florida, Gainesville, 571 pp.
- Miller J.Y., 1995. Castniidae. In: Heppner J.B. (Ed.). Checklist: Part 2. Hyblaeoidea-Pyraloidea-Tortricoidae. Atlas of Neotropical Lepidoptera, 3: 133-137, 176-177. Association for Tropical Lepidoptera/Scientific Publishers, Gainesville.
- Miller J.Y. & Sourakov A., 2009. Some observations on *Amauta cacica procera* (Boisduval) (Castniidae: Castniinae) in Costa Rica. Tropical Lepidoptera Research, 19: 113-114.
- Niepelt W., 1927. Neue Falter von Columbien. Internationale Entomologische Zeitschrift, 21: 239-241.
- Oberthür C., 1881. II. Lépidoptères d'Amérique. Etudes d'Entomologie, 6:xxv - xxvi, 27-38.
- Oberthür C., 1925. Lépidoptères de l'Amérique du Sud. Eudes de Lépidopterologie. Comparée, 9: 63-64.
- Rodríguez G., 2002. El naturalista Antoine Rouhaire (Hermano Nicéforo María) y el desarrollo de la Zoología sistemática en Colombia. Revista de la Academia Colombiana de Ciencias, 26: 229-237.
- Salazar J.A., 1999. Notas biográficas a una historia de la Lepidopterología en Colombia durante el siglo XX. Boletín Científico del Museo de Historia Natural, Universidad de Caldas, Manizales, 3: 71-102.
- Schaus W., 1896. New species of Heterocera from tropical America. Journal of the New York Entomological Society, 4: 147-154.
- Vélez J.H. & Salazar J.A., 1991. Mariposas de Colombia. Villegas Eds., Bogotá, Colombia, 167 pp.

Further records of two uncommon Crustaceans in Italian seas: *Maja goitziana* D'Oliveira, 1888 (Decapoda Brachyura Majidae) and *Xaiva biguttata* (Risso, 1816) (Decapoda Brachyura Portunidae)

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ABSTRACT

The presence of *Maja goitziana* D'Oliveira, 1888 (Decapoda Brachyura Majidae) is confirmed in the central Tyrrhenian Sea and in the Tuscan Archipelago. *Xaiva biguttata* (Risso, 1816) (Decapoda Brachyura Portunidae) is first recorded from the Western Sardinian coast and the Eastern Sicilian coast. The presence and spread of *M. goitziana* are considered a consequence of climatic changes. The presence of *X. biguttata* in Italian seas was probably underestimated, and its supposed rarity should be reassessed.

KEY WORDS

Maja goitziana; *Xaiva biguttata*; Mediterranean Sea; new record; climatic changes.

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INTRODUCTION

Maja goitziana D'Oliveira, 1888 (Decapoda Brachyura Majidae) and *Xaiva biguttata* (Risso, 1816) (Decapoda Brachyura Portunidae) are two Crustaceans generally considered rare in the Italian seas. In this paper are reported some further records of these species, and their current status in the Italian seas is discussed.

ABBREVIATIONS. CC = F. Crocetta collection, Napoli, Italy; CD = D. Di Franco collection, Gravina, Catania, Italy; CL = J. Langeneck collection, Pisa, Italy.

Maja goitziana D'Oliveira, 1888

EXAMINED MATERIAL. One male specimen (Figs. 1, 2) (carapace length 49 mm; carapace width 42

mm, including rostral and longest lateral spines) found in a gillnet set near the coast of Elba Island (Ligurian Sea) at a depth of 40-50 m, May 2008 (CL). One male specimen (carapace length 98 mm; carapace width 76 mm, including rostral and longest lateral spines) trawled on deep circalittoral bottoms at La Maddalena Island, October 2010 (CC).

REMARKS. The first specimen is a subadult male; the similar *M. squinado* (Herbst, 1788) is fairly common in the collecting area. While adult specimens of each species can be easily distinguished, the difference between subadult specimens is thinner. A visible difference between the specimen of *M. goitziana* and a subadult of *M. squinado* is the central series of five large spines, which in *M. squinado* are much smaller and shaped as tubercles. However, a remarkable affinity with *M. squinado* consists in the absence of the strong antero-dorsal spine on the meri of the pereopods, as it is de-

scribed by Holthuis & Gottlieb (1958). A comparison between the second right pereopod of both species shows that the legs of *M. squinado* (Fig. 3) and of sub-adult specimen of *M. goltziana* (Fig. 4) are, in fact, more similar than the legs of this last one compared to the adult of *M. goltziana* (Fig. 5). The absence of the spine on the meri in young specimens has been confirmed by further observations on eastern Mediterranean specimens (Galil, pers. comm.), but this characteristic was not highlighted in literature so far; it is remarkable that the larger specimen, caught at La Maddalena Island, shows well developed spines on the pereopods.

Xaiva biguttata (Risso, 1816)

EXAMINED MATERIAL. One male specimen (Fig. 6) (carapace length 8 mm; carapace width 7 mm) found stranded on the Is Arenas beach (Cuglieri, Western Sardinia) (CL) (August 2008). One male specimen (Fig. 7) (carapace length 9 mm; carapace width 9 mm) collected alive on shell grit at a depth of 1.7 m (Cannizzaro, Catania, July 2008, Eastern Sicily) (CD).

RESULTS AND DISCUSSION

M. goltziana is a widespread species, and it is considered quite common in the Eastern Atlantic Ocean (Manning & Holthuis, 1981; D'Udekem D'Acoz, 1999; Henriksen, 2009) and in the Eastern Mediterranean Sea (Holthuis & Gottlieb, 1958; Artüz, 2006; Lelli et al., 2008; Ateş et al., 2010). The first record of the species in the Mediterranean Sea dates back to the late 50's off the Israel coast (Holthuis & Gottlieb, 1958); in the Italian seas the species has been recorded first in the Ionian Sea (Pastore, 1983) and in the Sicilian Straight (Pipitone & Arculeo, 2003), while just recently it was recorded in the Adriatic Sea (Pallaoro & Dulcic, 2004), in the Tyrrhenian Sea (Soppelsa et al., 2005; Crocetta, 2007) and in the Ligurian Sea (Vignoli et al., 2004). Therefore, the new records do not widen the known distribution of the species; however, they confirm the presence of *M. goltziana* in the Western Tyrrhenian Sea and in the Ligurian Sea (Fig. 8).

M. goltziana is an eurybathic species with subtropical affinity, and has been first recorded in the

warmest Mediterranean sectors; its spread in central and Northern Mediterranean Sea is considered as a consequence of climatic changes (Vignoli et al., 2004; Soppelsa et al., 2005). The species seems to have spread either geographically (in the Adriatic and Tyrrhenian Sea) and numerically (Lelli et al., 2007, recorded more than 50 specimens in Lebanese waters, whereas every previous record concerned at most two or three specimens). Therefore, the hypothesis of the climatic changes consequence appears to be persuasive.

X. biguttata is known in the Eastern Atlantic Ocean (Manning & Holthuis, 1981; D'Udekem D'Acoz, 1999; Vieira & Morato, 2001) and in the Mediterranean Sea, where it was recorded along the Spanish coast (García Raso & Jiménez Millán, 1981), in the Eastern Mediterranean Sea (Lewinsohn & Holthuis, 1986; Ateş et al., 2010) and along the Italian coasts (Pastore, 1977; Pipitone & Arculeo, 2003; Bedini, 2004). The Italian records refer to the southern Tyrrhenian Sea, (Pipitone & Arculeo, 2003) and the Ionian Sea (Pastore, 1977); recently Bedini recorded one subadult female (carapace length 7 mm; carapace width 6 mm) on the Tuscan coast on *Posidonia* meadow (Bedini, 2004 and pers. comm.). The species has never been officially reported from the western Sardinian coast before. The record from Cannizzaro (Catania) confirms the presence of the species in the Ionian Sea (Fig. 9). *X. biguttata* has been recorded throughout the Mediterranean Sea (Lewinsohn & Holthuis, 1986), but with quite a few specimens for each record; therefore, the species is generally considered rare in the Mediterranean Sea (García Raso & Jiménez Millán, 1981; Bedini, 2004), while it is considered more common in the Atlantic Ocean (Vieira & Morato, 2001). In the Mediterranean Sea the abundance of *X. biguttata* is probably higher than what is commonly considered; however, it is hard to find this species as fishing by-catch because of its littoral habitat and small size.

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Figure 1. *Maja goitziana*, Rio Marina, Elba Island (Ligurian Sea). Figure 2. Idem, particular of the dorsal spines. Figure 3. Second right pereiopod of subadult *M. squinado*. Figure 4. Second right pereiopod of subadult *M. goitziana*. Figure 5. Second right pereiopod of *M. goitziana* (photo by courtesy of Dr. V. Vignoli). Figure 6. *Xaiva biguttata*, ecdysis from Western Sardinia, in frontal and ventral view. Figure 7. *X. biguttata*, specimen from Cannizzaro (Eastern Sicily), in frontal and ventral view.



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Figure 8. Map showing the known records of *Maja goltziana* in the Italian seas. The current records are represented by stars. 2: two specimens (Vignoli et al., 2003). 3: three specimens (Pallaoro & Dulcic, 2004).

Figure 9. Map showing the known records of *Xaiva biguttata* in Italian seas. The current records are represented by stars.

REFERENCES

- Boccone Artüz M.L., 2006. First record of *Maja goltziana* Oliveira, 1888 in Saros Bay, north Aegeis. *Zoonatantia*, 33-34.
- Ateş A.S., Kocataş A. & Özcan T., 2010. An updated list of decapod crustaceans on the Turkish coast with a new record of the Mediterranean shrimp, *Processa acutirostris* Nouvel and Holthuis 1957 (Caridea, Processidae). *North-Western Journal of Zoology*, 6: 209-217.
- Bedini R., 2004. Gli animali delle praterie a *Posidonia oceanica*: dai macroinvertebrati ai pesci. *Bandecchi & Vivaldi, Pontedera*, 543 pp.
- Crocetta F., 2007. First record of *Maja goltziana* D'Oliveira, 1888 (Decapoda, Brachyura, Majidae) in the western Tyrrhenian Sea. *Crustaceana*, 80: 631-633.
- D'Udekem D'Acoz C., 1999. Inventaire et distribution des crustacés décapodes de l'Atlantique nord-orientale, de la Méditerranée et des eaux continentales adjacentes au nord de 25°N. *Muséum National d'Histoire Naturelle, Collection Patrimoine Naturels* 40, Paris, 383 pp.
- García Raso J.E. & Jiménez Millán F., 1981. Algunas especies de decápodos (Crust.) del litoral malagueño. *Boletín de la Asociación Española de Entomología*, 4: 19-24.
- Henriksen C.S., 2009. Investigation of crustacean from shelf areas in the Gulf of Guinea, with special emphasis on Brachyura. Master thesis, University of Bergen, Norway, 71 pp.
- Holthuis L.B. & Gottlieb E., 1958. An annotated list of the decapod Crustacea of the Mediterranean coast of Israel, with an appendix listing the Decapoda of the eastern Mediterranean. *Bulletin of Research Council of Israel*, 7B: 1-126.
- Lewinsohn Ch. & Holthuis L.B., 1986. The Crustacea Decapoda of Cyprus. *Zoologische Verhandelingen*, 230: 1-64.
- Lelli S., Carpentieri P., Colloca F. & Ardizzone G.D., 2008. The spiny spider crab *Maja goltziana* (Crustacea: Majidae) in south Lebanese waters. *Marine Biodiversity Records*, 1, e83 doi:10.1017/S1755267207008676.
- Manning R.B. & Holthuis L.B., 1981. West African brachyuran crabs. (Crustacea: Decapoda). *Smithson Contributions to Zoology*, 306: 1-379.
- Pallaoro A. & Dulcic J., 2004. On the occurrence of the spider crab *Maja goltziana* (Crustacea: Majidae) an alien species in the Adriatic Sea. *Journal of the Marine Biological Association of the United Kingdom*, 84: 1007-1008.
- Pastore M., 1977. Presenza di *Thia scutellata* (Fabricius) e *Xaiva biguttata* (Risso) nel Golfo di Taranto (Mar Jonio). *Thalassia Salentina*, 7: 83-90.
- Pastore M., 1983. An Oxyrhynch crab new to the Ionian Sea: *Maja goltziana* D'Oliveira, 1888 (Decapoda: Brachyura). *Crustaceana*, 45: 232-237.
- Pipitone C. & Arculeo M., 2003. The marine Crustacea Decapoda of Sicily (central Mediterranean Sea): a checklist with remarks on their distribution. *Italian Journal of Zoology*, 70: 69-78.
- Soppelsa O., Crocetta F. & Pipitone C., 2005. *Maja goltziana* D'Oliveira, 1888 (Decapoda: Brachyura, Majidae) in the Southern Tyrrhenian Sea. *Crustaceana*, 78: 121-124.
- Vieira C.M. & Morato T., 2001. First record of the crabs *Pirimela denticulata* (Montagu 1808) and *Xaiva biguttata* (Risso, 1816) (Crustacea: Decapoda) from the Azores. *Life and Marine Sciences*, 18A: 89-91.
- Vignoli V., Caruso T. & Falciai L., 2004. Decapoda Brachyura from Monte Argentario (Mediterranean Sea, central Tyrrhenian). *Crustaceana*, 77: 177-186.

No end in sight? Further new records of amphibians and reptiles from Phong Nha – Ke Bang National Park, Quang Binh Province, Vietnam

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ABSTRACT

We report 11 new records of amphibian and reptile species and subspecies on the basis of newly collected specimens from the UNESCO World Heritage Site Phong Nha - Ke Bang National Park, Quang Binh Province, Vietnam: *Ingerophrynus macrotis*, *Limnonectes gyldenstolpei*, *Babina chapaensis*, *Theلودerma corticale*, *T. stellatum*, *Scincella rufocaudata*, *Oligodon cinereus pallidocinctus*, *Parahelicops annamensis*, *Rhynchophis boulengeri*, *Sinomicrurus macclellandii* and *Protobothrops mucrosquamatus*. The record of *T. corticale* from Phong Nha - Ke Bang National Park is the southernmost record generally known, that of *T. stellatum* the northernmost record within Vietnam, and, most remarkably, the finding of *Limnonectes gyldenstolpei* represents the first country record for Vietnam. In addition, we report the second known specimen and the first adult male of *Sphenomorphus tetradactylus*, a species recently described based on a single female only. At time, 151 species of amphibians and reptiles are known from Phong Nha - Ke Bang National Park, including 50 species of amphibians, 12 species of turtles, 31 species of lizards, and 58 species of snakes. In addition, an updated list of the local herpetofauna is provided, including recent taxonomic or nomenclatural changes.

KEY WORDS

herpetofauna; taxonomy; distribution; limestone habitat; Truong Son Mountain Range.

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INTRODUCTION

Phong Nha - Ke Bang National Park in the Truong Son Mountain Range in central Vietnam is known as one of the country's most famous protected areas in terms of herpetofaunal diversity. Ziegler & Herrmann (2000) published a first,

preliminary list of the karst forest area's herpetodiversity, based on own fieldwork, collection-based research and first Vietnamese reports, comprising 96 amphibian and reptile species. Four years later, the total number of amphibian and reptilian species known from the area as a result of further field work was increased to 128 species (Ziegler et al., 2004).

In a third updated herpetofaunal list for the area, Ziegler et al. (2006) reported of 140 amphibian and reptilian species, demonstrating a still ongoing increase in new species records. Ziegler et al. (2007) published a comprehensive review of the snake diversity of Phong Nha - Ke Bang including nine formerly not yet recorded species, thus increasing the total number of snakes known from Phong Nha - Ke Bang to 59 species. Hendrix et al. (2008) provided an updated anuran list comprising 47 taxa recorded for the Phong Nha - Ke Bang National Park, in which five species were recorded for the first time from that karst forest area. Recently, Ziegler & Vu (2009) published an updated checklist of the amphibians and reptiles from Phong Nha - Ke Bang National Park with a total of 138 species, including 45 species of amphibians and 93 species of reptiles. The total number of recorded amphibians and reptiles has decreased in this overview, because several doubtful or unconfirmed records, e.g., mentioned in Ziegler et al. (2007) and Hendrix et al. (2008), were removed from the list provided by Ziegler & Vu (2009), viz. *Bombina maxima* (Boulenger, 1905), *Eutropis chapaensis* (Bourret, 1937), *Scincella rupicola* (Smith, 1916), *Sphenomorphus buenloicus* (Darevsky et Nguyen, 1983), and *Malayemys subtrijuga* (Schlegel et Müller, 1844). In the years 2010 and 2011, additional herpetological field surveys were conducted in Phong Nha - Ke Bang National Park and extension area which revealed the existence of a number of so far not reported amphibian and reptile species. In addition to the eleven new herpetofaunal records for Phong Nha - Ke Bang National Park we provide an updated list of amphibians and reptiles occurring in this area.

MATERIALS AND METHODS

Field surveys were conducted in the Phong Nha - Ke Bang National Park area by Thomas Ziegler, Thanh Ngoc Vu, Kien Ngoc Dang, and Sladjana Miskovic (TZ and others) from June to July 2010, as well as from 12th July to 2nd August, and from 12th September to 1st October 2011 by Truong Quang Nguyen, Cuong The Pham, Dai Van Nguyen, Hang Thi An, and Kien Ngoc Dang (TQN and others) (Figs. 1, 2). After taking photographs, specimens were anaesthetized, fixed in 40-70% ethanol (am-



Figure 1. Map showing the location of Phong Nha - Ke Bang National Park, Quang Binh Province, Vietnam.

phibians) or 80-85% ethanol (reptiles) and subsequently stored in 70% ethanol. Measurements were taken with a digital calliper to the nearest 0.1 mm.

ABBREVIATIONS. a.s.l. = above sea level; SVL (snout-vent length) = from tip of snout to anterior margin of cloacal; TaL = tail length, from posterior margin of cloacal to tip of tail; terminology of morphological characters followed Nguyen et al. (2012) for amphibians and anuran webbing formula followed Glaw & Vences (2007) (except for forearm length, FAL = from axilla to elbow and hand length, HAL = from base of outer palmar tubercle to tip of finger III), Phung & Ziegler (2011) for lizards, and David et al. (2012) for snakes. Specimens were deposited in the collections of the Institute of Ecology and Biological Resources (IEBR), Vietnam Academy of Science and Technology Hanoi, Vietnam, Phong Nha - Ke Bang National Park (PNKB), Quang Binh Province, Vietnam, and the Zoologisches Forschungsmuseum Alexander Koenig (ZFMK), Bonn, Germany.

RESULTS

BUFONIDAE

Ingerophrynus macrotis (Boulenger, 1887)
Big-eyed Toad / Coc tai to (Fig. 3)

EXAMINED MATERIAL. One juvenile ZFMK 94263 collected by TZ and others during night time in June 2010 in the leaf litter of karst forest near Tam Co Cave, Tan Trach Commune, Bo Trach District and one adult female IEBR A.2013.7 (SVL: 58.7 mm) collected on 15 July 2011 by TQN and others in Da Lat forest, Thuong Hoa Commune, Minh Hoa District (17°40.124'N, 105°55.031'E, at an elevation of 312 m a.s.l.).

MORPHOLOGICAL CHARACTERS. SVL of adult female 58.7 mm; head wider than long (HW 20.3 mm, HL 18.7 mm); snout truncate, protruding, longer than horizontal diameter of eye (SL 6.6 mm, ED 5.9 mm); canthus rostralis rounded, loreal region concave; interorbital distance wider than internarial distance (IOD 4.7 mm, IND 4.1 mm); nostril closer to the tip of snout than to the eye (SN 1.7 mm; EN 3.6 mm); pupil rounded; tympanum distinct (TD 3.2 mm); parotoid gland 11.1 mm; vomerine teeth absent; tongue rounded posteriorly. Forelimbs: FAL 15.4 mm, HAL 30.1 mm; fingers free of webbing, relative length of fingers: II<IV<I<III; tips of fingers rounded, without discs; dermal fringe along outer finger absent; palmar tubercles distinct. Hindlimbs: femur longer than tibia and foot length (FML 26.0 mm, TBL 24.4 mm, FTL 23.2 mm); toes long and thin, relative length of toes: I<II<V<III<IV; tips of toes rounded; webbing basal; tarsal fold absent, dermal fringe along outer toe absent; subarticular tubercles present; inner metatarsal tubercle present (IMT 2.4 mm), outer metatarsal tubercle small (OMT 1.8 mm). Dorsal skin of body covered with tubercles or warts in different sizes, those on head smallest, few enlarged tubercles around vent.

Coloration in preservative: dorsal skin greyish brown with some symmetrical darker markings on snout and interorbital region; a V-shaped conversely mark in front of shoulder and dark spots near middle of back; dorsal tubercles on body, limbs grey to yellow; tympanum dark grey; upper lip with yellow and grey flecks. Ventral skin and concealed parts of limbs dirty greyish-yellow (determination after Inger et al., 1999).

DISTRIBUTION. In Vietnam, *I. macrotis* has been recorded from Thanh Hoa, Ha Tinh, Thua Thien-Hue, Da Nang, Quang Nam, Dak Lak, Lam Dong, and Dong Nai provinces. Our finding represents the first record for Phong Nha - Ke Bang National Park and for Quang Binh Province. Elsewhere, this species is known from northeastern India, Myanmar, Laos, Thailand, Cambodia, and Malaysia (Nguyen et al., 2009; Frost, 2013).

DICROGLOSSIDAE

Limnonectes gyldenstolpei (Andersson, 1916)
Gyldenstolpe's Frog / Ech gin-den-x-ton-pi (Fig. 4)

EXAMINED MATERIAL. One adult male IEBR A.2013.8 collected on 14 September 2011 in the evergreen forest, Hoa Son Commune, Minh Hoa District (17°42.166'N, 105°47.957'E, at an elevation of 449 m a.s.l.)

MORPHOLOGICAL CHARACTERS. SVL 69.6 mm; head longer than wide (HL 35.2 mm, HW 34.4 mm); snout longer than horizontal diameter of eye (SL 12.7 mm; ED 7.2 mm); canthus rostralis rounded; nostril directed laterally; loreal region concave; interorbital distance broader than internarial distance (IOD 8.5 mm, IND 7.3 mm); nostril closer to the tip of snout than to the eye (EN 7.1 mm; SN 4.7 mm); tympanum rounded, longer than tympanum-eye distance (TD 7.4 mm, TEY 6.4 mm); vomerine teeth present; tongue notched posteriorly; vocal sac indistinct in males. Forelimbs: FAL 13 mm, HAL 32 mm; fingers free of webbing, relative length of fingers: II<IV<I<III; tips of fingers rounded, without discs; dermal fringe along outer finger absent; palmar tubercles present; nuptial pad present in males. Hindlimbs: femur shorter than tibia and foot length (FML 32.7 mm, TBL 36.7 mm, FTL 34.7 mm); toes long and thin, relative length of toes: I<II<V<III<IV; tips of toes rounded; webbing formula: I₀(0)-(1)iII₀(0)-(1)iIII₀(1/2)-(1)iIV₀(2)-(0) iV; dermal fringe along outer toe absent; subarticular tubercles present; inner metatarsal tubercle present (IMT 4.3 mm), outer metatarsal tubercle indistinct. Dorsal skin of head smooth with a swollen flap (10.6 mm length and 10.2 mm width); dorsal surface of forelimbs, thigh and tarsus smooth; supratympanic fold distinct, from eye to shoulder; ventral surface smooth.

Coloration in preservative: head grey with a cream broad stripe between eyes; dorsum brown; dark dorsolateral spots; dark bars present on upper surface of forelimbs, tibia and thigh; venter cream with dark spots on throat (determination after Taylor, 1962; Ohler & Dubois, 1999).

DISTRIBUTION. The specimen from Phong Nha - Ke Bang National Park represents the first country record of *Limnonectes gyldenstolpei* for Vietnam. Elsewhere, this species is known from Laos, Cambodia, and Thailand (Frost, 2013).

REMARKS. The male specimen differs from the juvenile female in the description of Ohler & Dubois (1999) by having the tibia longer than femur (TBL 36.7 mm, FML 32.7 mm versus TBL 11.6 mm, FML 11.7 mm).

RANIDAE

Babina chapaensis (Bourret, 1937)
Chapa Frog / Chang sa pa (Fig. 5)

EXAMINED MATERIAL. Two adult males IEBR A.2013.9 and ZFMK 94258, one adult female IEBR A.2013.10 collected on 14 September 2011 and one adult male ZFMK 94259 collected by TQN and others on 16 September 2011 in the forest near Cha Lo Village, Hoa Son Commune, Minh Hoa District (17°42.213'N, 105°47.748'E, at an elevation of 570 m a.s.l.).

MORPHOLOGICAL CHARACTERS. SVL 43.0-46.0 mm in males (mean \pm SE 44.2 \pm 1.6, N = 3), 56.9 mm in the female; head longer than wide (HL 17.3-20.4 mm, HW 14.9-18.0 mm); snout longer than horizontal diameter of eye (SL 6.9-7.8 mm; ED 4.7-5.6 mm); canthus rostralis rounded; nostril directed laterally; loreal region concave; interorbital distance narrower than internarial distance (IOD 3.3-4.5 mm, IND 5.1-6.3 mm); nostril closer to the eye than to the tip of snout (EN 2.9-4.0 mm; SN 3.5-4.2 mm); tympanum rounded, longer than tympanum-eye distance (TD 3.9-4.2 mm, TEY 0.3-1.4 mm); vomerine teeth present; tongue notched posteriorly; vocal sac present in males. Forelimbs: FAL 8.8-10.3 mm, HAL 20.2-23.7 mm; fingers free of webbing, relative length of fingers: II<I=IV<III; tips of fingers rounded, without discs; dermal fringe along outer finger absent; palmar tubercles distinct; nup-

tial pad present in males. Hindlimbs: femur shorter than tibia and foot length (FML 21.4-25.2 mm, TBL 24.5-29.5 mm, FTL 24.1-29.2 mm); toes long and thin, relative length of toes: I<II<V<III<IV; tips of toes rounded; webbing formula: Io(1)-(1)iIIo(1/2)-(2)iIIIo(1)-(2)iIVo(2)-(1/2)iV; dermal fringe along outer toe absent; subarticular tubercles present; inner metatarsal tubercle present (IMT 2.2-2.5 mm), outer metatarsal tubercle indistinct.

Dorsal surface of head and dorsum smooth; dorsolateral fold distinct; lateral sides smooth; a small fold present along arm; ventral surface smooth. Coloration in preservative: head and dorsum light brown with a cream vertebral stripe, edged in dark brown, running from behind the eye to vent; posterior part of dorsum with some dark spots; upper jaw with a cream stripe, from below the nostril to axilla; dorsolateral fold yellowish brown, edged in black laterally; upper surface of tibia and thigh with some dark bars; venter cream (determination after Bourret, 1942; Chuaynkern et al., 2010).

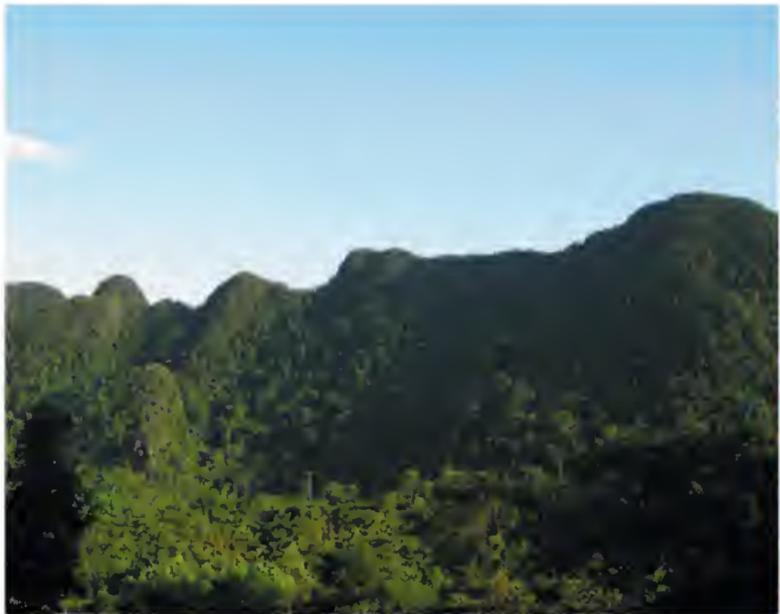
DISTRIBUTION. In Vietnam, *B. chapaensis* has been recorded from Lao Cai, Bac Giang, Ha Tinh, Kon Tum, Gia Lai, and Dak Lak provinces (Nguyen et al., 2009). This is the first record of this species from Phong Nha - Ke Bang National Park as well as from Quang Binh Province. Elsewhere, this species is known from Laos and Thailand (Nguyen et al., 2009).

RHACOPHORIDAE

Theloderma corticale (Boulenger, 1903)
Tonkin Bug-eyed Frog / Ech cay san bac bo (Fig. 6)

EXAMINED MATERIAL. Three adult males IEBR A.2013.11, ZFMK 94262 collected on 21 July 2011 by TQN and others in Da Lat forest, Thuong Hoa Commune, Minh Hoa District (17°39.032'N, 105°54.774'E, at an elevation of 516 m a.s.l.) and PN-KB 2011.204 collected by TQN and others on 28 July 2011 in Cha Noi forest, Xuan Trach Commune, Bo Trach District (17°37.758'N, 106°05.893'E, at an elevation of 470 m a.s.l.).

MORPHOLOGICAL CHARACTERS. SVL of males 61.3-69.7 mm; head wider than long (HL 24.1-27.5 mm, HW 26.3-28.6 mm); snout longer than horizontal diameter of eye (SL 9.0-10.0 mm; ED 6.2 mm); canthus rostralis rounded; loreal region concave; interorbital distance wider than internarial dis-



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Figure 2. Karst forest in Thung Hoa Commune, extension area of Phong Nha - Ke Bang National Park. Figure 3. Big-eyed Toad, *Ingerophrynus macrotis*. Figure 4. Gyldenstolpe's Frog, *Limnonectes gyldenstolpei*. Figure 5. Chapa Frog *Babina chapaensis*. Figure 6. Tonkin Bug-eyed Frog, *Theloderma corticale*. Figure 7. Taylor's Bug-eyed Frog, *Theloderma stellatum*. Photos: T. Q. Nguyen & T. Ziegler.

tance (IOD 6.1-6.5 mm, IND 3.7-4.4 mm); nostril closer to tip of snout than to eye (SN 2.5 mm; EN 7.1-8.3 mm); vocal sac absent; tympanum oval, greater than tympanum-eye distance (TD 4.0-4.9 mm, TEY 3.3-3.9 mm); vomerine teeth present; tongue notched posteriorly. Forelimbs: FAL 12.2-14.8 mm, HAL 33.2-34.7 mm; relative length of fingers: I<II<IV<III; tips of fingers and toes enlarged into round discs; webbing present at base of fingers III and IV; dermal fringe along outer finger present; palmar tubercles distinct; nuptial pad present. Hindlimbs: tibia longer than femur and foot length (TBL 31.8-34.0 mm, FML 25.5-32.2 mm, FTL 27.8-30.5 mm); relative length of toes: I<II<III<V<IV; webbing formula: Io(0)-(0)iIIo(0)-(0)iIIIo(0)-(1)iIVo(1)-(0)iV; dermal fringe along outer toe absent; subarticular tubercles present; inner metatarsal tubercle present (IMT 3.1-4.9 mm); outer metatarsal tubercle absent.

Dorsal surface of body covered with tubercles or warts of different sizes, those on head and back biggest; ventral skin with small tubercles. Coloration in preservative: dorsal colour olive-green marbled with red-brown spots; dark brown bars present on upper surface of fore and hind limbs; ventral surface greyish yellow (determination after Inger et al., 1999; Orlov et al., 2006).

DISTRIBUTION. *T. corticale* is currently known only from northern Vietnam: Ha Giang, Tuyen Quang, Cao Bang, Lang Son, Vinh Phuc, and Son La provinces (Nguyen et al., 2009; Frost, 2013). This is a new record for Phong Nha - Ke Bang National Park and for Quang Binh Province as well as the southernmost known record of the species.

Theلودerma stellatum Taylor, 1962

Taylor's Bug-eyed Frog / Ech cay san tay-lo (Fig. 7)

EXAMINED MATERIAL. One adult female ZFMK 94261 collected by TZ and others during night time on a tree trunk nearby a forest stream and one adult male IEBR A.2013.12 collected by TQN and others on 28 July 2011 in Cha Noi forest, Xuan Trach Commune, Bo Trach District (17°37.649'N, 106°05.806'E, at an elevation of 517 m a.s.l.).

MORPHOLOGICAL CHARACTERS. SVL 32.7-35.0 mm; head as long as wide (HL 13.5-13.9 mm, HW 13.6-14.0 mm); snout longer than horizontal diameter of eye (SL 5.3-5.4 mm; ED 4.5-4.7 mm); canthus rostralis rounded; loreal region concave;

interorbital distance wider than internarial distance (IOD 3.6-3.9 mm, IND 2.0-2.1 mm); nostril closer to tip of snout than to eye (SN 1.6-1.7 mm; EN 3.2-4.0 mm); tympanum rounded, greater than tympanum-eye distance (TD 2.2-2.9 mm, TEY 1.0 mm); vomerine teeth present; tongue notched posteriorly. Forelimbs: FAL 7.9-8.4 mm, HAL 17.5-17.9 mm; relative length of fingers: I<II<IV<III; tip of fingers and toes enlarged into large discs; webbing basal; dermal fringe along outer finger absent; palmar tubercles indistinct; nuptial pad present. Hindlimbs: tibia longer than femur and foot length (TBL 17.6-18.3 mm, FML 16.6-16.9 mm, FTL 15.6-16.0 mm); relative length of toes: I<II<III=V<IV; webbing formula: Io(1)-(1)iIIo(1/2)-(2)iIIIo(1)-(2)iIVo(2)-(1/2)iV; dermal fringe along outer toe absent; subarticular tubercles present; inner metatarsal tubercle present (IMT 1.3-1.5 mm).

Dorsal skin of head and body, upper surface of fore-arm, tibia, and tarsus, with tubercles covered in whitish granular asperities; ventral skin smooth. Coloration in preservative: dorsal head and body brownish with cream speckles; black spots present on snout and black marking present between shoulders; upper surface of thigh, tibia, tarsus, and foot with transverse dark bars; discs pinkish; chin and venter dark brown with light flecks (determination after Taylor, 1962; Inger et al., 1999; Orlov et al., 2006; Nguyen & Nguyen, 2008).

DISTRIBUTION. In Vietnam, *T. stellatum* has been recorded from Kon Tum, Gia Lai, Dak Lak, Dong Nai, and Kien Giang provinces (Nguyen et al., 2009). This is the first record of the species from Phong Nha - Ke Bang National Park as well as from Quang Binh Province, which at the same time is the northernmost country record. Elsewhere, this species is known from Thailand, southern Laos and Cambodia (Nguyen et al., 2009).

SCINCIDAE

Scincella rufocaudata (Darevsky et Nguyen, 1983)
Red-tailed ground skink / Than lan phe-no duoi do (Fig. 8)

EXAMINED MATERIAL. One adult male IEBR A.2013.13 collected on 21 July 2011 by TQN and others in Da Lat forest, Thuong Hoa Commune, Minh Hoa District (17°39.665'N, 105°55.800'E, at

an elevation of 448 m a.s.l.), 2 adult females IEBR A.2013.14 collected on 29 July 2011 by TQN and others in Khe Ma forest, Thuong Hoa Commune, Minh Hoa District (17°39.410'N, 106°03.592'E, at an elevation of 300 m a.s.l.), and ZFMK 94256 collected on 20 July 2011 by TQN and others in Hoa Son Commune, Minh Hoa District (17°39.120'N, 105°59.678'E, at an elevation of 250 m a.s.l.) and one juvenile ZFMK 94257 collected on 18 July 2011 by TQN and others in Thuong Hoa Commune, Minh Hoa District (17°40.057'N, 105°56.049'E, at an elevation of 513 m a.s.l.).

MORPHOLOGICAL CHARACTERS. SVL 45.5 mm in the male, 45.9-47.2 mm in females; TaL 51.0 mm in one female, regenerated or lost in others; snout obtuse; rostral wider than long, nostril in the nasal; frontonasal large; prefrontals separated from each other; frontal longer than frontoparietal; parietals large, in contact posteriorly; nuchals absent; supraoculars 4; supraciliaries 8; loreals 2; supralabials 7; temporals 2 + 2, upper overlapped by lower one; infralabials 6; ear-opening oval; lower eyelid with a transparent window; midbody scales in 30-34 rows, smooth; paravertebral scales 67-69; ventral scales 61-66; enlarged precloacals 2; limbs pentadactyl; subdigital lamellae under fourth toe 15-20.

Coloration in preservative: dorsal head and body brown with a row of dark vertebral spots, a black stripe present on upper part of the side; upper surface of tail reddish; venter cream (determination after Stuart & Emmett, 2006; Nguyen et al., 2011a).

DISTRIBUTION. In Vietnam, *S. rufocaudata* is known from Thua Thien - Hue, Quang Nam, Kon Tum, Gia Lai, Dak Lak, and Ba Ria - Vung Tau provinces (Nguyen et al., 2009). Records of this species in northern Vietnam (Bac Kan, Thai Nguyen and Vinh Phuc provinces) were reidentified as *S. tonkinensis* by Nguyen et al. (2011a). Elsewhere, this species is recorded from Laos and Cambodia (Nguyen et al., 2009).

REMARKS. The red-tailed ground skink was transferred from the genus *Sphenomorphus* to *Scincella* by Nguyen et al. (2011a).

Sphenomorphus tetradactylus (Darevsky et Orlov, 2005)

Four-fingered skink / Than lan phe-no bon ngon (Fig. 9)

EXAMINED MATERIAL. One adult male IEBR A.2013.15 collected on 17 July 2011 by TQN and others in Thuong Hoa Commune, Minh Hoa District (17°40.057'N, 105°56.049'E, at an elevation of 513 m a.s.l.).

MORPHOLOGICAL CHARACTERS. Size small, SVL 36 mm, TaL 49.9 mm, tail tip lost; rostral wider than high, in contact with frontonasal; frontonasal broader than long; prefrontals small, separated from frontal; supraoculars 4/4, first two in contact with frontal on each side; loreal single; lower eyelid scaly; external ear openings hidden with slightly recessed auricular depression; supraciliaries 7/7, first in contact with frontal; supralabials 6/6, third to fifth



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Figure 8. Red-tailed Ground Skink *Scincella rufocaudata*. Figure 9. Four-fingered Skink *Sphenomorphus tetradactylus*. Photos: K. N. Dang & T. Q. Nguyen.

below the eye; infralabials 7/7; nuchals 2/3; mid-body scale rows 20; paravertebral scales 48; ventral scales 51; enlarged precloacals 2; limbs very short, forelimb tetradactyl, first shortest; hind limbs pentadactyl; subdigital lamellae under fourth toe 9/10.

Coloration in preservative: dorsal head and body brown with longitudinal dark stripes along dorsum; venter cream with brown spots; legs dark above with indistinct black marks; free margins of upper and lower eyelids not edged in white (determination after Darevsky & Orlov, 2005; Nguyen et al., 2011a).

DISTRIBUTION. *S. tetradactylus* is currently known only from Phong Nha - Ke Bang National Park, Quang Binh Province, Vietnam (Nguyen et al., 2011a).

REMARKS. *S. tetradactylus* was originally described by Darevsky & Orlov (2005) as a member of the genus *Leptoseps* based on the holotype collected from Phong Nha - Ke Bang National Park. However, Nguyen et al. (2011a) removed this species from the genus *Leptoseps* to the genus *Sphenomorphus*. This is the second known specimen and the first reported adult male of the species.

COLUBRIDAE

Oligodon cinereus pallidocinctus (Bourret, 1934)
Guenther's Kukri Snake / Ran khiem xam (Fig. 10)

EXAMINED MATERIAL. One male, PNKB S.0154, collected by K.D. Ngoc in 2009.

MORPHOLOGICAL CHARACTERS. SVL 495 mm; TaL 90 mm; maxillary teeth 16/16; loreal 1/1; supralabials 8/8, fourth and fifth entering orbit; infralabials 8/8; preoculars 2; postoculars 2; temporals 1/2+2; dorsal scale rows 17 : 17 : 15, smooth; cloacal entire; ventral scales 3 + 167, subcaudals 42, divided.

Coloration in preservative: dorsal head with a grey chevron; dorsal surface of body yellowish brown with 38 grey, black-edged bands on body, 6 bands on tail; ventral surface cream with dark spots (identification after Bourret, 1936; Smith, 1943).

DISTRIBUTION. In Vietnam, this subspecies is known from Thua Thien - Hue, Ba Ria - Vung Tau, and Ho Chi Minh City ("Form IV" in Smith, 1943). This is the first record of *O. cinereus pallidocinctus* from Phong Nha - Ke Bang National Park, Quang Binh Province.

REMARKS. The male specimen differs from the description of Smith (1943) in having more light

bands on body (38 versus 27-34) and more bands on tail (6 versus 3-4).

Parahelicops annamensis Bourret, 1934
Annam Keelback / Ran binh mui trung bo (Fig. 11)

EXAMINED MATERIAL. Two males IEBR A.2013.16-A.2013.17 collected on 23 July 2011 by TQN and others in Hoa Son Commune, Minh Hoa District (17°42.612'N, 105°52.571'E, at an elevation of 537 m a.s.l.) and one female ZFMK 94255 collected on 16 September 2011 in Hoa Son Commune, Minh Hoa District (17°42.208'N, 105°46.970'E, at an elevation of 641 m a.s.l.).

MORPHOLOGICAL CHARACTERS. SVL 358-430 mm in males, 455 mm in the female; TaL 165-177 mm in males, 102 mm in the female; head distinct from neck; maxillary teeth 21/21; rostral flat, broader than high; nostril in the nasal; internasals narrowed anteriorly; prefrontals 2/2, slightly broader than long; frontal narrowed posteriorly, about half the length of the parietals; loreal single, elongated; preoculars 2/2, upper larger; postoculars 2/2; temporals 1 + 1; supralabials 8 or 9; fourth to sixth (in one male) or fifth and sixth bordering orbit; infralabials 10, first to fifth in contact with first chin shield; first pair of chin shield shorter than second pair, second pair divided by an elongated scale posteriorly; body scales rows 19 : 17 : 17, median rows strongly keeled posteriorly; dorsal scales on tail strongly keeled, eight longitudinal keel rows at base, decreasing to four rows distally; ventrals 167-169; cloacal divided; subcaudals divided, 95 and 121 in two males, 51 in the female.

Coloration in preservative: dorsal head with irregular brown markings; a yellow stripe present from posterior margin of eye to neck, continuing onto body as broken dorsolateral stripe, being less distinct posteriorly; tail iridescent yellowish-brown; ventral and subcaudal surface cream, outer margin of ventrals dark brown (determination after Bourret, 1936; Stuart, 2006; Ziegler et al., 2007).

DISTRIBUTION. In Vietnam, the species is only known from Da Nang and Kon Tum provinces (see Stuart, 2006; Nguyen et al., 2009). This is the first record from Phong Nha - Ke Bang National Park as well as from Quang Binh Province. Elsewhere, this species is reported from Laos (Xe Kong) (Nguyen et al., 2009).

REMARKS. *P. annamensis* was previously listed as *Amphiesma* sp. by Ziegler & Vu (2009).

Rhynchophis boulengeri Mocquard, 1897
Rhinoceros snake / Ran voi (Fig. 12)

EXAMINED MATERIAL. Two males deposited in PNKB.

MORPHOLOGICAL CHARACTERS. SVL 940-950 mm; TaL 350-360 mm; presence of a long pointed nasal appendage covered with small scales; internasals much smaller than the prefrontals; frontal narrowed posteriorly; loreal single, longer than wide; preocular single; postoculars 2; temporals 2+3; supralabials 8 or 10, fourth to fifth or fifth to seventh in contact with the eye; infralabials 11; midbody scale rows 19, slightly keeled dorsally; ventral scales 1 + 211 or 1 + 208; subcaudal scales 122 or 126, divided; cloacal plate divided.

Coloration in preservative: dorsum green, venter paler; thin black stripe behind eye; interstitial skin on the sides of the body bluish-black and white; light stripes on subcaudal fold (determination after Smith, 1943; Nguyen et al., 2011b).

DISTRIBUTION. In Vietnam, *R. boulengeri* has been recorded from the provinces of Son La, Thai Nguyen, Vinh Phuc, Ha Noi, Quang Ninh, Hai Phong, and Ha Tinh (Nguyen et al., 2009; Nguyen et al., 2011b). This is a new record for Phong Nha - Ke Bang National Park as well as for Quang Binh Province. Elsewhere, this species is known only from China (Nguyen et al., 2009).

ELAPIDAE

Sinomicrurus macclellandii (Reinhardt, 1844)
MacClelland's Coral Snake/ Ran la kho thuong (Figs. 13-14)

MORPHOLOGICAL CHARACTERS. Morphological characters based on photographic record: vertebral scales not larger than adjacent scales; subcaudals divided; dorsal surface reddish brown with 31 black cross-bands from behind head to tip of tail; head black with a wide, white cross-band behind eyes; ventral surface cream with black bands and black squarish marks (determination after Ziegler et al., 2007).

DISTRIBUTION. In Vietnam, this species is known from Lao Cai and Cao Bang provinces in the North southwards to Lam Dong and Dong Nai provinces (Nguyen et al., 2009). This is the first confirmed record for Phong Nha - Ke Bang National Park. Elsewhere, this species is reported

from India, Nepal, Myanmar, Thailand, China, Japan, Taiwan (Nguyen et al., 2009).

REMARKS. *S. macclellandii* was mentioned as unconfirmed record for Phong Nha - Ke Bang by Ziegler et al. (2007) and thus was subsequently removed from the herpetofaunal list of Phong Nha -Ke Bang by Ziegler & Vu (2009).

VIPERIDAE

Protobothrops mucrosquamatus (Cantor, 1839)
Chinese Habu / Ran luc cuom (Fig. 15)

EXAMINED MATERIAL. One specimen was found at night of 27 October 2009 by TZ and others in the vegetation nearby a forest path in the Cha Noi region and one male IEBR A.2013.18 (PN-KB 2011.51), collected on 16 July 2011 by TQN and others in Thuong Hoa Commune, Minh Hoa District (17°40.405'N, 105°56.656'E, at an elevation of 260 m a.s.l.).

MORPHOLOGICAL CHARACTERS. SVL 950 mm; TaL 225 mm; head long, narrow; single loreal pit; supralabials 10; gular scales smooth; mental bordering infralabial posteriorly; elongated subocular scales, divided from supralabials; dorsal scales strongly keeled, midbody scale rows 27; ventral scales 3 + 216; subcaudals 98; cloacal undivided.

Coloration in preservative: dorsal head brown, paler below; dorsum greyish brown, with a series of large brown, dark-edged spots; ventral surface cream, with light brown, light areas appearing as squarish spots; dorsal tail light brown, with a series of conspicuous black spots (determination after Smith, 1943; Ziegler et al., 2007; Nguyen et al., 2011b).

DISTRIBUTION. In Vietnam, *P. mucrosquamatus* has been recorded from Lao Cai, Ha Giang, Cao Bang, Bac Kan, Lang Son, Thai Nguyen, Vinh Phuc, Quang Ninh, Hai Phong, Hai Duong, Ha Noi, Ninh Binh, Nghe An, Ha Tinh, Quang Tri, Thua Thien-Hue, Kon Tum, and Gia Lai provinces (Nguyen et al., 2009). This is the first record of the species for Phong Nha - Ke Bang National Park and for Quang Binh Province. Elsewhere, this species is known from India, Bangladesh, China, Taiwan, and Myanmar (Nguyen et al., 2009).

REMARKS. The male specimen differs from the description of Smith (1943) in having more subcaudals (98 versus 76-91).



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Figure 10. Guenther's Kukri Snake, *Oligodon cinereus pallidocinctus*. Figure 11. Annam Keelback, *Parahelicops annamensis*. Photos: K. N. Dang & T. Q. Nguyen. Figure 12. Rhinoceros Snake, *Rhynchophis boulengeri*. Figures 13-14. MacClelland's Coral Snake, *Sinomicrurus macclellandii*. Figure 15. Chinese Habu, *Protobothrops mucrosquamatus*. Photos: K. N. Dang, T. Q. Nguyen & T. Ziegler.

Check-list of amphibians and reptiles recorded from Phong Nha - Ke Bang

Current check-list of amphibians and reptiles recorded from Phong Nha - Ke Bang after Ziegler & Vu (2009), including the herein listed new records (*), additions (**), according to Ziegler et al. (2010), Nguyen et al. (2011a), Hoang et al. (2012), and taxonomic reassignments (***) according to Blanck et al. (2006), Stuart & Fritz (2008), Fritz et al. (2008, 2010), Inger & Stuart (2010), McLeod (2010), Yu et al. (2010), David et al. (2011), Nguyen et al. (2011b,), Ohler et al. (2011), Rösler et al. (2011), Kuraishi et al. (2012), Uetz (2013), Frost (2013), Siler et al. (2013), and Patrick David (pers. comm. to replace *Amphiesma khasiense* in central Vietnam with *A. boulengeri*); snake species which have been previously listed but could not be confirmed as occurring in Phong Nha - Ke Bang by Ziegler et al. (2007) are excluded from the list: *Typhlops diardi* Schlegel, 1839, *Calamaria pavementata* Duméril, Bibron et Duméril, 1854, *C. septentrionalis* Boulenger, 1890, *Dendrelaphis pictus* (Gmelin, 1789), *Lycodon septentrionalis* (Günther, 1875), *Orthriophis moellendorffi* (Boettger, 1886), and *Sibynophis collaris* (Gray, 1853).

AMPHIBIA
ANURA
MEGOPHRYIDAE

Brachytarsophrys intermedia (Smith, 1921)
Leptobrachium chapaense (Bourret, 1937)
Leptolalax aereus Rowley, Stuart, Richards, Phimmachak et Sivongxay, 2010 (***)
Ophryophryne hansii Ohler, 2003
Xenophrys major (Boulenger, 1908)

BUFONIDAE

Duttaphrynus melanostictus (Schneider, 1799)
Ingerophrynus galeatus (Günther, 1864)
Ingerophrynus macrotis (Boulenger, 1887) (*)

HYLIDAE

Hyla simplex Boettger, 1901

MICROHYLIDAE

Kalophrynus interlineatus (Blyth, 1854)

Kaloula pulchra Gray, 1831
Microhyla berdmorei (Blyth, 1856)
Microhyla butleri Boulenger, 1900
Microhyla fissipes Boulenger, 1884
Microhyla heymonsi Vogt, 1911
Microhyla inornata (Boulenger, 1890)
Microhyla marmorata Bain et Nguyen, 2004
Microhyla pulchra (Hallowell, 1861)

DICROGLOSSIDAE

Fejervarya limnocharis (Gravenhorst, 1829)
Hoplobatrachus rugulosus (Wiegmann, 1834) (***)
Limnonectes bannaensis Je, Fei et Jiang, 2007 (***)
Limnonectes gyldenstolpei (Andersson, 1916) (*)
Limnonectes limborgi (Sclater, 1892) (***)
Limnonectes poilani (Bourret, 1942)
Occidozyga lima (Gravenhorst, 1829)
Occidozyga martensii (Peters, 1867)

RANIDAE

Amolops cremnobatus Inger et Kottelat, 1998
Babina chapaensis (Bourret, 1937) (*)
Hylarana attigua (Inger, Orlov et Darevsky, 1999)
Hylarana guentheri (Boulenger, 1882)
Hylarana maosonensis Bourret, 1937
Hylarana nigrovittata (Blyth, 1856)
Odorrana chloronota (Günther, 1876)
Odorrana tiannanensis (Yang et Li, 1980)
Rana johnsi Smith, 1921

RHACOPHORIDAE

Chiromantis vittatus (Boulenger, 1887)
Gracixalus quyeti (Nguyen, Hendrix, Böhme, Vu, et Ziegler, 2008)
Kurixalus banaensis (Bourret, 1939)
Kurixalus bisacculus (Taylor, 1962) (***)
Polypedates megacephalus Hallowell, 1861 (***)
Polypedates mutus (Smith, 1940)
Rhacophorus annamensis Smith, 1924
Rhacophorus dennysi Blanford, 1881
Rhacophorus exechopygus Inger, Orlov et Darevsky, 1999
Rhacophorus kio Ohler et Delorme, 2006
Rhacophorus orlovi Ziegler et Köhler, 2001
Rhacophorus rhodopus Liu et Hu, 1960
Theloderma asperum (Boulenger, 1886)
Theloderma corticale (Boulenger, 1903) (*)
Theloderma stellatum Taylor, 1962 (*)

REPTILIA

TESTUDINES

PLATYSTERNIDAE

Platysternon megacephalum Gray, 1831

GEOEMYDIDAE

Cuora cyclornata Blanck, McCord et Le, 2006 (***)

Cuora galbinifrons Bourret, 1939

Cuora mouhotii (Gray, 1862)

Cyclemys oldhamii Gray, 1863 (***)

Heosemys grandis (Gray, 1860)

Mauremys mutica (Cantor, 1842)

Ocadia sinensis (Gray, 1834)

Sacalia quadriocellata (Siebenrock, 1903)

TESTUDINIDAE

Manouria impressa (Günther, 1882)

TRIONYCHIDAE

Palea steindachneri (Siebenrock, 1906)

Pelodiscus cf. parviformis Tang, 1997 (***)

SQUAMATA: SAURIA

GEKKONIDAE

Cyrtodactylus cryptus Heidrich, Rösler, Vu, Böhme et Ziegler, 2007

Cyrtodactylus phongnhakebangensis Ziegler, Rösler, Herrmann et Vu, 2003

Cyrtodactylus roesleri Ziegler, Nazarov, Orlov, Nguyen, Vu, Dang, Dinh et Schmitz, 2010 (**)

Gehyra mutilata (Wiegmann, 1834)

Gekko palmatus Boulenger, 1907

Gekko reevesii Gray, 1831 (***)

Gekko scientiaventura Rösler, Ziegler, Vu, Herrmann et Böhme, 2004

Hemidactylus frenatus Duméril et Bibron, 1836

Ptychozoon lionotum Annandale, 1905 (**)

AGAMIDAE

Acanthosaura lepidogaster (Cuvier, 1829)

Calotes emma Gray, 1845

Calotes versicolor (Daudin, 1802)

Physignathus cocincinus Cuvier, 1829

ANGUIDAE

Dopasia gracilis Gray, 1845 (**)

VARANIDAE

Varanus salvator (Laurenti, 1768)

LACERTIDAE

Takydromus hani Chou, Nguyen et Pauwels, 2001

Takydromus kuehnei van Denburgh, 1909

Takydromus sexlineatus Daudin, 1802

SCINCIDAE

Eutropis longicaudata (Hallowell, 1856)

Eutropis macularia (Blyth, 1853)

Eutropis multifasciata (Kuhl, 1820)

Lygosoma boehmei Ziegler, Schmitz, Heidrich, Vu et Nguyen, 2007

Lygosoma quadrupes (Linnaeus, 1766)

Plestiodon elegans (Boulenger, 1887)

Plestiodon quadrilineatus Blyth, 1853

Scincella melanosticta (Boulenger, 1887)

Scincella rufocaudata (Darevsky et Nguyen, 1983) (*)

Sphenomorphus indicus (Gray, 1853)

Sphenomorphus tetradactylus (Darevsky et Orlov, 2005) (***)

Tropidophorus cocincinensis Duméril et Bibron, 1839

Tropidophorus noggei Ziegler, Vu et Bui, 2005

SQUAMATA: SERPENTES

TYPHLOPIDAE

Ramphotyphlops braminus (Daudin, 1803)

XENOPELTIDAE

Xenopeltis hainanensis Hu et Zhao, 1972

Xenopeltis unicolor Boie, 1827

BOIDAE

Broghammerus reticulatus (Schneider, 1801) (***)

Python molurus (Linnaeus, 1758)

XENODERMATIDAE

Fimbrios smithi Ziegler, David, Miralles, Doan et Nguyen, 2008

COLUBRIDAE

Ahaetulla prasina (Boie, 1827)
Amphiesma andreae Ziegler et Le, 2006
Amphiesma boulengeri (Gressitt, 1937) (***)
Amphiesma leucomystax David, Bain, Nguyen, Orlov, Vogel, Vu et Ziegler, 2007
Amphiesma stolatum (Linnaeus, 1758)
Boiga bourreti Tillack, Ziegler et Le, 2004
Boiga guangxiensis Wen, 1998
Boiga multomaculata (Boie, 1827)
Calamaria thanhi Ziegler & Le, 2005
Chrysopelea ornata (Shaw, 1802)
Coelognathus radiatus (Boie, 1827)
Cyclophiops major (Günther, 1858)
Cyclophiops multicinctus (Roux, 1907)
Dendrelaphis ngansonensis (Bourret, 1935)
Dryocalamus davisonii (Blanford, 1878)
Enhydris plumbea (Boie, 1827)
Liopeltis frenatus (Günther, 1858)
Lycodon fasciatus (Anderson, 1897)
Lycodon futsingensis (Pope, 1928)
Lycodon paucifasciatus Rendahl, 1943
Lycodon cf. rufozonatum Cantor, 1842 (***)
Lycodon ruhstrati (Fischer, 1886)
Oligodon chinensis (Günther, 1888)
Oligodon cinereus pallidocinctus (Bourret, 1934) (*)
Oreocryptophis porphyraceus (Cantor, 1839)
Orthriophis taeniurus Cope, 1861
Parahelicops annamensis Bourret, 1934 (*)
Pareas carinatus Wagler, 1830
Pareas hamptoni (Boulenger, 1905)
Pareas macularius Blyth, 1868
Pareas margaritophorus (Jan, 1866)
Psammodynastes pulverulentus (Boie, 1827)
Pseudoxenodon macrops (Blyth, 1854)
Ptyas korros (Schlegel, 1837)
Ptyas mucosa (Linnaeus, 1758)
Rhabdophis chrysargos (Schlegel, 1837)
Rhabdophis subminiatus (Schlegel, 1837)
Rhadinophis prasinus (Blyth, 1854) (***)
Rhynchophis boulengeri Mocquard, 1897 (*)
Sinonatrix percarinata (Boulenger, 1899)
Xenochrophis flavipunctatus (Hallowell, 1860)

ELAPIDAE

Bungarus candidus (Linnaeus, 1758)
Bungarus fasciatus (Schneider, 1801)
Naja cf. atra Cantor, 1842

Ophiophagus hannah (Cantor, 1836)
Sinomicrurus maccllellandii (Reinhardt, 1844) (*)

VIPERIDAE

Protobothrops cornutus (Smith, 1930)
Protobothrops mucrosquamatus (Cantor, 1839) (*)
Protobothrops sieversorum (Ziegler, Herrmann, David, Orlov et Pauwels, 2000)
Trimeresurus albolabris (Gray, 1842) (***)
Trimeresurus truongsoneensis (Orlov, Ryabov, Bui et Ho, 2004) (***)
Trimeresurus vogeli (David, Vidal et Pauwels, 2001) (***)

DISCUSSION

This study brings the confirmed species number of amphibians and reptiles recorded from Phong Nha - Ke Bang National Park to 151, including 50 species of amphibians (5 Megophryidae, 3 Bufonidae, 1 Hylidae, 9 Microhylidae, 8 Dicroglossidae, 9 Ranidae, 15 Rhacophoridae), 12 species of turtles (1 Platysternidae, 8 Geoemydidae, 1 Testudinidae, 2 Trionychidae), 31 species of lizards (9 Gekkonidae, 4 Agamidae, 1 Anguinae, 1 Varanidae, 3 Lacertidae, 13 Scincidae), and 58 species of snakes (1 Typhlopidae, 2 Xenopeltidae, 2 Boidae, 1 Xenodermatidae, 41 Colubridae, 5 Elapidae, 6 Viperidae), see also fig. 16. An updated list, including recent taxonomic/nomenclatural changes since the last review by Ziegler & Vu (2009), is provided. The research history of the herpetofauna of Phong Nha - Ke Bang clearly shows that even after more than a decade of very intensive herpetological surveys, additional species can be recorded or even discovered as new to science. Since the description of the first herpetological discovery from Phong Nha - Ke Bang, *Cyrtodactylus phongnhakebangensis* by Ziegler et al. (2002), a series of new species descriptions took place to date, amongst others eight snake and four gecko taxa, to mention only the most outstanding examples (see overview in Ziegler & Vu, 2009). And we are aware of further new discoveries to be described from the region in the near future. This does not only underline the importance of Phong Nha - Ke Bang National Park in a regional scale and the Truong Son Mountain Range along the border between Vietnam and Laos

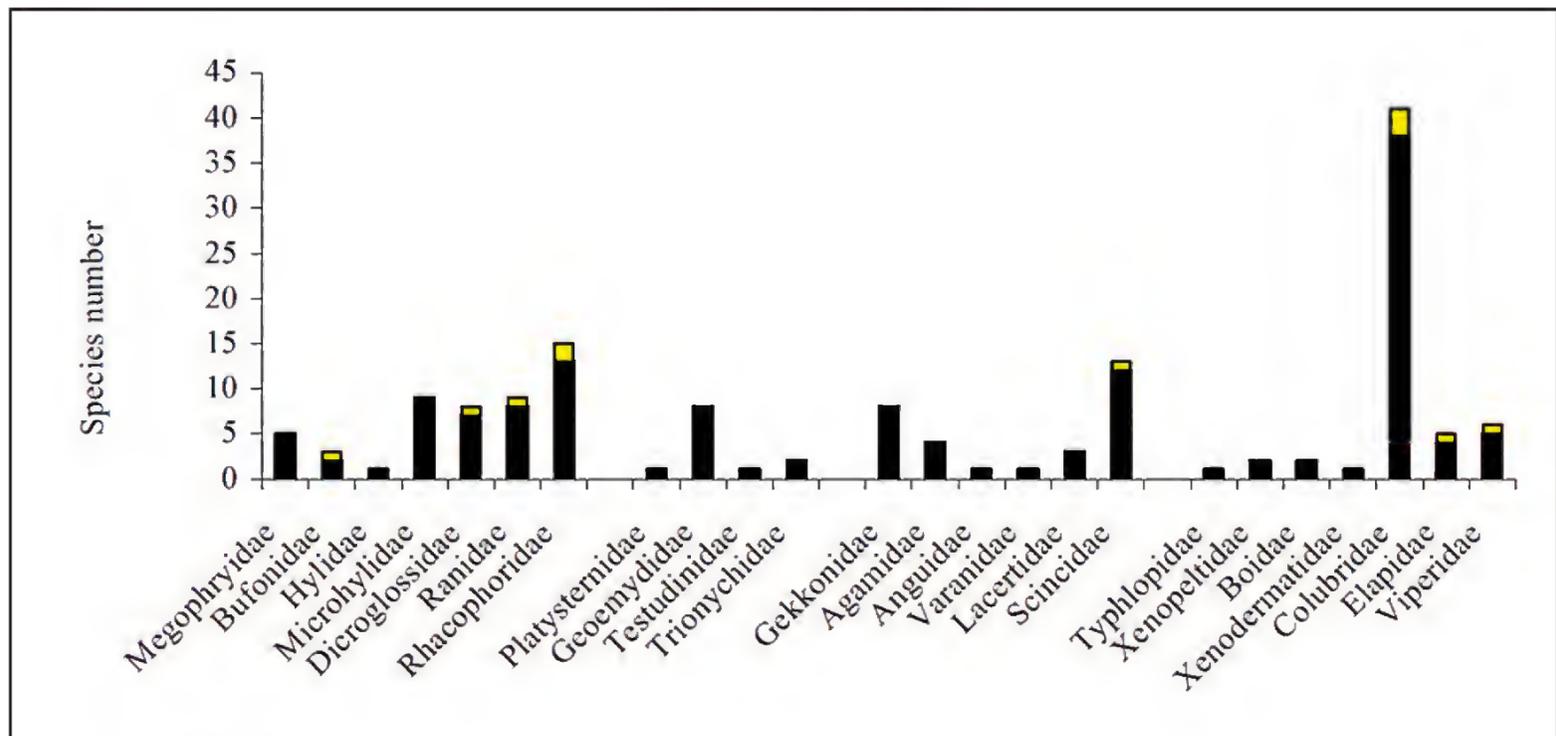


Figure 16. Species richness of amphibian and reptile families from Phong Nha – Ke Bang National Park (new records are marked by open rectangles).

in a wider geographical scale as centres of biodiversity and endemism, but also shows that longterm biodiversity research is crucial for covering the total species richness in tropical environment, which is prerequisite for appropriate evaluation of the conservation status and application of adequate protection measures.

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REFERENCES

- Blanck T., McCord W. P. & Le M., 2006. On the variability of *Cuora trifasciata* (Bell, 1825), the rediscovery of the type specimen, with descriptions of a new *Cuora* species and subspecies, and remarks on the distribution, habitat and vulnerability of these species. Chimaira, Frankfurt am Main.
- Bourret R., 1936. Les serpents de l'Indochine, II, Catalogue systématique descriptif. H. Basuyau, Toulouse.
- Bourret R., 1942. Les Batraciens de l'Indochine [Hanoi]: Institut Océanographique de l'Indochine.
- Chuaynkern Y., Ohler A., Inthara C., Duengkae P., Makchai S. & Salangsingha N., 2010. A revision of species in the subgenus *Nidirana* Dubois, 1992, with special attention to the identity of specimens allocated to *Rana adenopleura* Boulenger, 1909, and *Rana chapaensis* (Bourret, 1937) (Amphibia: Anura: Ranidae) from Thailand and Laos. Raffles Bulletin of Zoology, 58: 291-310.
- Darevsky I.S. & Orlov N. L., 2005. New species of limb-reduced lygosomine skink genus *Leptoseps* Greer,

- 1997 (Sauria, Scincidae) from Vietnam. Russian Journal of Herpetology, 12: 65-68.
- David P., Nguyen T.Q., Nguyen T.T., Jiang K., Chen T. B., Teynié A. & Ziegler T., 2012. A new species of the genus *Oligodon* Fitzinger, 1826 (Squamata: Colubridae) from northern Vietnam, southern China and central Laos. Zootaxa, 3498: 45-62.
- David P., Vogel G. & Dubois A., 2011. On the need to follow rigorously the Rules of the Code for the subsequent designation of a nucleospecies (type species) for a nominal genus which lacked one: the case of the nominal genus *Trimeresurus* Lacépède, 1804 (Reptilia: Squamata: Viperidae). Zootaxa, 2992: 1-51.
- Fritz U., Gong S., Auer M., Kuchling G., Schneeweiß N. & Hunsdörfer A. K., 2010. The word's economically most important chelonians represent a diverse species complex (Testudines: Trionychidae: *Pelodiscus*). Organisms Diversity & Evolution, 10: 227-242.
- Fritz U., Guicking D., Auer M., Sommer R.S., Wink M. & Hunsdörfer A.K., 2008. Diversity of the Southeast Asian leaf turtle genus *Cyclemys*: how many leaves on its tree of life? Zoologica Scripta, 37: 367-390.
- Frost, D.R., 2013. Amphibian Species of the World: an Online Reference. Version 5.6 (9 January 2013). Electronic Database accessible at <http://research.amnh.org/herpetology/amphibia/index.html>. American Museum of Natural History, New York, USA.
- Glaw F. & Vences M., 2007. A field guide to the amphibians and reptiles of Madagascar. Third Edition, Frosch Verlag, Cologne, 496 pp.
- Hendrix R., Nguyen T.Q., Böhme W. & Ziegler T., 2008. New anuran records from Phong Nha - Ke Bang National Park, Truong Son, central Vietnam. Herpetology Notes, 1: 23-31.
- Hoang N.T., Ho A.T. & Hoang Q.D., 2012. New record of *Ptychozoon lionotum* Annandale, 1905 (Squamata: Sauria: Gekkonidae) in Phong Nha - Ke Bang National Park, Quang Binh Province. Pp. 255-259 (in Vietnamese). In: Hoang X.Q. et al. (Eds.), Proceedings of the second National Scientific Workshop on Amphibia and Reptilia in Vietnam. Vinh University Press.
- Inger R.F. & Stuart B. L., 2010. Systematics of *Limnonectes* (Taylorana) Dubois. Current Herpetology, 29: 51-68.
- Inger R.F., Orlov N.L. & Darevsky I.S., 1999. Frogs of Vietnam: A report on new collections. Fieldiana: Zoology, New Series, 92: 1-46.
- Kuraishi N., Matsui M., Hamidy A., Belabut D. M., Ahmad N., Panha S., Sudin A., Yong H.S.Y., Jiang J.-P., Ota H., Thong H.T. & Nishikawa K., 2012. Phylogenetic and taxonomic relationships of the *Polypedates leucomystax* complex (Amphibia). Zoologica Scripta, doi:10.1111/j.1463-6409.2012.00562.x
- McLeod D.S., 2010. Of least concern? Systematics of a cryptic species complex: *Limnonectes kuhlii* (Amphibia: Anura: Dicroglossidae). Molecular Phylogenetics and Evolution, 56: 991-1000.
- Nguyen Q.T. & Nguyen V.K., 2008. First record of *Theioderma stellatum* Taylor, 1962 from Phu Quoc Island, Kien Giang Province, southern Vietnam. Herpetology Notes 1: 61-62.
- Nguyen Q.T., Böhme W., Nguyen T.T., Le K.Q., Pahl K.R., Haus T. & Ziegler T., 2011a. Review of the genus *Dopasia* Gray, 1853 (Squamata: Anguillidae) in the Indochina subregion. Zootaxa 2894: 58-68.
- Nguyen V.S., Ho T. C. & Nguyen Q. T., 2009. Herpetofauna of Vietnam. Edition Chimaira, Frankfurt am Main, 768 pp.
- Nguyen Q.T., Le D. M., Pham T.C., Nguyen T.T., Bonkowski M. & Ziegler T., 2012. A new species of *Gracixalus* (Amphibia, Anura, Rhacophoridae) from northern Vietnam. Organisms Diversity and Evolution, doi: 10.1007/s13127-012-0116-0.
- Nguyen Q.T., Schmitz A., Nguyen T.T., Orlov N.L., Böhme W. & Ziegler T., 2011b. A review of the genus *Sphenormorphus* Fitzinger, 1843 (Squamata: Sauria: Scincidae) in Vietnam, with description of a new species from northern Vietnam and Hainan Island, southern China and the first record of *S. mimicus* Taylor, 1962 from Vietnam. Journal of Herpetology, 45: 145-154.
- Nguyen Q. T., Stenke R., Nguyen H.X. & Ziegler T., 2011c. The terrestrial reptilian fauna of the Biosphere Reserve Cat Ba Archipelago, Hai Phong, Vietnam. In: Schuchmann, K-L. (Ed.), Tropical Vertebrates in a Changing World. Bonner zoologische Monographien, 57: 99-115.
- Ohler A. & Dubois A., 1999. The identity of *Elachyglossa gyldenstolpei* Andersson, 1916 (Amphibia, Ranidae), with comments on some aspects of statistical support to taxonomy. Zoologica Scripta, 28: 269-279.
- Ohler A., Wollenberg K.C., Grosjean S., Hendrix R., Vences M., Ziegler T. & Dubois A., 2011. Sorting out *Lalos*: description of new species and additional taxonomic data on megophryid frogs from northern Indochina (genus *Leptolalax*, Megophryidae, Anura). Zootaxa, 3147: 1-83.
- Orlov N.L., Dutta S.K., Ghate H.V. & Kent Y., 2006. New species of *Theioderma* from Kon Tum Province (Vietnam) and Nagaland State (India) (Anura: Rhacophoridae). Russian Journal of Herpetology 13: 165-175.
- Phung M.T. & Ziegler T., 2011. Another new *Gekko* species (Squamata: Gekkonidae) from southern Vietnam. Zootaxa, 3129: 51-61.
- Rösler H., Bauer A.M., Heinicke M.P., Greenbaum E., Jackman T., Nguyen Q.T. & Ziegler T., 2011. Phylogeny, taxonomy, and zoogeography of the genus

- Gekko* Laurenti, 1768 with the revalidation of *G. reevesii* Gray, 1831 (Sauria: Gekkonidae). *Zootaxa*, 2989: 1-50.
- Siler C.D., Oliveros C.H., Santanen A. & Browne R.M., 2013. Multilocus phylogeny reveals unexpected diversification patterns in Asian wolf snakes (genus *Lycodon*). *Zoologica Scripta*, doi:10.1111/zsc.12007.
- Smith M.A., 1943. The fauna of British India, Ceylon and Burma, including the whole of the Indo-Chinese sub-region. Vol. 3-Serpentes. Taylor and Francis, London.
- Stuart B.L., 2006. A second specimen of *Parahelicops annamensis* Bourret, 1934 (Serpentes: Colubridae: Natricinae). *Hamadryad*, 30: 167-171.
- Stuart B.L. & Emmett D.A., 2006. A collection of amphibians and reptiles from the Cardamom Mountains, southwestern Cambodia. *Fieldiana: Zoology*, 109: 1-27.
- Stuart B.L. & Fritz U., 2008. Historical DNA from museum type specimens clarifies diversity of Asian leaf turtles (*Cyclemys*). *Biological Journal of the Linnean Society*, 94: 131-141.
- Taylor E.H., 1962. The amphibian fauna of Thailand. *University of Kansas Science Bulletin*, 63: 265-599.
- Uetz P., 2013. The Reptile Database, <http://www.reptile-database.org>, accessed 31 January, 2013.
- Yu G.-H., Zhang M.-W. & Yang J.-X., 2010. A species boundary within the Chinese *Kurixalus odontotarsus* species group (Anura: Rhacophoridae): new insights from molecular evidence. *Molecular Phylogenetics and Evolution*, 56: 942-950.
- Ziegler T., Hendrix R., Vu N.T., Vogt M., Forster B. & Dang N.K., 2007. The diversity of a snake community in a karst forest ecosystem in the central Truong Son, Vietnam, with an identification key. *Zootaxa*, 1493: 1-40.
- Ziegler T. & Herrmann H.-W., 2000. Preliminary list of the herpetofauna of the Phong Nha - Ke Bang area in Quang Binh province, Vietnam. *Biogeographica*, 76: 49-62.
- Ziegler T., Herrmann H.-W., Vu N.T., Le K.Q., Nguyen T.H., Cao X.C., Luu M.T. & Dinh H.T., 2004. The amphibians and reptiles of the Phong Nha - Ke Bang National Park, Quang Binh Province, Vietnam. *Hamadryad, Tamil Nadu*, 28: 19-42.
- Ziegler T., Nazarov R., Orlov N., Nguyen Q.T., Vu N.T., Dang N.K., Dinh H.T. & Schmitz A., 2010. A third new *Cyrtodactylus* (Squamata: Gekkonidae) from Phong Nha - Ke Bang National Park, Truong Son, Vietnam. *Zootaxa*, 2413: 20-36.
- Ziegler T., Ohler A., Vu N.T., Le K.Q., Nguyen X.T., Dinh H.T. & Bui N.T., 2006. Review of the amphibian and reptile diversity of Phong Nha - Ke Bang National Park and adjacent areas, central Truong Son, Vietnam. In: Vences, M., Köhler, J., Ziegler, T. & W. Böhme (Eds.): *Herpetologia Bonnensis II*: 247-262. Proceedings of the 13th Ordinary General Meeting of the Societas Europaea Herpetologica, Bonn.
- Ziegler T., Rösler H., Herrmann H.-W. & Vu N.T., 2002. *Cyrtodactylus phongnhakebangensis* sp. n., a new bent-toed gecko from the Annamitic karst forest massif, Vietnam. *Herpetofauna*, 24: 11-25.
- Ziegler T. & Vu N.T., 2009. Ten years of herpetodiversity research in Phong Nha - Ke Bang National Park, central Vietnam. In: Vo V. T., Nguyen D. T., Dang K. N. & Pham Y. H. T. (Eds.). *Phong Nha - Ke Bang National Park and Cologne Zoo, 10 years of cooperation*: 103-124.

First contribution to the reptile fauna of Quang Ngai Province, central Vietnam

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ABSTRACT

Based on recent field surveys, we provide a first preliminary list of reptiles from Quang Ngai Province, central Vietnam, comprising 35 recorded species, including 16 species of lizards (Agamidae: 6, Gekkonidae: 2, Lacertidae: 1, Scincidae: 6, Anguinae: 1), 18 species of snakes (Xenodermatidae: 1, Colubridae: 14, Viperidae: 3), and 1 species of turtle (Geomydidae: 1). The taxonomic status of *Fimbrios* cf. *klossi* from Quang Ngai needs further examination.

KEY WORDS

herpetofauna; taxonomy; distribution; Kon Tum Plateau.

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INTRODUCTION

According to the checklist of Nguyen et al. (2009) 368 species of reptiles are known to occur in Vietnam. In the following year 16 species were added to the country's reptile fauna (see overview in Ziegler & Nguyen, 2010), thus increasing the number of Vietnamese reptile species to 384. Since then new country records and new species descriptions of reptiles were regularly published from Vietnam (e.g., Nguyen et al., 2011a, b; David et al., 2012; Nazarov et al., 2012; Luu et al., 2013), showing that the Vietnamese reptile fauna is still little understood. One of the most poorly studied regions in terms of herpetodiversity is Quang Ngai Province at the south central coast of Vietnam (Fig. 1). Only recently, a first preliminary list of amphibians oc-

curing in this province has been published by Tran et al. (2010) comprising 16 species of anurans. Nguyen et al. (2009) listed only two terrestrial reptile species with definite records from Quang Ngai Province, i.e., the lizard *Leiolepis guentherpetersi*, and the snake *Oligodon ocellatus*. We herein provide a first preliminary reptile inventory for Quang Ngai Province, based on recent field research in particular in the evergreen forest in a transitional area between the Kon Tum Plateau and the lowlands.

MATERIALS AND METHODS

Preliminary field work was conducted by Quyet Khac Le (QKL) and Khoi Le Vu (KLV) in the ever-

green forest in the vicinity of Mo Nit Village, Son Ky Town, Son Ha District, Quang Ngai Province, Vietnam (14°51'N, 108°31'E, elevation 800 m a.s.l.), from 12 to 21 July 2008 (Fig. 2). The survey site is located in a transitional area between the Kon Tum Plateau and the lowlands.

Additional surveys were conducted by Khoi Vu Nguyen, Paul Moler, Randall Babb, Ab Abercrombie, Chris Hope, and Wayne Van Devender (hereafter KVN and others) in Ba To District, during May and June 2011 (camp site 14°39'36.7"N, 108°36'27.0"E, elevation 750 m), in March 2012 (camp site 14°37'10.2"N, 108°35'04.2"E, elevation 920 m), and from May to June 2012 (camp site 14°37'05.9"N, 108°30'10.6"E, elevation 1,025 m). The only specimens which were not collected at the camps in the highlands are *Hemidactylus frenatus* (derive from human environment in lowlands), *Leiolepis guentherpetersi* and *Lygosoma bowringii* (collected at the beach east of Quang Ngai), as well as *Enhydryis subtaeniata* (fished in lowlands). Specimens were photographed in the field. A few individuals were collected by hand for subsequent proper identification. Collected specimens were anaesthetised and euthanized with ethyl acetate, fixed in 80-90% ethanol and subsequently stored in 70% ethanol. Specimens were deposited in the following collections: Institute of Ecology and Biological Resources (IEBR), Hanoi, Vietnam; Zoological Museum, Vietnam National University (VNUH), Hanoi, Vietnam; Zoologisches Forschungsmuseum Alexander Koenig (ZFMK), Bonn, Germany.

Taxonomic determination followed Pope (1935), Smith (1935, 1943), Bourret (1936, 2009), Gressitt (1937), Taylor (1963), Musters (1983), Darvsky & Kupriyanova (1993), Murphy & Voris (1994), Manthey & Grossmann (1997), Ziegler & Vogel (1999), David et al. (2001, 2007), Ziegler (2002), Leviton et al. (2003), Orlov et al. (2006), Vogel & David (2006), Ziegler et al. (2006, 2007, 2010), Fritz et al. (2008), Rösler et al. (2008), Green (2010), Grismer & Grismer (2010), Karns et al. (2010), Nguyen et al. (2009, 2010, 2011a, b), and Hartmann et al. (2013). Morphological characters were given based on the recorded specimens, deviations from literature or in between literature records were presented under remarks. Sex was identified by examination of external characters such as hemipenis swellings or through dissection



Figure 1. Map showing the survey site in Quang Ngai Province, central Vietnam.

(inspection of gonads, retracted copulatory organs). Scientific and common names (in English and Vietnamese) as well as distribution records (except otherwise noticed) followed Nguyen et al. (2009) and David et al. (2011).

Measurements were taken with callipers to the nearest 0.1 mm. Dorsal scale row formula is given as dorsal scales around body at one head length behind head : at midbody : one head length before cloaca.

ABBREVIATIONS. HD = head depth at the pari-etal region; HL = head length (from the posterior edge of the corner of jaw to the snout tip); HW = head width at the level of tympanum; O = diameter of the orbit; SnL = snout length (from the anterior edge of the orbital cavity to the snout tip); SVL (snout-vent length) = distance between tip of snout and vent; T = tympanum diameter; TAL = tail length (measured from posterior margin of cloaca to tip of tail; + = tail reduced or regenerated).

RESULTS

SQUAMATA SAURIA AGAMIDAE

Acanthosaura lepidogaster (Cuvier, 1829) Scale-bellied tree lizard; O ro vay

EXAMINED MATERIAL. Specimens examined (n = 2). One adult male collected by QKL and KLV (ZFMK 94265), SVL: 74.1 mm, TAL: 119.6 mm); one adult female coll. by KVN and others (IEBR 3277, SVL: 75.7 mm, TAL: 108.7 mm) (Fig. 3).

MORPHOLOGICAL CHARACTERS. Body laterally compressed; head about 1.5 times longer than wide; snout shorter than orbit; frontal region deeply concave; scales on upper head unequal, obtusely keeled, much smaller in size in posterior region; canthus rostralis and supraciliary edge strongly projecting; a spine present at the end of the supercilium; another one on the nape, mid-way between the tympanum and the nuchal crest, with enlarged scales at the base; ear opening distinct, visible; supralabials 10-12; infralabials 11 or 12; gular sac absent, gular scales strongly keeled, smaller than ventrals; a strong oblique fold present in front of the shoulder, almost extending across the throat; nuchal crest composed of long, narrow, compressed spines, with two rows of shorter ones at the base; dorsal crest not continuous with the nuchal crest, forming a prominent ridge, composed of broad, triangular scales; dorsal scales very small, keeled, intermixed with much larger, strongly keeled ones, upper scales pointing upwards, lateral scales pointing backwards and upwards, sometimes downwards; hind-limbs reaching or almost reaching to snout tip; third and fourth fingers equal or nearly so, fourth toe distinctly longer than third; femoral pores absent; tail feebly compressed, subtriangular at the base, covered with equally keeled scales above, strongly keeled and elongated scales below; ventrals as large as the largest dorsal, strongly keeled (determination after Smith, 1935; Ziegler, 2002; Bourret, 2009).

The colouration of the preserved specimens is olive grey or reddish brown, with light and dark lateral marbling; a large dark diamond-shaped patch on the neck, the rest of the head being light brown; tail alternately barred with light and dark; belly whitish, uniform, or spotted with black; for colouration in life see figure 3.

DISTRIBUTION. Vietnam: from the Chinese border southwards to Lam Dong, Binh Phuoc, and Dong Nai provinces (this is the first record of the species from Quang Ngai Province); elsewhere: South China (Guangdong, Guangxi, Yunnan, Fujian, Hainan Island), southern Myanmar, Laos, Thailand, Cambodia.

REMARKS. There are some discrepancies regarding morphological characters given in the literature. According to Smith (1935) the head is shorter (less than one and a half time its width), whereas Bourret (2009) mentioned the head being $1\frac{3}{4}$ longer than broad. Smith (1935) stated that the dorsal crest forming a prominent ridge, whereas such feature is absent in the description of Bourret (2009). Whether this is due to imprecise descriptions, individual variation or points to cryptic taxa within *A. lepidogaster* (e.g., Wood et al., 2010) must be dealt with in detail elsewhere.

NATURAL HISTORY NOTES. The testicles of the male measured 7.3 x 4.7 mm (left side) and 7.5 x 4.9 mm (right side).

Acanthosaura nataliae Orlov, Nguyen et Nguyen, 2006 Natalia's tree lizard; O ro na-ta-li-a

EXAMINED MATERIAL. Specimens examined (n = 3). One adult female collected by QKL and KLV (ZFMK 94266, SVL: 120.1 mm, TAL: 212.1 mm); one adult male collected by QKL and KLV (ZFMK 94267, SVL: 148.4 mm, TAL: 276.5 mm); one adult male coll. by KVN and others (IEBR 3276, SVL: 120.5 mm, TAL: 234.6 mm) (Figs. 4, 5).

MORPHOLOGICAL CHARACTERS. A large-sized *Acanthosaura*, postorbital spine present; spine on occiput between tympanum and nuchal crest absent; both sexes with well-developed gular pouch; lateral and dorsal surface of body with large keeled scales intermixed with small scales; hindlimbs with heterogeneous imbricate scales intermixed with larger scales; 2 or 3 distinct rows of papillary scales present on the midline of belly (determination after Orlov et al., 2006).

The colouration of the preserved specimens is brownish grey, reddish brown, or bluish; upper head light or dark brown; orbital region blackish brown, a dark stripe extending from behind the eye to the tympanum; labial region lighter; tail with broad, al-

ternating dark and light bands; belly yellowish white; for colouration in life see figures 4, 5.

DISTRIBUTION. Vietnam: Thanh Hoa, Nghe An, Quang Tri, Thua Thien-Hue, Da Nang, Quang Nam, Kon Tum, and Gia Lai provinces (this is the first record of the species from Quang Ngai Province); elsewhere: southern Laos (Saravane and Xe Kong provinces).

REMARKS. Enlarged scales in the cloacal region as described by Orlov et al. (2006) were not seen in the specimens from Quang Ngai.

NATURAL HISTORY NOTES. A total of 8 small and 10 larger oocytes were found in the female (ZFMK 94266), of which the larger eggs measured 6.5-7.9 mm (left side) and 6.6-8 mm (right side). Testicle sizes in the male (ZFMK 94267) were 14.2 x 9.5 mm (left side) and 16.8 x 8.3 mm (right side).

Calotes mystaceus Duméril et Bibron, 1837
Blue-crested lizard; Nhung xam

EXAMINED MATERIAL. Specimens examined (n = 2). One adult was photographed by RB (Fig. 6); another adult female, collected by KVN and others (IEBR 3278, SVL: 82.7 mm, TAL: 206 mm; see Fig. 7).

MORPHOLOGICAL CHARACTERS. Body compressed; head more than 1.5 times longer than wide (ratio HL/HW=1.8); snout distinctly longer than the orbit (10.9 versus 8 mm); frontal region feebly concave; upper head-scales unequal, smooth or keeled; canthus rostralis and supraciliary edge sharp; postorbital spine absent; two short, separated spines present on each side of the nape, the lower one separated from the tympanum by 4 or 5 scales; a row of 3 or 4 enlarged scales between the eye and the tympanum; tympanum diameter about half of the orbit (ratio T/O=0.4); supralabials 11; infralabials 10 or 11; gular pouch small, gular scales strongly keeled, mucronate, larger than ventrals; an oblique fold present in front of the shoulder, covered with small granular scales; dorsal scales strongly keeled, pointing backwards and upwards, nearly twice as large as ventrals; scales around midbody 54; limbs moderate; third and fourth fingers nearly equal; fourth toe distinctly longer than third toe; hind-limb reaching to the posterior corner of orbit; tail feebly compressed, covered with subequal, keeled scales; ventrals strongly keeled (determination followed Smith, 1935, compared with Hartmann et al., 2013).

The colouration of the preserved specimen is greyish blue on body with six large chocolate-coloured spots along the vertebral line; head brownish, with thin dark lines radiating from the eye; fold in front of the shoulder black; an eponymous whitish stripe on upper lip extends from between nostril and eye to the neck; tail pale blue; dirty whitish below; for colouration in life see figures 6, 7.

DISTRIBUTION. Vietnam: from Son La, Lang Son, and Nghe An provinces in the North southwards to Kien Giang Province (this is the first record of the species from Quang Ngai Province); elsewhere: India, China, Myanmar, Laos, Thailand, and Cambodia.

Draco indochinensis Smith, 1928
Indochinese flying lizard; Than lan bay dong duong

EXAMINED MATERIAL. Specimen examined (n = 1). One adult female collected by QKL and KLV (ZFMK 94268, SVL: 110.7 mm, TAL: 205.5 mm) (Figs. 8, 9).

MORPHOLOGICAL CHARACTERS. Body large; pata-gial ribs 5; head moderate (HL/SVL 0.21 and HD/HL 0.44); snout length 0.44 times of the head length; snout longer than the diameter of the orbit; nostrils directed almost straight upwards; ear opening distinct; upper head-shields unequal, strongly keeled, compressed and more or less erected over the canthus rostralis; supralabials 10 or 11; two median teeth present on upper jaw; no thornlike scale on the supraciliary edge, but a rounded tubercle; gular appendage 0.76 times of the head length, with enlarged scales; dorsal scales 173, unequal, smooth or faintly keeled, smaller than the ventral scales; ventrals strongly keeled; a series of enlarged scales present on the border between body and patagium, widely separated from each other, strongly keeled; subdigital lamellae under the fourth finger 28 or 29, keeled, under the fourth toe 33-35; hindlimbs 0.5 times of the snout-vent length; fore-limb reaching to beyond the snout, hindlimb nearly reaching to the axilla; fringelike scales present on posterior edge of thigh and on base of tail; tail length 1.86 times the snout-vent length; ventrals 144, keeled, larger than dorsals (determination after Smith, 1935; Musters, 1983; Bourret, 2009).

The colouration of the preserved specimen is greyish or bronze and bluish above, with numerous small black spots; wing-membranes reddish-brown



Figure 2. Primary forest in Quang Ngai Province, photo. Q.K. Le. Figure 3. *Acanthosaura lepidogaster*, adult female, photo R. Babb. Figure 4. *Acanthosaura nataliae*, adult male, photo R. Babb. Figure 5. *Acanthosaura nataliae*, portrait of adult male, photo Q.K. Le. Figure 6. *Calotes mystaceus*, uncollected adult, photo R. Babb.

above, with four distinct, light-bordered, curved transverse black bands which bifurcate as they approach the body; ventral surface of patagium with a black stripe along the outer margin; chin spotted with black; throat blue, with a broad, black, transverse bar extending to the inner sides of the wattles; belly yellowish grey; for colouration in life see figures 8, 9.

DISTRIBUTION. Vietnam: Khanh Hoa, Kon Tum, Lam Dong, Dong Nai, and Tay Ninh provinces (this is the first record of the species from Quang Ngai Province); elsewhere: Cambodia.

REMARKS. The specimen from Quang Ngai differs from the description provided by Musters (1983) in some aspects: 10 or 11 instead of 8-10 supralabials, 28 or 29 instead of 25 or 26 subdigital lamellae under fourth finger, 33-35 instead of 29-32 subdigital lamellae under fourth toe, 144 instead of 123-129 ventrals, and 173 instead of 189-210 dorsals; however, it must be taken into account that the description of *D. blanfordii indochinensis* in Musters (1983) was based on only two specimens.

NATURAL HISTORY NOTES. The female contained one egg on the left side (15.8 mm) and two eggs on the right side (14.8-15.7 mm).

Leiolepis guentherpetersi Darevsky et Kupriyanova, 1993

Peter's butterfly lizard; Nhung cat soc

EXAMINED MATERIAL. Specimen photographed (n = 1): one adult was photographed by RB (Fig. 10).

MORPHOLOGICAL CHARACTERS. Identification of the photographed specimen is based on characteristic body shape and colour pattern (determination after Darevsky & Kupriyanova, 1993; Nguyen et al., 2009; Grismer & Grismer, 2010).

DISTRIBUTION. Vietnam: Thua Thien-Hue, Da Nang, Quang Nam, and Quang Ngai provinces; elsewhere: this species is currently known only from central Vietnam.

Physignathus cocincinus Cuvier, 1829
Indochinese water dragon / Rong dat

EXAMINED MATERIAL. Specimens photographed (n = 2): two subadult to adult specimens were photographed by QKL and RB (Fig. 11).

MORPHOLOGICAL CHARACTERS. Identification of the photographed specimens is based on character-

istic body shape and colour pattern, such as dorsal scales small; distinctly enlarged scale row present below infralabials; some scattered enlarged scales present behind mandible; transverse skin fold present in posterior gular region; nuchal, dorsal and tail crests well developed; tail laterally compressed; toes without distinct lobes (determination after Ziegler, 2002).

DISTRIBUTION. Vietnam: entire country (however, this is the first documented record of the species from Quang Ngai Province); elsewhere: Southern China, Myanmar, Laos, southeastern Thailand, and Cambodia.

GEKKONIDAE

Cyrtodactylus pseudoquadrivirgatus Rösler, Vu, Nguyen, Ngo et Ziegler, 2008

Pretended four-striped forest gecko; Thach sung ngon gia bon vach

EXAMINED MATERIAL. Specimens examined (n = 3): two adult males (IEBR 3270, SVL: 67.4 mm, TAL: 54.7 mm; IEBR 3272, SVL: 65.4 mm, TAL: 6.5+ mm); one adult female collected by KVN and others (IEBR 3271, SVL: 57.4 mm, TAL: 61.3 mm).

MORPHOLOGICAL CHARACTERS. A medium-sized *Cyrtodactylus*; lateral fold narrow, with enlarged lateral tubercles; interorbital scales 34-45; tubercles present on dorsum of head, body, limbs and tail; dorsal tubercles in 18 to 20 rows; lamellae under first finger 11-13, lamellae under first toe 11-13, lamellae under fourth toe 18-23; ventral scales at midbody in 39-46 longitudinal rows; precloacal pores 7 or 8, in angular series in males, absent in adult female; enlarged precloacal scales 8-11, behind angular pore series; enlarged femoral scales absent; femoral pores and a precloacal groove absent; transversely enlarged subcaudals absent (determination after Rösler et al., 2008).

Colouration of the preserved specimens: dorsal surface brown, mottled in dark brown; neck band medially interrupted; tail with dark and light bands; for colouration in life (uncollected specimens from Quang Ngai Province) see figure 12.

DISTRIBUTION. Vietnam: Quang Tri, Thua Thien-Hue, Da Nang, and Kon Tum (this is the first record of the species from Quang Ngai Province); elsewhere: this species is currently known only from Vietnam.



7



8



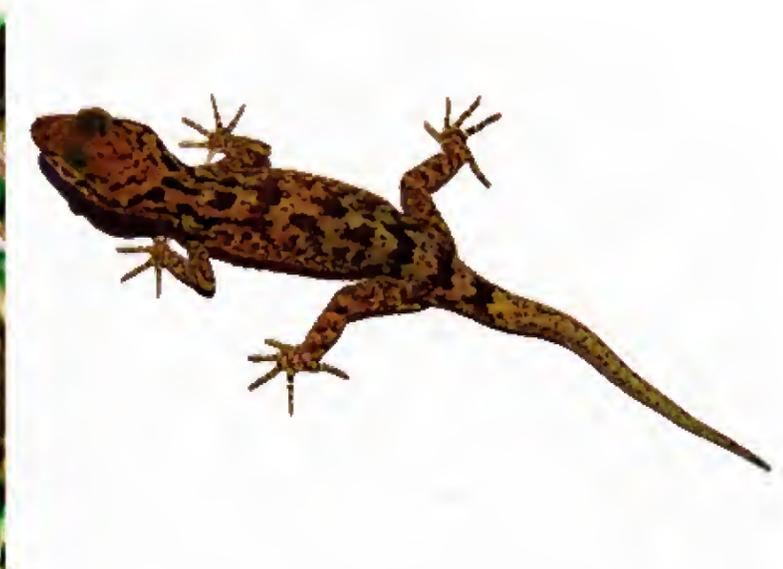
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11



12

Figure 7. *Calotes mystaceus*, female, photo R. Babb. Figure 8. *Draco indochinensis*, adult female in dorsal view, photo Q.K. Le. Figure 9. *Draco indochinensis*, adult female in ventral view, photo Q.K. Le. Figure 10. *Leiolepis guentherpetersi*, photo R. Babb. Figure 11. *Physignathus cocincinus*, photo R. Babb. Figure 12. *Cyrtodactylus pseudoquadrivirgatus*, photo Q.K. Le.

Hemidactylus frenatus Schlegel, 1836
Common house gecko; Thach sung duoi san

EXAMINED MATERIAL. Specimens examined (n = 2): two adult males collected by KVN and others (ZFMK 94660, SVL: 49.6 mm, TAL: 56 mm; ZFMK 94661, SVL: 44.8 mm, TAL: 9.1+ mm).

MORPHOLOGICAL CHARACTERS. Head large; snout obtusely pointed, longer than the distance between eye and ear-opening; snout with large scales, posterior part of head covered with small granules; dorsum with small granules intermixed with scattered, rounded tubercles; nostril surrounded by rostral, first labial, and three or four small scales; rostral distinctly broader than high, quadrangular, with median groove; supralabials 11 or 12; infralabials 9; ear-opening oval, oblique, less than half of the eye diameter; mental large, subtriangular; postmentals two pairs, well-developed, outer pair slightly smaller than the inner; gular region with small granular scales; fingers and toes free of webbing; lamellae medially forked, 4 or 5 (some missing) under the first toe, 10 under the fourth toe; hind-limb not reaching to the axilla; tail feebly depressed, oval in section, verticillate, dorsal surface covered with small scales and series of six enlarged pointed tubercles; ventrolateral skin fold absent; belly with smooth, rounded, imbricate scales; ventrals in 35 and 37 rows; males with 28-32 precloacal-femoral pores, in continuous series; precloacal tubercles 2; ventral tail with a median series of transversely enlarged scales (determination after Smith, 1935; Manthey & Grossmann, 1997; Ziegler, 2002; Bourret, 2009).

The colouration of the preserved specimens is greyish-brown above, with indistinct darker markings; a bright line along the side of the head; yellowish white below.

DISTRIBUTION. Vietnam: entire country; elsewhere: worldwide in tropical and subtropical regions.

REMARKS. The examined specimens differ from the description by Manthey & Grossmann (1997) in the number of ventral scales (35-37 versus 28-36).

LACERTIDAE

Takydromus sexlineatus Daudin, 1802
Asian grass lizard; Liu diu chi

EXAMINED MATERIAL. Specimen examined (n =

1): one adult male collected by KVN and others (ZFMK 94659, SVL: 63.5 mm, TAL: 253.7 mm).

MORPHOLOGICAL CHARACTERS. Head narrow and elongate, pointed anteriorly; nasals just touching each other behind the rostral; fronto-nasal single, as long as wide; prefrontals in contact with each other; supraoculars 3, in contact with the supraciliaries, the first two the largest, anterior in contact with posterior loreal; supraciliaries 3; interparietal about half the size of fronto-parietals, larger than the occipital; anterior loreal smaller than the posterior; temporal scales strongly keeled, upper ones bordered with parietal, enlarged; fifth supralabial in contact with subocular; chin shields 3 pairs, the first pair in contact, third pair largest in size; collar indistinct; gular scales 23, in a line between chin shield and collar, scales on the anterior half of the gular region more elongate and considerably smaller than those on the posterior half; dorsal plates truncate and shortly mucronate behind, in 6 rows across the nape, in 4 across the back; lateral scales small, more or less granular, bordered above and below by larger ones, 10 in a vertical series between the dorsal and ventral plates; tail very long; caudal scales as large as dorsal plates, strongly keeled and mucronate; ventral scales strongly keeled and mucronate, in 12 longitudinal series; scales between collar and groin 29; a single femoral pore present on each side; precloacal scale single (determination after Smith, 1935; Manthey & Grossmann, 1997; Bourret, 2009).

The colouration of the preserved specimen is brown to bluish-brown above, with metallic gloss; a light, dorso-lateral stripe starting from above the eye and extending on to the base of the tail, edged above with black spots, below with a black line; flanks with a series of white black-edged ocelli; brown colour terminated half way down the flank and bordered by a thin black stripe, starting from the nostril to above the ear; upper head and tail brown; venter and upper lip yellowish and bluish-white.

DISTRIBUTION. Vietnam: from the Chinese border southwards to Dong Nai, Tay Ninh and Binh Duong provinces (this is the first record of the species from Quang Ngai Province); elsewhere: India, southern China, Taiwan, Myanmar, Laos, Thailand, Cambodia, Malaysia, and Indonesia.

REMARKS. The specimen matches the description of Smith (1935) except for only one pair of temporal scales bordering the parietal being larger than the

others; also only the first pair of chin shields is in contact in the examined specimen instead of the first two pairs, as was mentioned by Smith (1935).

SCINCIDAE

Eutropis longicaudatus (Hallowell, 1856)
Long-tailed mabuya; Than lan bong duoi dai

EXAMINED MATERIAL. Specimen photographed (n = 1): one individual was photographed by RB (Fig. 13).

MORPHOLOGICAL CHARACTERS. Identification of the photographed specimen is based on characteristic body shape and colour pattern, such as dorsal scales with two weakly developed longitudinal keels; well developed limbs with five fingers and toes each overlapping when laterally adressed to the body; ear opening immersed, visible; supranasals present, touching each other; postnasal present on each side (determination after Ziegler, 2002).

DISTRIBUTION. Vietnam: entire country; elsewhere: Southern China, Taiwan, Laos, Thailand, Cambodia, and Malaysia.

Eutropis multifasciatus (Kuhl, 1820)
Many-lined sun skink; Than lan bong hoa

EXAMINED MATERIAL. Specimen examined (n = 1): one juvenile specimen collected by KVN and others (ZFMK 94662, SVL: 39.5 mm, TAL: 33.1+ mm).

MORPHOLOGICAL CHARACTERS. Supranasals just touching each other; fronto-nasal broader than long; postnasal 1; anterior loreal as large as posterior loreal; supraoculars 4, large; parietals divided by a large interparietal; lower eyelid scaly, without disc; supralabials 7, the fifth below the eye; infralabials 7; temporal scales smooth or feebly keeled; ear-opening visible, moderately large, subcircular, sunken, with small, pointed lobules anteriorly; nuchals in 1 pair; dorsal scales with 3, more or less strongly keeled, lateral scales feebly keeled; scales around the midbody 30; vertebrals between parietals and tail base 45; digits moderately long, with smooth lamellae, 19 beneath the fourth toe; limbs well developed, hind-limb reaching to elbow when adresses along body; precloacals not enlarged (de-

termination after Smith, 1935; Manthey & Grossmann, 1997; Ziegler, 2002; Bourret, 2009).

The colouration of the preserved specimen is uniform olive-brown above; upper parts of flanks dark brown with white spots; light dorso-lateral stripe present.

DISTRIBUTION. Vietnam: entire country; elsewhere: India, China, Taiwan, Myanmar, Laos, Thailand, Cambodia, Malaysia, Indonesia, Philippines, and New Guinea.

Lygosoma bowringii (Guenther, 1864)
Bowring's supple skink; Than lan chan ngan bao-ring

EXAMINED MATERIAL. Specimen photographed (n = 1): one individual was photographed by RB (Fig. 14).

MORPHOLOGICAL CHARACTERS. Identification of the photographed specimen is based on characteristic body shape and colour pattern, such as ground colouration being brown above; each dorsal scale generally with a darker spot forming more or less continuous longitudinal lines; dark brown or black dorsolateral stripe of variable thickness, edged in light above; sides of neck and body usually thickly spotted with black and white; white longitudinal stripe across supralabials until ear opening; yellow below; sides of neck, body and tail often red in life; fifth supralabial longest, below the eye; ear opening subcircular, about half as large as the eye, with one very small projecting lobule anteriorly (determination after Smith, 1935; Manthey & Grossmann, 1997).

DISTRIBUTION. Vietnam: from Hai Duong Province in the North to Kien Giang Province in the South (this is the first record of the species from Quang Ngai Province); elsewhere: India, China, Myanmar, Laos, Thailand, Cambodia, Malaysia, and Philippines.

Scincella melanosticta (Boulenger, 1887)
Black-spotted smooth skink; Than lan co dom den

EXAMINED MATERIAL. Specimens examined (n = 2): one adult female collected by QKL and KLV (ZFMK 94391, SVL: 51.3 mm); one adult male collected by KVN and others (IEBR 3274, SVL 37.4 mm, Fig. 15).

MORPHOLOGICAL CHARACTERS. Size small, tail regenerated in both specimens; prefrontals in contact

with each other; supraoculars 4; nuchals absent; supralabials 7; infralabials 6; primary temporals 2; secondary temporals 2, lower one overlapped by upper one; external ear opening present, without lobes on anterior margin; tympanum deeply sunken; midbody scales in 34 rows; dorsal scales smooth, in 8 rows across the dorsum; paravertebral scales 67, not widened; subdigital lamellae under fourth toe 14-15 (determination after Smith, 1935; Taylor, 1963).

The colouration of the preserved specimens is bronze brown on back and dorsal tail base with a row of large black spots; a dark stripe running from snout to anterior corner of eye and from posterior corner of eye to shoulder; upper lateral zone with large black spots from axilla to tail base; chin with some dark dots, throat and belly cream.

DISTRIBUTION. Vietnam: Quang Binh, Lam Dong, and Ba Ria-Vung Tau provinces (this is the first record of the species from Quang Ngai Province); elsewhere: Myanmar, Laos, Thailand, and Cambodia.

REMARKS. Specimens from Quang Ngai also resemble *S. rupicola*, however, they were assigned to *S. melanosticta* by having a higher number of midbody scale rows (34 vs. 30) and vertebral row of dark spots unpaired anteriorly (see Taylor, 1963).

Sphenomorphus indicus (Gray, 1853)

Indian forest skink; Than lan phe-no an do

EXAMINED MATERIAL. Specimens examined (n = 3): one adult male collected by KVN and others (ZFMK 94663, SVL: 65.4 mm, TAL: 125.1 mm, Fig. 16); one adult female collected by QKL & KLV (ZFMK 94269, SVL: 75.6 mm, TAL: 56 + mm); one subadult collected by QKL & KLV (ZFMK 94393, SVL: 43.4 mm).

MORPHOLOGICAL CHARACTERS. Size large; nostril in a big nasal; supranasals absent; prefrontals separated from each other; supraoculars 4; loreals 2; supraciliaries 8 or 9; lower eyelid scaly; primary temporals 2; supralabials 7 or 8; external ear present, with 2 or 3 small lobules on anterior margin; tympanum deeply sunken; nuchals absent; midbody scales smooth, in 30-34 rows; paravertebral scales 69, not widened; limbs pentadactyl; lamellae under fourth toe 16-19 (determination after Smith, 1935; Taylor, 1963; Ziegler, 2002; Nguyen et al., 2011b).

The colouration of the preserved specimens is bronze-brown above with irregular black dots; light

dorsolateral stripe present on neck and shoulder; upper lateral zone with a dark stripe from behind eye to tail base; lower lateral zone with light bars; ventral surface cream; for colouration in life see figure 16.

DISTRIBUTION. Vietnam: from Lao Cai, Cao Bang, and Bac Kan provinces in the North southwards to Dong Nai Province (this is the first record of the species from Quang Ngai Province); elsewhere: India, Bhutan, China, Taiwan, Myanmar, Laos, Thailand, Cambodia, Malaysia, and Indonesia.

NATURAL HISTORY NOTES. The adult female contained 17 oocytes, 0.5-1.8 mm in size.

Tropidophorus cocincinensis Duméril et Bibron, 1839

Cochinchinese water skink; Than lan tai nam bo

EXAMINED MATERIAL. Specimens examined (n = 3): three adult specimens collected by QKL and TNV (ZFMK 94270, SVL: 87.5 mm, TAL: 81.6+ mm; ZFMK 94271, SVL: 76.3 mm, TAL: 73.3+ mm; ZFMK 94272, SVL: 73.4 mm, TAL: 114 mm), see figure 17.

MORPHOLOGICAL CHARACTERS. Upper headshields strongly striated; frontonasal undivided; prefrontals in broad contact, touching each other or with a small azygous shield in between loreals 2 (posterior loreal fused with frontonasal on right side in one specimen), separated from supralabials by a series of small scales; superciliaries 7, superciliary row not completed along the entire length of lateral edge of supraoculars; supralabials 7 (8 in one specimen), fifth largest, below the eye; infralabials 6-8; postmental undivided; nuchals in 3 or 4 pairs; dorsals strongly keeled; paravertebral scales 41-44; midbody scales in 30 or 32 rows; ventrals in 46 or 47 transverse rows; enlarged precloacal shields 2; scale rows at position of tenth subcaudal on tail 14 or 15; dorsal keels on the tail forming strong ridges; two series of moderately elevated spines along middle of tail dorsum, continuous with those on back; subdigital lamellae under fourth toe 18-20 (determination after Nguyen et al., 2010).

The colouration of the preserved specimens is reddish-brown above with indistinct black spots or transverse markings on back; large white spots starting behind the head, extending over the flanks, paler on the tail, arranged in 1 or 2 longitudinal rows; belly brownish-white.



13



14



15



16



17



18

Figure 13. *Eutropis longicaudata*, photo R. Babb. Figure 14. *Lygosoma bowringii*, photo R. Babb. Figure 15. *Scincella melanosticta*, photo R. Babb. Figure 16. *Sphenomorphus indicus*, photo R. Babb. Figure 17. *Tropidophorus cocincinensis*, photo Q.K. Le. Figure 18. *Dopasia gracilis*, photo Q.K. Le.

DISTRIBUTION. Vietnam: Quang Binh, Quang Tri, Thua Thien-Hue, Da Nang, Quang Nam, and Kon Tum provinces (this is the first record of the species from Quang Ngai Province); elsewhere: Laos, Cambodia, and Thailand (see also Nguyen et al., 2010).

REMARKS. One specimen from Quang Ngai shows 8 instead of 7 supralabials. Compared with the diagnosis of *T. cocincinensis* in Nguyen et al. (2010), the Quang Ngai specimens have 3 to 4 pairs of nuchals (versus 1-3), and the number of scale rows at position of tenth subcaudal on tail is 14 or 15 (versus 13 or 14).

NATURAL HISTORY NOTES. The females (ZFMK 94270-94271) contained about 10-20 follicles of up to 2.1 cm in size on the left side and about 13-20 follicles of up to 2.6 cm in size on the right side, respectively.

ANGUIDAE

Dopasia gracilis Gray, 1845

Asian glass lizard; Than lan ran

EXAMINED MATERIAL. Specimens examined (n = 2): one subadult male collected by QKL and KLV (VNUH 2008.7.10, SVL: 105.0 mm, TAL: 212.0 mm) (Fig. 18).

MORPHOLOGICAL CHARACTERS. Body cylindrical, without limbs; ear opening 2 times greater than nostril; nasal separated from frontonasal by 3 scales; supraoculars 5; supraciliaries 6; supralabials 10, first and second bordering nostril; infralabials 9; dorsal scales strongly keeled; longitudinal scale rows between lateral folds 18; number of scales along lateral fold 81–87; ventral scales in 10 longitudinal rows; vertebrae from atlas to remnants of hind limb bones 47 (determination after Nguyen et al., 2011a).

The colouration of the preserved specimen is brown or grey brown dorsally with longitudinal series of small brown spots on anterior part of back; two dark stripes present on each side of body: dorsolateral stripe from one head-length behind ear opening to tail tip, progressively broader posteriorly; ventrolateral stripe narrower but more distinct than dorsolateral stripe, from angle of jaw to vent, changing to a series of small spots on tail; for colouration in life see figure 18.

DISTRIBUTION. Vietnam: Cao Bang, Ha Giang, Yen Bai, Quang Binh, and Quang Ngai provinces (see Nguyen et al., 2011a); elsewhere: India, China, Myanmar, Laos, and Thailand.

SQUAMATA SERPENTES

XENODERMATIDAE

Fimbrios cf. klossi Smith, 1921

Kloss' snake; Ran ma

EXAMINED MATERIAL. Specimen examined (n = 1): one adult male collected by KVN and others (IEBR 3275, SVL: 203.1 mm, TAL: 51.3 mm; Fig. 19), ratio TAL/TL: 0.25.

MORPHOLOGICAL CHARACTERS. Nostril in the anterior part of a large concave nasal; rostral triangular, not visible from above; suture between internasals shorter than that between prefrontals; internasals separated from rostral by a horizontal skin fold; frontal broadly truncate in front, broader than long, as long as its distance from the tip of snout, much shorter than parietals, about three times as broad as the supraoculars; preocular small, just touching the frontal; large quadrangular loreal in contact with eye; postoculars 3; subocular 1; temporals 5; supralabials 9 or 10, first 5 very small with strongly raised edges, the last one more elongated; infralabials 11, first 7 very small with raised edges like supralabials; mental absent; a pair of large chin shields, in contact with the first ventral; dorsal scales in 28 or 29 rows at anterior part of body; dorsal scale rows: 28 or 29 : 30 : 31; interstitial skin partly visible between anterior scales, scales feebly imbricate posteriorly; ventrals 161; cloacal scale undivided; subcaudals 62, unpaired (determination after Bourret, 1936; Smith, 1943; Ziegler et al., 2008).

The colouration of the preserved specimen is black above, brighter ventrally; edges of ventrals and of subcaudals tinged with dark grey.

DISTRIBUTION. Vietnam: Quang Tri, Thua Thien-Hue, Kon Tum, Gia Lai, Dak Lak, and Lam Dong provinces (this is the first record of the species from Quang Ngai Province); elsewhere: Cambodia.

REMARKS. The collected individual differs from previous descriptions (Bourret, 1936; Smith, 1943; Ziegler et al., 2008) by a lower number of infralabials

(11 versus 12), a higher number of temporals (5 versus 2-3) and subcaudals (62 versus 43-60), a less developed scale imbrication, no mental shield, and a different TAL/TL ratio (0.25 versus 0.126 to 0.2).

COLUBRIDAE

Ahaetulla prasina (Boie, 1827)

Oriental whip snake; Ran roi thuong

EXAMINED MATERIAL. Specimen examined (n = 1): one specimen collected by KVN and others (ZFMK 94664, SVL: 584.3 mm, TAL: 319.2 mm; Fig. 20).

MORPHOLOGICAL CHARACTERS. Head shields large; pupil horizontal; snout pointed, projecting, without dermal appendage, snout more than twice as long as eye diameter; canthus rostralis sharp; nostrils lateral, not valvular; nasal in contact with the labials; loreals 3, small; frontal followed by two symmetric parietals of size equal to frontal; preocular 1, in contact with frontal; postoculars 2; temporals 1 or 2 + 2; supralabials 9, fourth to sixth touching the eye, entire; infralabials 8, first 4 in contact with anterior chin shields, shorter than the posterior; mental groove present; dorsals smooth, slightly keeled in the sacral region; dorsal scale rows at midbody 15; ventrals 196; cloacal scale divided; subcaudals 168, divided (determination after Bourret, 1936; Smith, 1943; Manthey & Grossmann, 1997; Ziegler, 2002).

The colouration of the preserved specimen is bluish-green above, with a yellowish-white line on both sides of the ventral part; interstitial skin in the neck region black and white.

DISTRIBUTION. Vietnam: entire country; elsewhere: India, Bangladesh, Bhutan, China, Myanmar, Laos, Thailand, Cambodia, Malaysia, Singapore, Brunei Darussalam, Indonesia, and Philippines.

Amphiesma boulengeri (Gressitt, 1937)

Boulenger's keelback; Ran sai bau-len-go

EXAMINED MATERIAL. Specimens examined (n = 2): one subadult specimen collected by KVN and others (ZFMK 94665, SVL: 107.2 mm, TAL: 46.6 mm; see Fig. 21); one adult male collected by QKL and KLV (ZFMK 94273, SVL: 370 mm, TAL: 179 mm).

MORPHOLOGICAL CHARACTERS. Nostrils lateral; internasals truncated; preocular 1; postoculars 2; temporals 1 + 2, anterior at least twice as long as posterior; supralabials 9, fourth to sixth touching the eye, seventh to ninth very large; infralabials 9 or 10, first five in contact with anterior chin shields; anterior chin shields two-thirds as long as posterior pair; outermost dorsal scale row smooth, remainder finely keeled; dorsal scale rows 19 : 19 : 17; ventrals 140-145; subcaudals 89-98, divided (determination after Gressitt, 1937; David et al., 2007).

The colouration of the preserved specimen is black dorsally; head brown above; anterior supralabials white, posterior black with a median elongated cream colored streak, forming a postocular stripe extending on the neck, followed by white dorsolateral spots extending to the anterior part of the tail; venter white.

DISTRIBUTION. Vietnam: Vinh Phuc, Thua Thien-Hue, Dak Lak, and Lam Dong provinces (this is the first record of the species from Quang Ngai Province); elsewhere: China.

REMARKS. Both specimens differ from the original description by Gressitt (1937) in the number of posterior temporals (2 instead of 1). The adult specimen moreover shows a slightly lower number of ventrals (140 vs. 143-147).

Boiga guangxiensis Wen, 1998

Guangxi cat snake; Ran rao quang Tay

EXAMINED MATERIAL. Specimen photographed (n = 1): one adult specimen was photographed by KVN (Fig. 22).

MORPHOLOGICAL CHARACTERS. Identification of the photographed specimen is based on characteristic body shape and colour pattern; single loreal; postoculars 2; temporals 3 + 3; supralabials 8, third to fifth touching the eye; dorsal scales smooth (determination after Ziegler et al., 2006, 2010).

DISTRIBUTION. Vietnam: from Lao Cai, Cao Bang and Lang Son in the north southwards to Dong Nai Province (this is the first record of the species from Quang Ngai Province); elsewhere: southern China, Laos.

Calamaria pavementata Duméril, Bibron et Duméril, 1854

Collared reed snake; Ran mai gam lat

EXAMINED MATERIAL. Specimen examined (n = 1): one adult female collected by KVN and others (IEBR 3292, SVL: 231.1 mm, TAL: 18.6 mm; Fig. 23).

MORPHOLOGICAL CHARACTERS. Head covered with large shields; pupil round; nostrils lateral, not valvular; rostral wider than high, partly visible from above, 0.6 times as long as interprefrontal suture; supranasals absent; frontal longer than broad, shorter than parietals, 2 times wider than supraoculars, followed by two symmetrical parietals; loreal absent; preocular 1; postocular 1; temporal absent; supralabials 4, second and third touching the eye, second and fourth largest; first pair of infralabials in contact with each other behind the mental; mental groove present; chin shields in 2 pairs, in contact with each other, anterior longer than posterior; middorsal scale rows 13, smooth; tail pointed; ventrals 151, more than twice as broad as adjacent dorsals; ventrals and subcaudals without notches; cloacal scale entire; subcaudals 20, divided (determination after Bourret, 1936; Smith, 1943; Ziegler, 2002; Ziegler et al., 2007).

The colouration of the preserved specimen is reddish-brown above, with six dark dorsolateral lines and three paler ones, consisting of small spots; neck dark brown; belly yellowish; tail ventrally yellowish, with a dark line medially across the subcaudals.

DISTRIBUTION. Vietnam: From Lao Cai and Son La in the West eastwards to Quang Ninh and southwards to Quang Nam, and Lam Dong provinces (this is the first record of the species from Quang Ngai Province); elsewhere: China, Myanmar, Laos, Cambodia, Thailand, Malaysia, Indonesia, and Japan.

Dendrelaphis ngansonensis (Bourret, 1935)
Nganson bronzeback; Ram leo cay ngan son

EXAMINED MATERIAL. Specimen examined (n = 1): one adult male collected by KVN and others (IEBR 3287, SVL: 728.5 mm, TAL: 392.2 mm; Fig. 24), ratio TAL/TL: 0.35.

MORPHOLOGICAL CHARACTERS. Eye as long as its distance from the nostrils; pupil round; nostrils lateral, not valvular; rostral much broader than high, visible from above; internasals a little shorter than prefrontals; frontal 1.4 times longer than broad, as long as its distance from the tip of snout, shorter than symmetrical parietals; loreal elon-

gated; preocular 1; postoculars 2; temporals 2 + 2; supralabials 9, fourth to sixth touching the eye; first five infralabials in contact with anterior chin shields, anterior chin shields shorter than the posterior; dorsals smooth, dorsal scale rows 15 : 15 : 11; vertebral scales enlarged, variable in width, not broader than the outermost scale row at midbody, posterior margin rounded; ventrals 177, keeled; cloacal scale divided; subcaudals 148, divided (determination after Bourret, 1936; Smith, 1943; Ziegler & Vogel, 1999; Ziegler, 2002).

The colouration of the preserved specimen is bluish and bronze-brown above; interstitial skin black and white; dorsal head bronze brown; a black stripe present along the side of the head, strongly marked on the temple and extending to the neck; supralabials yellow; cream below; for colouration in life see figures 24, 25.

DISTRIBUTION. Vietnam: From Ha Giang and Cao Bang provinces in the North southwards to Quang Nam Province (this is the first record of the species from Quang Ngai Province); elsewhere: Laos (Xieng Khouang Province).

Enhydris subtaeniata (Bourret, 1934)
Mekong mud snake; Ran bong me-kong

EXAMINED MATERIAL. Specimen examined (n = 1): one adult collected by KVN and others (IEBR 3289, SVL: 300 mm, TAL: 56.6 mm; Fig. 26), ratio TAL/TL: 0.16.

MORPHOLOGICAL CHARACTERS. Body stout; snout blunt, squarish; nasals contiguous; internasal 2 times wider than long, in contact with triangular loreal (loreal divided on left side); preocular 1; postoculars 2; temporals 1 + 2; supralabials 8, fourth in contact with eye; infralabials 3, in contact with anterior chin shields; posterior pair of chin shields longer than anterior pair, separated from each other by small scales; dorsal scale rows 21 : 21 : 21; ventrals 143; subcaudals 45, divided (determination after Bourret, 1936; Smith, 1943; Murphy & Voris, 1994; Karns et al., 2010).

The colouration of the preserved specimen is olive-grey above, with indistinct blackish spots; ventrals and 3 outer scale rows yellowish; outer margins of the ventrals and adjacent scale-rows heavily margined with dark grey; a series of dark spots forming a median ventral line at the posterior



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Figure 19. *Fimbrios* cf. *klossi*, photo R. Babb. Figure 20. *Ahaetulla prasina*, photo R. Babb. Figure 21. *Amphiesma boulen-geri*, juvenile, photo R. Babb. Figure 22. *Boiga guangxiensis*, adult, photo K.V. Nguyen. Figure 23. *Calamaria pavimentata*, photo R. Babb. Figure 24. *Dendrelaphis ngansonensis*, photo R. Babb.

part of the body; a darker, continuous line medially across the subcaudals.

DISTRIBUTION. Vietnam: Kon Tum, Tay Ninh, Ho Chi Minh City, Soc Trang, Kien Giang, and Ca Mau provinces (this is the first record of the species from Quang Ngai Province); elsewhere: Laos, Thailand, and Cambodia.

REMARKS. Murphy (2007) revalidated *Enhydris subtaeniata*, which was originally described as a subspecies of *E. enhydris* (Bourret, 1934) and subsequently synonymized with *E. jagorii* by Smith (1943). According to Nguyen et al. (2009), previous records of *E. jagorii* from Vietnam and neighbouring countries should be assigned to *E. subtaeniata*.

Oligodon chinensis (Günther, 1888)

Chinese kukri snake; Ran khiem trung quoc

EXAMINED MATERIAL. Specimens examined (n = 2): one adult male collected by QKL and KLV (ZFMK 94274, SVL: 514.2 mm, TAL: 115.7 mm); one adult male collected by KVN and others (ZFMK 94672, SVL: 557.6 mm, TAL: 126.2 mm, Fig. 27).

MORPHOLOGICAL CHARACTERS. Nasal divided; internasals 2; rostral partly visible from above, as long as its distance from frontal; suture of internasals shorter than sutures of prefrontals; frontal longer than its distance to the tip of snout, as long as parietals; loreal somewhat longer than broad; preocular 1; postoculars 2; subocular 1, temporals 1 + 2; supralabials 7 or 8, fourth and fifth touching the eye; infralabials 8 or 9, fourth in contact with anterior chin shields; anterior pair of chin shields longer than posterior ones; dorsal scale rows 17 : 17 : 15; ventrals 170 or 172; cloacal scale undivided; subcaudals 58 or 59 (determination after Bourret, 1936; Smith, 1943; Ziegler, 2002; Green, 2010).

The colouration of the preserved specimens is reddish-brown dorsally; with dark, rounded blotches; blotches on the back with dark margins, occupying about 3 to 4 scale rows along the vertebral line, descending laterally; several similar spots on the tail; the darker edges of the scales between these spots forming less visible equidistant fasciatures in each section; head olive brown with a dark brown stripe across the eyes, edged in black, running upwards to the posterior end of the rostral and the upper lip; a long arrowhead-shaped

dark brown spot, edged in black, tip of arrow at the posterior third of the frontal, the two rear ends extending to the side of the neck, almost up to the ventrals; temporal bars absent; ventral surface white, with a longitudinal row of quadrangular black blotches forming along each side, disappearing gradually at the tail base.

DISTRIBUTION. Vietnam: Lao Cai, Bac Kan, Lang Son, Vinh Phuc, Quang Ninh, Hai Phong, Hai Duong, Nghe An, Ha Tinh, Quang Binh, and Gia Lai provinces (this is the first record of the species from Quang Ngai Province); elsewhere: China.

Pareas hamptoni (Boulenger, 1905)

Hampton's slug snake; Ran ho may ham-ton

EXAMINED MATERIAL. Specimen examined (n = 1): one adult male collected by KVN and others (ZFMK 94666, SVL: 317.2 mm, TAL: 110.1 mm; Fig. 28), ratio TAL/TL: 0.26.

MORPHOLOGICAL CHARACTERS. Body elongated, strongly compressed; pupil vertical; snout short; rostral wider than high, visible from above; internasals about 0.6 times as long as prefrontals; prefrontals touching the eye; frontal somewhat longer than broad, longer than its distance from the snout tip; supraocular about half as wide as frontal; nasal complete; loreal small, higher than long, separated from the eye by 1 or 2 small preoculars; postocular 1, small; subocular 1, long and slender, separating the eye from the labials; temporals 2 + 3, anterior larger than posterior ones; supralabials 7, fourth and fifth below the eye, seventh very long; mental groove absent; chin shields in 3 pairs, large, anterior ones longer than wide; dorsal scales smooth, 15 rows at midbody; ventrals 189, more than 2 times as broad as adjacent dorsals; cloacal scale undivided; subcaudals 78, divided (determination after Bourret, 1936; Smith, 1943; Ziegler, 2002).

The colouration of the preserved specimen is light brown dorsally, with dorsolateral rows of alternating spots, forming a zigzag line, spots absent at the margin of the ventrals, not more than 2 scales in length; two parallel brown lines, starting from the posterior part of the supraoculars, bordering the head and ending at the nape; two other bands from behind the parietals forming a λ on the neck; a few larger spots forming a stripe from the eye to the oral commissure.

DISTRIBUTION. Vietnam: Lao Cai, Ha Giang, Bac Kan, Thai Nguyen, Vinh Phuc, Hai Duong, Ha Tinh southwards to Lam Dong and Dong Nai provinces (this is the first record of the species from Quang Ngai Province); elsewhere: China, Myanmar, Laos, and Cambodia.

REMARKS. In contrast to Bourret (1936) and Smith (1943), the vertebral scales of the examined specimen are not enlarged.

Pareas margaritophorus (Jan, 1866)

White-spotted slug snake; Ran ho may ngoc

EXAMINED MATERIAL. Specimen examined (n = 1): one adult male collected by KVN and others (IEBR 3294, SVL: 219.9 mm, TAL: 60 mm; Fig. 29), ratio TAL/TL: 0.21.

MORPHOLOGICAL CHARACTERS. Eye moderate, diameter equal to its distance from the mouth; preocular 1, triangular; postocular 1; subocular 1, long, crescentic, united with postocular on left side; temporals 2 or 3 + 1, elongated; supralabials 7, not touching the eye, fourth and fifth below the eye; infralabials 7; chin shields in 4 pairs, large; dorsal scale rows 15 at midbody, smooth, equal; vertebrals not enlarged; ventrals 144, more than twice as broad as adjacent dorsals; cloacal scale undivided; subcaudals 55, divided (determination after Bourret, 1936; Smith, 1943; Manthey & Grossmann, 1997; Ziegler, 2002).

The colouration of the preserved specimen is dark grey above with irregular transverse rows of black and white blotches, the scales white anteriorly and posteriorly; a white nuchal collar present; ventral surface yellowish white, densely spotted with black.

REMARKS. In contrast to the description of Bourret (1936), the specimen shows only 1 + 1 temporals on one side instead of 2 + 3, 4 pairs of chin shields instead of 3 pairs.

DISTRIBUTION. Vietnam: Vinh Phuc, Hai Duong, Hoa Binh, Ha Tay, Ninh Binh, Ha Tinh, Quang Binh, Quang Tri, Gia Lai, Lam Dong, Tay Ninh, Ho Chi Minh City, and Kien Giang provinces (this is the first record of the species from Quang Ngai Province); elsewhere: China, Myanmar, Laos, Thailand, Cambodia, and Malaysia.

Pseudoxenodon macrops (Blyth, 1854)

Big-eyed bamboo snake; Ran ho xien mat to

EXAMINED MATERIAL. Specimen examined (n = 1): one adult male collected by KVN and others (IEBR 3300, SVL mm: 587, TAL: 127.1 mm; Fig. 30).

MORPHOLOGICAL CHARACTERS. Nostril large, between two nasals; rostral slightly visible from above; suture between internasals half as long as suture between prefrontals; frontal 1.3 times longer than broad, shorter than its distance from the snout tip, shorter than parietals; loreal large, longer than high; preocular 1, not touching the frontal; postoculars 3; temporals 2 + 2 or 3; supralabials 8, fourth and fifth in contact with the eye, seventh highest; infralabials 9, first five in contact with anterior chin shields; first pair of chin shields a little shorter than the posterior; dorsal scales strongly keeled except the outermost row, scale rows 19 : 17 : 15; ventrals 151; cloacal scale divided; subcaudals 63, divided (determination after Bourret, 1936; Smith, 1943; Manthey & Grossmann, 1997).

The colouration of the preserved specimen is greyish-brown and reddish-brown above, with a vertebral series of large, pale-orange spots, edged in black, extending over the whole body and tail; neck with a yellowish white, chevron-shaped mark, the tip pointing forward; ventral surface yellowish-white, with large, blackish-brown, quadrangular blotches anteriorly, blotches paler posteriorly.

DISTRIBUTION. Vietnam: Lai Chau, Lao Cai, Vinh Phuc, Nghe An, Ha Tinh, Quang Binh, Da Nang, Kon Tum, and Lam Dong provinces (this is the first record of the species from Quang Ngai Province); elsewhere: India, Nepal, China, Myanmar, Laos, Thailand, and Malaysia.

Rhabdophis subminiatus (Schlegel, 1837)

Red-necked keelback; Ran hoa co nho

EXAMINED MATERIAL. Specimen examined (n = 1): one adult female collected by KVN and others (ZFMK 94667, SVL: 494.9 mm, TAL: 48.6 mm; Fig. 31), TAL/TL: 0.1.

MORPHOLOGICAL CHARACTERS. Body rather stout; eye large; pupil round; nostrils lateral, not valvular; mental groove present; rostral 2 times as wide as high, visible from above; internasals conjoint, a little broader than long, truncated at the

front, shorter than prefrontals; frontal 1.4 times longer than wide, longer than its distance from the snout tip, shorter than parietals; loreal as high as long; preocular 1; postoculars 3; temporals 2 + 3; supralabials 8, third to fifth touching the eye, seventh largest; infralabials 10, first 5 in contact with anterior chin shields, anterior chin shields a little shorter than posterior; dorsal scales in 19 rows at midbody, strongly keeled, the outermost row smooth; ventrals 161, more than twice as broad as adjacent dorsals; cloacal scale divided; subcaudals 23 (tail tip lost), divided (determination after Bourret, 1936; Smith, 1943; Manthey & Grossmann, 1997; Ziegler, 2002; Ziegler et al., 2007).

The colouration of the preserved specimen is bluish above, head and neck greenish; body with white, transverse spots; a black oblique bar radiated from below the eye; venter yellowish anteriorly, strongly spotted posteriorly.

DISTRIBUTION. Vietnam: From Cao Bang Province in the North westwards to Lao Cai and Son La provinces, eastwards to Quang Ninh and southwards to Tay Ninh, Ho Chi Minh City, and Kien Giang provinces (this is the first record of the species from Quang Ngai Province); elsewhere: India, Bangladesh, Nepal, Bhutan, China, Myanmar, Laos, Thailand, Cambodia, Malaysia, Singapore, and Indonesia.

Sibynophis collaris (Gray, 1853)

Common black-headed snake; Ran rong co den

EXAMINED MATERIAL. Specimen examined (n = 1): one male specimen collected by KVN and others (ZFMK 94668, SVL: 360 mm, TAL: 72 mm, Fig. 32).

MORPHOLOGICAL CHARACTERS. Preocular single, postoculars 2; loreal 1; fourth to sixth supralabials entering orbit, eighth very large, in contact with anterior temporal; temporals 1 + 2, lower posterior one divided vertically; parietal touching upper postocular only; dorsal scales smooth, in 17 rows at midbody; cloacal undivided (determination after Pope, 1935; Smith, 1943; Ziegler et al., 2007).

The colouration of the preserved specimen is greyish brown dorsally; venter whitish cream with a black dot on the edge of each ventral; head olive grey with dark markings in the snout region and two black transverse bars (one behind the eyes and an-

other across the occiput); a distinct dark neck band followed by a white transverse band; a black edged white horizontal line present along the supralabials.

DISTRIBUTION. Vietnam: from Dien Bien, Son La and Ninh Binh southwards to Lam Dong and Dong Nai provinces (this is the first record of the species for Quang Ngai Province); elsewhere: India, Nepal, China, Taiwan, Myanmar, Laos, Thailand, Cambodia, and Malaysia.

REMARKS. The specimen was damaged so that only the above mentioned scale counts could be taken.

Sinonatrix percarinata (Boulenger, 1899)

Mountain water snake; Ran hoa can van den

EXAMINED MATERIAL. Specimen examined (n = 1): one juvenile specimen collected by KVN and others (ZFMK 94671, SVL: 198.9 mm, TAL: 68.4 mm; Fig. 33), ratio TAL/TL: 0.26.

MORPHOLOGICAL CHARACTERS. Body stout; eye moderate; pupil round; nostrils directed slightly upwards, not valvular; rostral 2 times wider than high; nasal completely divided; internasals longer than wide, distinctly narrowed anteriorly, longer than the prefrontals; loreal as long as high; preocular 1; postoculars 3; suboculars 2; temporals 2 or 3 + 3; supralabials 9, fourth and fifth touching the eye; dorsal scale rows: 19 : 17 : 17, keeled, except outermost row; ventrals 136, more than twice as broad as adjacent dorsals; cloacal scale divided; subcaudals 76, paired (determination after Bourret, 1936; Smith, 1943; Ziegler, 2002).

The colouration of the preserved specimen is greyish brown above with 28 vertical black bars on each side, not symmetrical, getting wider towards the back, where all are confluent, dark bars in anterior part of body ending in the middle of ventrals, forming broken rings in width of 2 or 3 scale rows; upper head dark olive brown, supralabials white posteriorly; chin and venter white, except for the black rings.

DISTRIBUTION. Vietnam: From Lao Cai, Ha Giang, and Cao Bang in the North, southwards to Kon Tum, Gia Lai, and Dong Nai provinces (this is the first record of the species for Quang Ngai Province); elsewhere: India, China, Taiwan, Myanmar, Laos, and Thailand.

REMARKS. The colouration of the specimen is typical for young individuals (see Smith, 1943). Ac-



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Figure 25. Uncollected *Dendrelaphis ngansonensis*, 23.VI.2009, feeding on *Polypedates* sp., photo T. Geismann. Figure 26. Preserved *Enhydris subtaeniata* (IEBR 3289), photo R. Babb. Figure 27. *Oligodon chinensis*, photo R. Babb. Figure 28. *Pareas hamptoni*, photo R. Babb. Figure 29. *P. margaritophorus*, photo R. Babb. Figure 30. *Pseudoxenodon macrops*, photo R. Babb.

According to the key of Ziegler et al. (2007), two supralabials entering the eye are typical for *Sinonatrix percarinata*, as well as vertical or Y-shaped black bars on the body sides, whereas the number of these dark body marks (fewer than 30) is typical for *Sinonatrix aequifasciata* (which, however, in contrast normally has not more than one supralabial entering the eye, and which has broad, rounded X-shaped dark marks on sides of body instead).

Xenochrophis flavipunctatus (Hallowell, 1861)
Yellow-spotted keelback; Ran nuoc dom vang

EXAMINED MATERIAL. Specimen examined (n = 1): one adult male collected by KVN and others (ZFMK 94669, SVL: 370 mm, TAL: 172.8 mm; Fig. 34), ratio TAL/TL: 0.32.

MORPHOLOGICAL CHARACTERS. Body stout; pupil round; eye shorter than its distance from the nostril; nostril slightly directed upwards, not valvular; rostral visible from above; contiguous internasals strongly narrowed towards the front, subtriangular, with the anterior angle truncated, nearly as long as prefrontals; frontal constricted in the middle, 2.3 times as long as broad, longer than its distance from the snout tip, a little shorter than pari-etsals; loreal as long as high; preocular 1; postoculars 3; temporals 2 + 2; supralabials 9, third to fourth or to fifth touching the eye; infralabials 5, in contact with anterior chin shields; mental groove present; dorsal scales in 19 rows at midbody, more or less strongly keeled, 3 outermost rows smooth; ventrals 128, more than twice as broad as adjacent dorsals; cloacal scale divided; subcaudals 83, divided (determination after Bourret, 1936; Smith, 1943; Ziegler, 2002; Vogel & David, 2006).

The colouration of the preserved specimen is pale olive above, with black spots, spots larger laterally; a pale, dark V-shaped marking on nape; two well-defined subocular streaks present on neck, posterior one extending from the eye to the corner of the mouth; ventral surface yellow, ventral and subcaudal scales with entire, broad, dark margins.

DISTRIBUTION. Vietnam: entire country; elsewhere: Bangladesh, China, Myanmar, Laos, Thailand, Cambodia, Malaysia, and Indonesia.

VIPERIDAE

Protobothrops mucrosquamatus (Cantor, 1839)
Brown-spotted pitviper / Ran luc cuom

EXAMINED MATERIAL. Specimen examined (n = 1): one subadult specimen collected by KVN and others (ZFMK 94673, SVL: 437.3 mm, TAL: 90.6 mm; see Fig. 35), ratio TAL/TL: 0.17.

MORPHOLOGICAL CHARACTERS. Head elongate; upper head scales unequal, extremely small, granular, smooth; snout 2.75 times as long as eye diameter; rostral slightly broader than high; supraoculars long and narrow, entire; internasals separated from each other by 3 small scales, separated from supra-oculars by two enlarged scales; scales between the supraoculars 15; postoculars 4, small; subocular 1, separated from the labials by 2 scale rows; temporal scales 2 or 3 rows, enlarged, smooth; supralabials 10, the first completely separated from the nasal, the second forming the anterior margin of the loreal pit, the third largest; dorsal scales keeled; dorsal scale rows 31 : 28-30 : 24; ventrals 232; cloacal scale undivided; subcaudals 96, divided (determination after Bourret, 1936; Smith, 1943; Leviton et al., 2003).

The colouration of the preserved specimen is pale brown above, with a series of large, dark-brown blotches; lower lateral with a series of smaller blotches, all edged in black; a dark brown line from the eye to the angle of the mouth, edged in black; ventral surface brownish with white blotches.

DISTRIBUTION. Vietnam: From Lao Cai, Ha Giang, and Cao Bang provinces in the North eastwards to Quang Ninh and southwards to Kon Tum, and Gia Lai provinces (this is the first record of the species from Quang Ngai Province); elsewhere: India, Bangladesh, China, Taiwan, and Myanmar.

REMARKS. In contrast to the descriptions of Smith (1943) and Leviton et al. (2003) all the head scales of the specimen are smooth. The number of dorsal scale rows, ventrals, and subcaudals is somewhat higher than in the previous descriptions. The ratio TAL/TL is smaller than in Smith's description (1943). The internasals are only 2 times, not 5 to 10 times longer than the adjacent scales (see Leviton et al., 2003).

Trimeresurus albolabris Gray, 1842
White-lipped pitviper / Ran luc mep trang

EXAMINED MATERIAL. Specimen examined (n =



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Figure 31. *Rhabdophis subminiatus*, photo R. Babb. Figure 32. *Sibynophis collaris*, photo T. Ziegler. Figure 33. *Sinonatrix percarinata*, photo R. Babb. Figure 34. Preserved *Xenochrophis flavipunctatus* (IEBR 3297), photo R. Babb. Figure 35. *Protbothrops mucrosquamatus*, photo R. Babb. Figure 36. *Trimeresurus albolabris*, photo R. Babb.

1): one adult male collected by KVN and others (ZFMK 94670, SVL: 485.2 mm, TAL: 135.9 mm; see Fig. 36), ratio TAL/TL: 0.22.

MORPHOLOGICAL CHARACTERS. Pupil vertical; snout 2.4 times as long as eye diameter; loreal pit between nostril and eye; canthus rostralis sharp, rostral wider than high; scales on top of head small, smooth, subequal, subimbricate; scales between supraoculars 12; internasals about 3 times larger than adjacent scales, in contact with each other; preoculars 3; postoculars 2, small; subocular 1, in contact with third labial; scale rows between subocular and labials 1-3; temporal scales feebly keeled; supralabials 9-10, not in contact with the eye, the first partially fused to the nasal, the second bordering loreal pit, the third largest; infralabials 12-13; dorsal scales keeled; dorsal scale rows 20 : 21 : 15; ventrals 166, more than twice as broad as the adjacent dorsals; cloacal scale entire; subcaudals 76, divided (determination after Bourret, 1936; Smith, 1943; Manthey & Grossmann, 1997; Ziegler, 2002; Leviton et al., 2003).

The colouration of the preserved specimen is blue above; supralabials pale blue; ventral surface yellowish blue.

DISTRIBUTION. Vietnam: From Lao Cai and Cao Bang provinces in the North southwards to Dong Nai, Tay Ninh, Kien Giang, and Ca Mau provinces (this is the first record of the species from Quang Ngai Province); elsewhere: Northeast India, China, Myanmar, Laos, Thailand, and Cambodia.

Trimeresurus vogeli David, Vidal et Pauwels, 2001

Vogel's green pitviper; Ran luc von-gen

EXAMINED MATERIAL. Specimens examined (n = 2): one adult female collected by QKL and KLV (ZFMK 94275, SVL: 462 mm, TAL: 83 mm); one adult male collected by KVN and others (IEBR 3305, SVL: 508.8 mm, TAL: 119 mm; Fig. 37), tail average, ratio TaL/TL of 0.15 in the female.

MORPHOLOGICAL CHARACTERS. Dorsum green; a white lateral stripe, edged in red below in males, and a narrow yellow stripe without red in females; a constant lack of red color in the postocular streak in both males and females; not more than 25 % of tail tip rusty red; tail average, with a ratio TaL/TL of 0.15 in the female; labial region somewhat

lighter greenish than green head colouration; first supralabial totally separated from the corresponding nasal; internasals separated from each other by 0-2 scales; dorsal scales 21 rows at midbody, strongly keeled; ventrals 155-158, plus 2-3 preventrals; cloacal entire; subcaudals paired, 60-67; hemipenis short and strongly spinose (determination after David et al., 2001; Ziegler et al., 2007).

DISTRIBUTION. Vietnam: from Ha Tinh and Quang Binh southwards to Dak Lak and Lam Dong provinces (this is the first record of the species from Quang Ngai Province); elsewhere: Laos, Thailand, Cambodia.

REMARKS. The specimens differ somewhat from the original description of David et al. (2001) by having a lower ventral count (155-158 versus 163-173); the head streak is not distinct; the eyes are greenish orange instead of greenish yellow to yellow; the internasals in the male IEBR 3305 are not separated (usually separated by 1-3 scales), and the dorsum bears no faint dark crossbands and no white vertebral spots.

TESTUDINES GEOEMYDIDAE

Cyclemys pulchristriata Fritz, Gaulke et Lehr, 1997

Striped leaf turtle; Rua dua soc

EXAMINED MATERIAL. Specimens photographed (n = 2): two subadults were photographed by QKL and RB (see Figs. 38-40).

MORPHOLOGICAL CHARACTERS. Identification of the photographed specimens is based on characteristic scalation and colour pattern, such as plastron entirely yellow or prevalent plastral colour yellow; femoral mid-seam shorter than cloacal mid-seam; cloacal notch small to wide and acute-angled to obtuse-angled; throat uniformly white coloured; light head and neck stripes (yellow to salmon in live specimens) wide; if black radiating pattern present on plastron, radiating lines short and stout (determination after Fritz et al., 2008).

DISTRIBUTION. Vietnam: Quang Nam, Gia Lai, and Lam Dong provinces (this is the first record of the species from Quang Ngai Province); elsewhere: according to Fritz et al. (2008) easternmost Cambodia.



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Figure 37. *Trimeresurus vogeli*. Figure 38. *Cyclemys pulchristriata*. Figure 39. *Cyclemys pulchristriata*, portrait. Figure 40. *Cyclemys pulchristriata*, ventral view. Photos R. Babb.

DISCUSSION

We herein provide a list of 35 identified reptile species (16 lizards, 18 snakes, and 1 turtle) based on our recent field surveys in Quang Ngai Province. Fourteen of the recorded species belong to the family Colubridae, which is the most species-rich reptilian family in Quang Ngai, followed by 6 agamid and 6 scincid species. Nguyen et al. (2009) also listed *Oligodon ocellatus* as occurring in Quang Ngai Province, which brings the total reptilian number known from that province to 36. Nguyen et al. (2009) further list the terrestrial reptilian species *Gekko gekko*, *Coelognathus radiatus*, and *Enhydryis plumbea* as occurring in the whole country, so that there is high probability that they

also will be recorded from Quang Ngai Province in the future. Regardless, *G. gekko* from Vietnam recently has been revised, and it has not yet been determined whether *G. gekko* or *G. reevesii* is involved (see Rösler et al., 2011). A further number of species are listed in Nguyen et al. (2009) as occurring along Vietnam's central coasts, but without definite records for Quang Ngai Province. The data presented herein thus serve only as a preliminary reptilian list, which must be extended in the future based on further field research. Also the taxonomic status of *Fimbrios cf. klossi* from Quang Ngai needs further examination. There exist clear differences between the available specimen and known variation of *F. klossi*. The combination of the number of temporals, the lack of a mental, and the longer tail

would suggest a distinct species. However, because only one individual is available at this time, an anomalous specimen cannot be excluded with certainty. Together with the 16 amphibian species recorded from this area (Tran et al., 2010), the herpetofaunal list for Quang Ngai Province currently covers 52 amphibian and reptile species. Compared with the herpetofaunal composition of other central Vietnamese provinces, such as Quang Binh Province (see Ziegler & Vu, 2009), species numbers could easily be doubled to tripled in the near future. Such further research also will be essential for evaluating the conservation status of Quang Ngai forested areas, in particular as protected areas have not yet been established in this province until today.

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REFERENCES

- Bourret R., 1936. Les serpents de l'Indochine. I. Etudes sur la faune. Henry Basuyau et Cie, Toulouse, 505 pp.
- Bourret R., 2009. Les lézards de l'Indochine. Edition Chimaira, Frankfurt am Main, 624 pp.
- Darevsky, I.S. & Kupriyanova L.A., 1993. Two new all-female lizard species of the genus *Leiolepis* Cuvier, 1829 from Thailand and Vietnam (Squamata: Sauria: Uromastycinae). *Herpetozoa*, 6: 3-20.
- David P., Bain R.H., Nguyen, T.Q., Orlov N.L., Vogel G., Vu T.N. & Ziegler T., 2007. A new species of the natricine snake genus *Amphiesma* from the Indochinese Region (Squamata: Colubridae: Natricinae). *Zootaxa*, 1462: 41-60.
- David P., Nguyen T.Q., Nguyen T.T., Jiang K., Cchen T., Teynié A. & Ziegler T., 2012. A new species of the genus *Oligodon* Fitzinger, 1826 (Squamata: Colubridae) from northern Vietnam, southern China and central Laos. *Zootaxa*, 3498: 45-62.
- David P., Vidal N. & Pauwels O.S.G., 2001. A morphological study of Stejneger's pitviper *Trimeresurus stejnegeri* (Serpentes, Viperidae, Crotalinae), with the description of a new species from Thailand. *Russian Journal of Herpetology*, 8: 205-222.
- David P., Vogel G. & Dubois A. 2011. On the need to follow rigorously the Rules of the Code for the subsequent designation of a nucleospecies (type species) for a nominal genus which lacked one: the case of the nominal genus *Trimeresurus* Lacépède, 1804 (Reptilia: Squamata: Viperidae). *Zootaxa*, 2992: 1-51.
- Fritz U., Guicking D., Auer M., Sommer R.S., Wink M. & Hundsdoerfer A.K., 2008. Diversity of the Southeast Asian leaf turtle genus *Cyclemys*: how many leaves on its tree of life? *Zoologica Scripta*, 37: 367-390.
- Green M.D., 2010. Molecular phylogeny of the snake genus *Oligodon* (Serpentes: Colubridae), with an annotated checklist and key. Master thesis, University of Toronto, 161 pp.
- Gressitt J.L., 1937. A new snake from southeastern China. *Proceedings of the Biological Society of Washington*, 50: 125-128.
- Grismer J.L. & Grismer L.L., 2010. Who's your mommy? Identifying maternal ancestors of asexual species of *Leiolepis* Cuvier, 1829 and the description of a new endemic species of asexual *Leiolepis* Cuvier, 1829 from Southern Vietnam. *Zootaxa*, 2433: 47-61.
- Hartmann T., Geissler P., Poyarkov N.A., Ihlow F., Galoyan E.A., Rödder D. & Böhme W., 2013. A new species of the genus *Calotes* Cuvier, 1817 (Squamata: Agamidae) from southern Vietnam. *Zootaxa*, 3599: 246-260.
- Karns D.R., Lukoschek V., Osterhage J., Murphy J.C. & Voris H.K., 2010. Phylogeny and biogeography of the *Enhydris* clade (Serpentes: Homalopsidae). *Zootaxa*, 2452: 18-30.
- Leviton A.E., Wogan G.O.U., Koo M.S., Zug G.R., Lucas R.S. & Vindum J.V., 2003. The dangerously venomous snakes of Myanmar. Illustrated checklist with keys. *Proceedings of the California Academy of Sciences*, ser. 4, 54: 407-460.
- Luu V.Q., Nguyen T.Q., Pham C.T., Dang K.N., Vu T.N., Miskovic S., Bonkowski M. & Ziegler T., 2013. No end in sight? Further new records of amphibians and reptiles from Phong Nha - Ke Bang National Park,

- Quang Binh Province, Vietnam. *Biodiversity Journal*, 4: 285-300.
- Manthey U. & Grossmann W., 1997. Amphibien und Reptilien Südostasiens. Natur und Tier-Verlag, Münster, 512 pp.
- Murphy J.C., 2007. Homalopsid snakes: evolution in the mud. *Krieger*, 249 pp.
- Murphy J. C. & Voris H. K., 1994. A key to the homalopsine snakes. *The Snake*, 26: 123-133.
- Musters C.J.M., 1983. Taxonomy of the genus *Draco* L. (Agamidae, Lacertilia, Reptilia). *Zoologische Verhandelingen*, 199: 1-120.
- Nazarov R., Poyarkov N.A., Orlov N.I., Phung T.M., Nguyen T.T., Hoang D. M. & Ziegler T. 2012. Two new cryptic species of the *Cyrtodactylus irregularis* complex (Squamata: Gekkonidae) from southern Vietnam. *Zootaxa*, 3302: 1-24.
- Nguyen S.V., Ho C.T., Nguyen T.Q., 2009. Herpetofauna of Vietnam. Edition Chimaria, Frankfurt am Main, 768 pp.
- Nguyen T.Q., Böhme W., Nguyen T.T., Le Q.K., Pahl K. R., Haus T. & Ziegler T., 2011a. Review of the genus *Dopasia* Gray, 1853 (Squamata: Anguillidae) in the Indochina subregion. *Zootaxa*, 2894: 58-68.
- Nguyen T.Q., Nguyen S.V., Orlov N.L., Hoang T.N., Böhme W. & Ziegler, T., 2010. A review of the genus *Tropidophorus* (Squamata, Scincidae) from Vietnam with new species records and additional data on natural history. *Zoosystematics and Evolution*, 86: 5-19.
- Nguyen T.Q., Schmitz A., Nguyen T.T., Orlov N.L., Böhme W. & Ziegler T., 2011b. Review of the genus *Sphenomorphus* Fitzinger, 1843 (Squamata: Sauria: Scincidae) in Vietnam, with description of a new species from northern Vietnam and southern China and the first record of *Sphenomorphus mimicus* Taylor, 1962 from Vietnam. *Journal of Herpetology*, 45: 145-154.
- Orlov N.L., Truong N.Q. & Sang N.V., 2006. A new *Acanthosaura* allied to *A. capra* Günther, 1861 (Agamidae, Sauria) from central Vietnam and southern Laos. *Russian Journal of Herpetology*, 13: 61-76.
- Pope C.H., 1935. The reptiles of China. Turtles, crocodilians, snakes, lizards. *Natural History of central Asia*. Vol. X. American Museum of Natural History, New York, 604 pp.
- Rösler H., Bauer A.M., Heinicke M.P., Greenbaum E., Jackman T., Nguyen T.Q. & Ziegler T., 2011. Phylogeny, taxonomy, and zoogeography of the genus *Gekko* Laurenti, 1768 with the revalidation of *G. reevesii* Gray, 1831 (Sauria: Gekkonidae). *Zootaxa*, 2989: 1-50.
- Rösler H., Vu T.N., Nguyen T.Q., Ngo T.V. & Ziegler T., 2008. A new *Cyrtodactylus* (Squamata: Gekkonidae) from central Vietnam. *Hamadryad*, 33: 48-63.
- Smith M. A., 1935. The fauna of British India including Ceylon and Burma. Reptilia and Amphibia. Vol. II. Sauria. Taylor and Francis (London), 440 pp.
- Smith M.A., 1943. The fauna of British India, Ceylon and Burma, including the whole of the Indo-Chinese Subregion. Reptilia and Amphibia. Vol. III. Serpentes. Taylor and Francis (London), 583 pp.
- Taylor E.H., 1963. The lizards of Thailand. *University of Kansas Science Bulletin*, 44: 687-1077.
- Tran D. T. A., Le K. Q., Le K. V., Vu T. N., Nguyen T. Q., Böhme W. & Ziegler T., 2010. First and preliminary frog records (Amphibia: Anura) from Quang Ngai Province, Vietnam. *Herpetology Notes*, 3: 111-119.
- Vogel G. & David P., 2006. On the taxonomy of the *Xenochrophis piscator* complex (Serpentes, Natricidae). In: Vences M., Kohler J., Ziegler T. & Böhme W. (Eds.). *Herpetologia Bonnensis II: Proceedings of the 13th Congress of the Societas Europaea Herpetologica*, Bonn, pp. 241-246.
- Wood P.L., Grismer L.L., Grismer J.L., Neang T., Chav T. & Holden J., 2010. A new cryptic species of *Acanthosaura* Gray, 1831 (Squamata: Agamidae) from Thailand and Cambodia. *Zootaxa*, 2488: 22-38.
- Ziegler T., 2002. Die Amphibien und Reptilien eines Tieflandfeuchtwald-Schutzgebietes in Vietnam. *Natur & Tier Verlag, Münster*, 342 pp.
- Ziegler T., David P., Miralles A., Dang K.N., Nguyen T.Q., 2008. A new species of the snake genus *Fimbrios* from Phong Nha - Ke Bang National Park, Truong Son, central Vietnam (Squamata: Xenodermatidae). *Zootaxa*, 1729: 37-48.
- Ziegler T., Hendrix R., Vu T.N., Vogt M., Forster B., Dang K.N., 2007. The diversity of a snake community in a karst forest ecosystem in the central Truong Son, Vietnam, with an identification key. *Zootaxa*, 1493: 1-40.
- Ziegler T. & Nguyen T.Q., 2010. New discoveries of amphibians and reptiles from Vietnam. *Bonn zoological Bulletin*, 57: 137-147.
- Ziegler T., Ohler A., Vu T.N., Le Q. K., Nguyen T.X., Dinh T.H. & Bui T.N., 2006. Review of the amphibian and reptile diversity of Phong Nha - Ke Bang National Park and adjacent areas, central Truong Son, Vietnam. In: Vences M., Köhler J., Ziegler T. & Böhme W. (Eds.): *Herpetologia Bonnensis II. Proceedings of the 13th Ordinary General Meeting of the Societas Europaea Herpetologica*, Bonn, pp. 247-262.
- Ziegler T., Orlov N.L., Giang T., Nguyen T.Q., Nguyen T.T., Le Q.K., Nguyen K.V. & Vu T.N., 2010. New provincial records of cat snakes, *Boiga* Fitzinger, 1826 (Squamata: Serpentes: Colubridae), from Vietnam, inclusive of an extended diagnosis of *Boiga*

- bourreti* Tillack, Le & Ziegler, 2004. *Zoosystematics and Evolution*, 86: 263-274.
- Ziegler T. & Vogel G., 1999. On the knowledge and specific status of *Dendrelaphis ngansonensis* (Bourret, 1935) (Reptilia: Serpentes: Colubridae). *Russian Journal of Herpetology*, 6: 199-208.
- Ziegler T. & Vu T.N., 2009. Ten years of herpetodiversity research in Phong Nha - Ke Bang National Park, central Vietnam. In: Vo Van Tri, Nguyen Tien Dat, Dang Ngoc Kien & Pham Thi Hai Yen (Eds.): *Phong Nha - Ke Bang National Park and Cologne Zoo, 10 years of cooperation (1999-2009)*. Quang Binh, pp. 103-124.

Foraging behaviour of three primate species in a Costa Rican coastal lowland tropical wet forest

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ABSTRACT

Primates are predominantly distributed across tropical regions, many of which are threatened by deforestation. Removal of mature trees can harm primate populations by reducing available food resources. Understanding the dietary requirements of primates at local levels can help identify key habitats to conserve, and protect plant species on which primates rely. Little is known about local diets of *Alouatta palliata* (mantled howler monkey), *Ateles geoffroyi* (black-handed spider monkey), and *Cebus capucinus* (white-faced capuchin) in Costa Rica's lowland tropical wet forests. Because diet and activity levels are closely connected, studies examining one provide insight into the other. We used group scan sample methods to record activity and diet, identifying all plant species on which the primates fed. We identified nine families of plants eaten by *Ateles geoffroyi*, four families eaten by *Alouatta palliata*, and two families eaten by *Cebus capucinus*. Activity budgets demonstrated that *Alouatta palliata* was the least active species and *Cebus capucinus* the most active. We also found differences in the type of plant parts consumed by the three primate species; *Alouatta palliata* and *Ateles geoffroyi* fed mostly on fruit and new leaves, whereas *Cebus capucinus* fed on fruit and insects. The nine families of plants identified in this study are potentially important for all three primate species locally, and warrant conservation.

KEY WORDS

Primate; Activity budget; Foraging; Lowland wet forest; Costa Rica.

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INTRODUCTION

New World primates have evolved to fill specific niches through variable body size, activity levels, and dietary preference (Rosenberger, 1992). However, these distinct niches may be contingent on intact forest. Timber extraction increases interspecies competition by narrowing the number of preferred plant species, in addition to reducing the total biomass of food resources. Studying basic primate natural history by recording aspects such as diet can assist conservation land management prescriptions at a local scale by identifying key habitats

and plants that primates use, and protecting them as food resources.

In recent history, Costa Rica has suffered habitat loss of up to 4% forest cover per annum, mostly from expanding agriculture and human frontiers (Myers et al., 2000; Sanchez-Azofeifa et al., 2001; Achard et al., 2002). The country sought to redress this issue by the formation of national parks, and has recently expanded these to include wildlife corridors that connect reserve land to benefit primates, among a myriad of diverse wildlife (Canet-Desanti & Finegan, 2010). Costa Rica is biologically di-

verse, and has four species of primates that live in its tropical forests; *Saimiri oerstedii* (Reinhardt, 1872) (Central American squirrel monkey), *Cebus capucinus* (Linnaeus, 1758) (white-faced capuchin), *Alouatta palliata* (Gray, 1849) (mantled howler monkey), and *Ateles geoffroyi* (Kellogg et Goldman, 1944) (Geoffroy's or black-handed spider monkey). Despite their iconic status within Costa Rica's eco-tourism industry, surprisingly little is known about the diet of *A. palliata*, *Ateles geoffroyi*, and *C. capucinus* among these reserve lands, especially at local levels.

Group size and social structure can mitigate intra- and inter-species competition for food resources. Mantled howler monkeys form large, stable groups ranging from 2-39 individuals (Crockett & Eisenberg, 1987). They can live in large groups without intense food competition because their fitness is limited by access to mates rather than food; leaves are an abundant and easily accessible food source (Di Fiore & Campbell, 2007). Species with a higher proportion of fruit in their diet often use grouping strategies that allow access to this widely dispersed food source. Black-handed spider monkeys have a fission-fusion social structure (Di Fiore & Campbell, 2007), and live in groups of 15-25 individuals, forming sub-groups of 3 individuals (Robinson & Janson, 1987). Fission-fusion social structures may be a way of avoiding direct competition over food resources with conspecifics, by dispersing in small groups to scattered fruit sources (Di Fiore & Campbell, 2007). White-faced capuchins also feed predominantly on fruit, and form mixed-sex groups of 10-35 individuals (Robinson & Janson, 1987; Jack, 2007). Large group size might be a way to increase frequency of detecting fruit sources and defending these sources against other groups (Janson, 1988). Capuchins' smaller body size means that they have to intake fewer calories, mitigating competition within each group.

This study was performed at Caño Palma Biological Station, 8 km north of the coastal village of Tortuguero, in NE Costa Rica. Caño Palma is a small 5,000 m² reserve of mixed lowland tropical wet forest with dominant stands of *Manicaria* and *Raphia* palms (Lewis et al., 2010). The main objective of this study was to identify plant species and parts consumed by *A. palliata*, *Ateles geoffroyi*, and *C. capucinus*. In addition, each primate species was monitored for activity budget and food competition,

to create an ethogram to determine whether they fed on overlapping plant species and plant parts.

MATERIALS AND METHODS

The study period lasted 28 survey days from 8 April to 20 May 2011. Each day, the study site was surveyed commencing at 06:00. The first located species of primate was followed and monitored through the day until nightfall or until they became inaccessible. Observational frequency of all three primate species was adjusted in the field to ensure equal time budgets were allocated to each species. Namely, if one species had been followed more often than another, but was the first to be located during a survey, this species was immediately followed until an encounter with a less frequently observed species. For each data point, GPS coordinates were recorded to create distributional maps of each primate species across the site.

Activity budget data were collected using a group scan sample method (Martin & Bateson, 1993). At two-minute intervals the activity of each individual was recorded as one of four categories; inactive, travelling, feeding, and social interaction (Pavelka & Knopff, 2004). The age and sex of each individual was also recorded. Juveniles were not divided by sex, and adults of unknown sex were not included in analysis. Infants were excluded from activity budgets because of dependence on mothers for food (Pavelka & Knopff, 2004). When an individual was feeding, the species of plant and/or plant part was recorded. The five categories of plant parts were new leaf, mature leaf, unknown leaf, fruit, and stalk (Pavelka & Knopff, 2004). Plant parts that could not be identified were recorded as 'unknown'. Unknown plant species were included in the analysis of activity budget and plant parts, but discounted in analysis of plant species. For insectivores, such as *C. capucinus*, the number of insect feeding bouts was recorded, but the species of insect was not identified due to the complexity of deciphering specific species for each insect.

Data analyses of activity budgets and food budgets were conducted using R (version 2.11.1). Food budgets were sub-divided into separate analyses for plant species and plant parts. Individual identification of primates was not possible, and therefore, repeat sampling of some groups likely occurred. We

attempted to control for repeat sampling by using group scan sampling. The time budget spent for each activity was measured as a proportion of the time observed (Pavelka & Knopff, 2004). Therefore, time spent by a primate on an activity, the dependent variable, was measured as a percentage. Activity budget analyses used a 3 (species) x 2 (age) x 2 (sex) three-way ANOVA on mean frequency of each activity. Variation in plant parts consumed was analyzed by a 2 (sex) x 2 (age) x 3 (species) three-way ANOVA on mean frequency of type of plant part consumed.

RESULTS

The dataset comprised 28 survey days, of which monkeys were observed on 17 days, for a total of approximately 49 hours. Totals of 933 *A. palliata*, 368 *Ateles geoffroyi*, and 156 *C. capucinus* observations were recorded. Individual monkeys often provided multiple observations upon encounter.

Population and Distribution

A. palliata were found in groups of 3-4 individuals, *Ateles geoffroyi* in groups of 3-7 individuals, and *C. capucinus* in groups of 12-20 individuals. Distribution maps for each primate species indicated that most groups were located, and foraged, in edge and transitional (occasionally flooded) habitat (Fig. 1). Only *A. palliata* were found farthest north of the reserve among *Manicaria* swamp habitat (Fig. 1).

Activity Budgets

Overall activity budget for *A. palliata*, including all age and sex groups, indicated they spent 77% of time inactive, 14% moving, 7% feeding, and 2% engaging in social behaviour. *Ateles geoffroyi* spent 41% of time moving, 31% inactive, 20% feeding, and 8% engaging in social behaviour. *C. capucinus* spent 76% of time moving, 10% engaging in social behaviour, 8% feeding, and 6% inactive (Fig. 2). A 3 (species) x 2 (age) x 2 (sex) three-way ANOVA on mean frequency of each activity produced a statistical interaction between activity and primate species. The percentage of time spent on each activity differed significantly between primate species, $F(6, 192) = 8.2069$, $P = 0.001$ (Fig. 2).

Diet

For time engaged in feeding, *A. palliata* spent 35% feeding on new leaves, 32% on fruit, 30% on unknown leaves, 2% on stalks, and 2% on unknown plant parts. *Ateles geoffroyi* spent 44% feeding on new leaves, 28% feeding on fruit, 17% on unknown leaves, 11% on plant stalks, and 1% on mature leaves. *C. capucinus* spent 77% of the time feeding on fruit, 15% on insects, and 8% on unknown parts (Fig. 3). A 2 (sex) x 2 (age) x 3 (species) three-way ANOVA on mean frequency of type of plant part consumed produced an interaction between plant part and primate species. Primate species ate different plant part, $F(10, 291) = 2.347$, $p = 0.0123$, but not different plant families (Table 1).

Nine families of plants were identified as food for *A. geoffroyi*; Anacardiaceae, Araceae, Arecaceae, Clusiaceae, Melastomaceae, Moraceae, Myrtaceae, Rubiaceae and Tiliaceae. *A. palliata* fed on four plant families (Anacardiaceae, Araceae, Arecaceae, Clusiaceae), and *C. capucinus* fed on two plant families (Anacardiaceae and Melastomaceae) (Table 1).

DISCUSSION

Population and Distribution

All three species of primate were observed around Caño Palma's reserve land without disturbing normal activity. This suggested that all three species were habituated to human presence, likely due to the long-term presence of researchers at Caño Palma Biological Station and regular ecotourism to the area.

Caño Palma Biological Station's reserve land features lowland tropical wet forest edge, lowland tropical wet transitional (occasionally flooded) forest, and *Manicaria* swamp forest (Lewis et al., 2010). All three species of primates in this study were located, and observed foraging among edge and transitional vegetative zones within Caño Palma's reserve land. Only *A. palliata* was located in *Manicaria* swamp forest habitat. This is possibly due to the higher diversity of food providing trees and high vegetation within the transitional forest zone (Lewis et al., 2010). The observations of group numbers of *A. palliata*, *Ateles geoffroyi*, and *C. ca-*

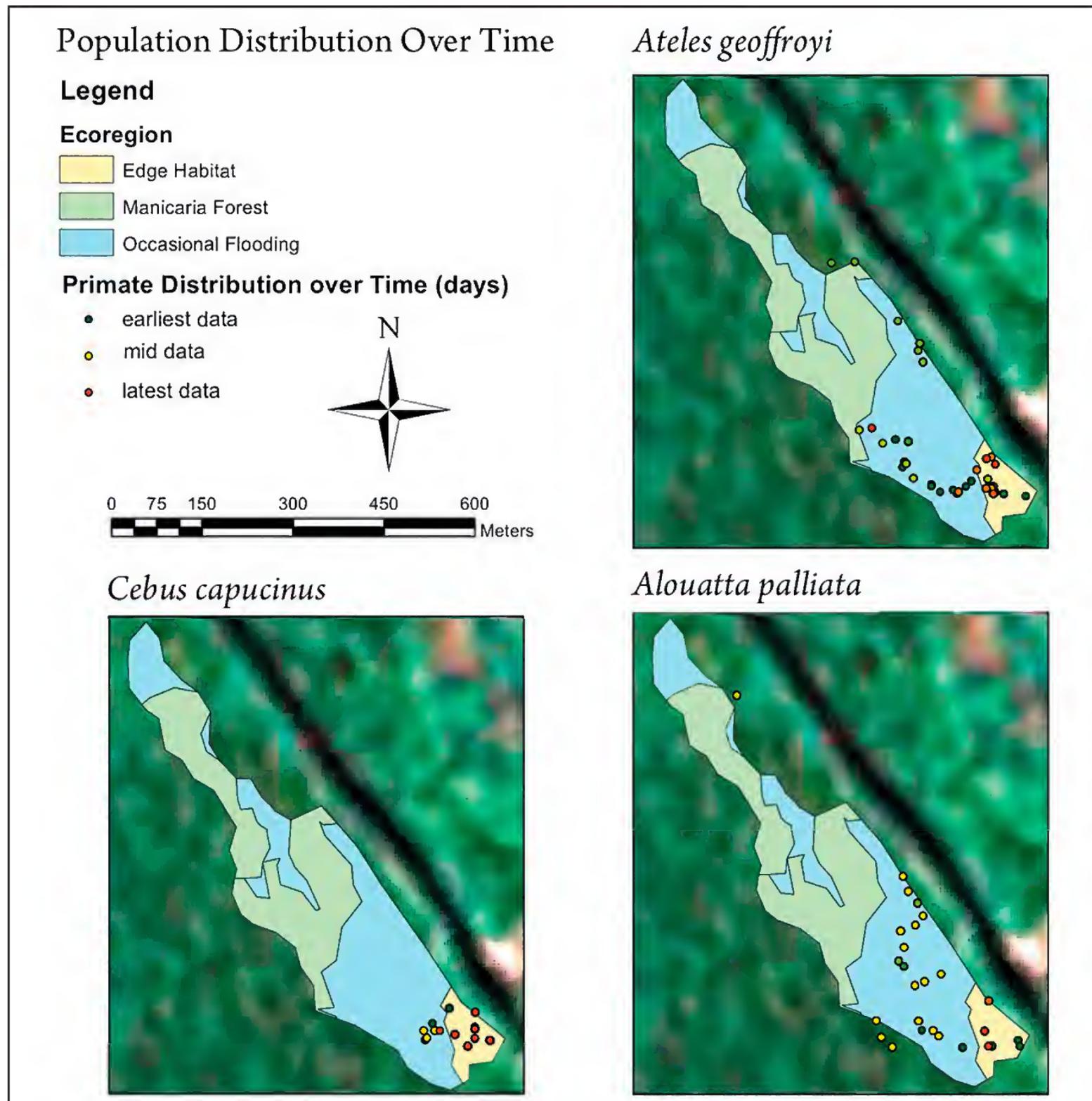


Figure 1. Distribution of each primate species across the study site as a function of time.

pucinus concurred with known group numbers for each species. *A. palliata* were found in groups of 3-4 individuals, within the reported range of 2-39 individuals (Crockett & Eisenberg, 1987). *Ateles geoffroyi* were found in small groups of 3-7 individuals that were possibly sub-groups, although they have been observed at Caño Palma Biological Station in larger groups (P. Grant & R. Ballard, pers. comm.). *Ateles geoffroyi* are usually found in fission-fusion structured social groups of 15-25 individuals, and form sub-groups of up to three

individuals (Robinson & Janson, 1987; Di Fiore & Campbell, 2007). These fission-fusion social structures may be a way of avoiding direct competition over food resources with conspecifics (Di Fiore & Campbell, 2007). *C. capucinus* groups ranged from 12-20 and are known to form mixed-sex groups of 10-35 individuals (Jack, 2007; Robinson & Janson, 1987). *C. capucinus* were only observed on 3 non-consecutive days of 28 survey days, travelling through the study site. It is possible that Caño Palma's reserve is only a portion of this group's range.

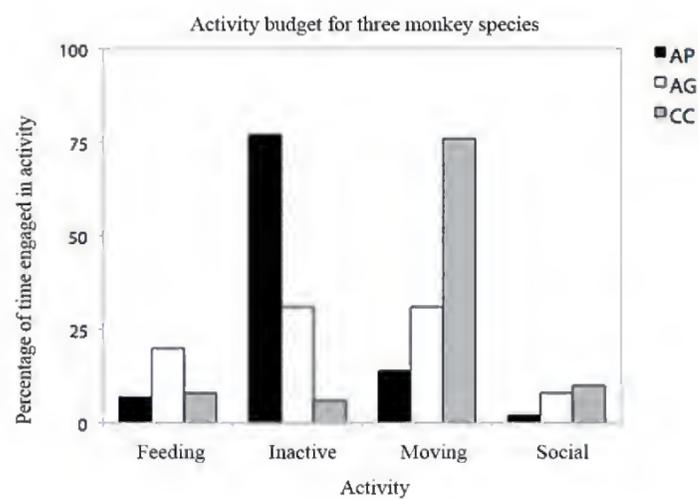


Figure 2. Activity budget by species (*Ateles geoffroyi* - black, *Alouatta palliata* - white, *Cebus capucinus* - grey); percentage of total time observed performing each activity. The percentage of time spent on each activity differed significantly between primate species, $F(6, 192) = 8.2069$, $P = 0.001$.

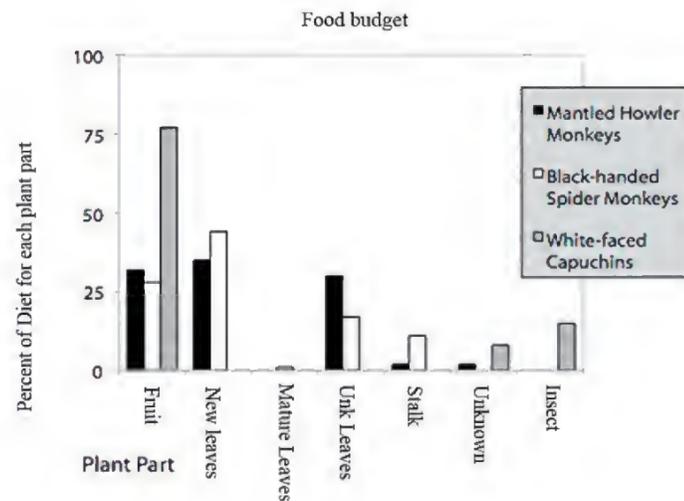


Figure 3. Food budget by species (*Ateles geoffroyi* - black, *Alouatta palliata* - white, *Cebus capucinus* - grey); percentage of total time observed feeding on each plant part.

Table 1. Food budget by species, age, and sex; percentage of total time observed feeding on each plant species.

Species	<i>Ateles geoffroyi</i>				<i>Alouatta palliata</i>				<i>Cebus capucinus</i>				
	Age	All	A	J	Age	All	A	J	Age	All	A	J	
Sex		All	F	M	Unk	All	F	M	Unk	All	F	M	Unk
Anacardiaceae	23	15	28	50	44	41	47	50	8	14	0	0	
Araceae	11	10	17	0	2	0	0	0	0	0	0	0	
Arecaceae	23	29	22	0	5	5	7	10	0	0	0	0	
Clusiaceae	1	2	0	0	18	20	20	10	0	0	0	0	
Melastomataceae	4	6	0	0	0	0	0	0	46	43	0	100	
Moraceae	7	6	6	10	0	0	0	0	0	0	0	0	
Myrtaceae	1	2	0	0	0	0	0	0	0	0	0	0	
Rubiaceae	5	6	0	10	0	0	0	0	0	0	0	0	
Tiliaceae	16	15	17	20	0	0	0	0	0	0	0	0	
Unknown	9	8	11	10	32	34	27	30	31	14	100	0	
Insect	0	0	0	0	0	0	0	0	15	29	0	0	

During this study, little interspecific competition was observed between primate species despite their overlapping distribution. This is possibly because each species foraging strategy led them to feed on different plant parts and plant species. It is possible that each primate species filled a specific niche, although a year-long study would clarify this concept and determine whether competition increases during periods of lower food availability.

Activity Budgets and Food Choice

A. palliata, *Ateles geoffroyi*, and *C. capucinus* exhibited different activity budgets, and fed on different plant parts to sustain activity. Differing activity budgets are known for all three species (Schoener, 1971; Crockett & Eisenberg, 1987; Di Fiore & Campbell, 2007). *A. palliata* was observed to consume mostly leaves and fruit, and did not

travel as much as *Ateles geoffroyi* or *C. capucinus*. These findings are consistent with the hypothesis that *A. palliata* exhibits a strategy of energy minimization. Namely, they receive less energy from the leaves they eat, and therefore exert less energy (Di Fiore & Campbell, 2007). *A. palliata* is primarily folivorous, with a diet similar to colobines and indriids, but without a specialized digestive tract to efficiently digest fibre (Milton, 1979). Although their capacious gut allows *A. palliata* to digest leaves, they do not extract the same amount of nutrients as their old world relatives (Milton, 1979). Across primate species, diets high in leaves correlate to low levels of activity (Dasilva, 1992). At Caño Palma, *A. palliata* exhibited a preference for young leaves, which may be because they contain higher protein content, and are generally lower in fibre, thus easier to digest (Milton, 1979). *A. palliata* can remain in stable social groups sharing the same area without intense competition because leaves are abundant and readily available in high density (Di Fiore & Campbell, 2007). At Caño Palma we did not observe intraspecific competition for food resources either within or between howler monkey groups.

Ateles geoffroyi are known to move to specific areas to exploit seasonally ripe fruit and can spend between 18.9% and 50.5% of their day feeding (Robinson & Janson, 1987). Spider monkeys in this study ate fruit and leaves from a wide variety of plant species, and were more active than *A. palliata*. Unlike *A. palliata*, *Ateles geoffroyi* live in fission-fusion societies, possibly as a response to their dietary preference for ripe fruit (Di Fiore & Campbell, 2007). Because fruit is a densely but sparsely distributed resource, spider monkeys often divide into sub-groups to avoid competition while foraging (Di Fiore & Campbell, 2007). This was evident within Caño Palma's spider monkey groups from the low group sizes encountered. *Ateles geoffroyi* maximize energy intake by moving quickly to sources of high-energy foods (Di Fiore & Campbell, 2007). To gain the energy required to travel and forage; they must eat fruit and, synchronously to eat fruit, they must travel to foraging areas. At Caño Palma, *Ateles geoffroyi* ranged constantly in the field as was observed in their distribution. *Ateles geoffroyi* do not have the capacious gut of *A. palliata* and therefore possibly cannot extract sufficient calories from leaves alone.

C. capucinus can spend 70-80% of their day foraging and move seasonally to find ripe fruit (Robin-

son & Janson, 1987). Our observations showed *C. capucinus* to be more active than *Ateles geoffroyi*, eating mainly fruit, as well as occasional insects. This diet of high energy fruit and insects could allow higher activity levels for capuchins. According to optimal foraging theory, individuals should select fruit based on caloric/nutritional profitability even when other familiar food sources are available (Schoener, 1971). Considering this, *C. capucinus* should consume the available fruit with the highest energy content. A study to investigate capuchin seasonal diet at Caño Palma would confirm this aspect. Diets between neighbouring groups of *C. capucinus* can vary and such differences in diet between groups at Caño Palma could be cultural, intraspecific, or due to food profitability (Chapman & Fedigan, 1990).

Diet Composition

In this study, the three primate species fed on a total of nine families of plants, some of which overlapped across two, or all three species. The difference in plant families consumed may be explained by the preferred plant parts of each primate species, and possibly by plant distribution. *A. palliata* has been known to consume mostly young leaves and fruit, and the morphology of their teeth suggests they have a predominantly folivorous diet (Crockett & Eisenberg, 1987; Di Fiore & Campbell, 2007). Past studies have shown that the proportion of fruit in the diet of *A. palliata* affects their activity levels, because fruit is a higher energy source than leaves (Pavelka & Knopff, 2004). At Caño Palma, *A. palliata* confirmed their known ecological behaviour trait as inactive frugivore-folivores by their selection of vegetative food (Table 1).

Our observations of *Ateles geoffroyi* diet confirm their ecological behaviour as active frugivore-folivores that prefer ripe fruit (Robinson & Janson, 1987; Di Fiore & Campbell, 2007). At Caño Palma, *Ateles geoffroyi* were seen consuming *Philodendron* sp. (Araceae). *Philodendron* is a genus known for its toxic properties due to the presence of calcium oxalate crystals (Genua & Hillson, 1985). Calcium oxalate crystals are a secondary compound that defends certain plant species against herbivores (Franceschi & Horner, 1980). Other mammal species, with ruminating or complex guts, have been known to eat high concentrations of oxalates (Freeland & Janzen, 1974). Humans also consume some oxalate

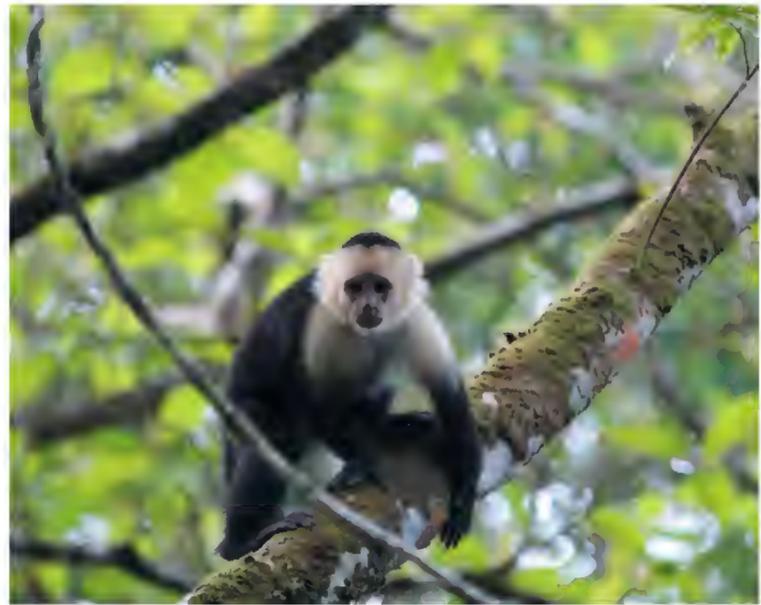
rich foods such as rhubarb, spinach, nuts, and tea, and over-consumption can lead to adverse health effects (Massey et al., 1993). *Ateles geoffroyi* may possess a tolerance to oxalate crystals that allow them to consume calcium oxalate rich plants, such as *Philodendron* spp., in conjunction with other plant foods when preferred sources are scarce (Franceschi & Horner, 1980). This food choice could also be an act of self-medication (Huffman, 1997). *Ateles geoffroyi* in certain parts of Costa Rica have lower parasite loads due to the ingestion of fig leaves (Glander, 1994), and it is possible that calcium oxalate acts as a similar vermicide.

C. capucinus confirmed their ecological behaviour as very active frugivore-insectivores (Robinson & Janson, 1987). Their diet is known to be variable, comprising mostly seasonal fruit or insects, and they are known to hunt small vertebrates (Jack, 2007). At Caño Palma, *C. capucinus* consumed species of plant not atypically described for the species at other sites across Costa Rica and the neotropics (Jack, 2007).

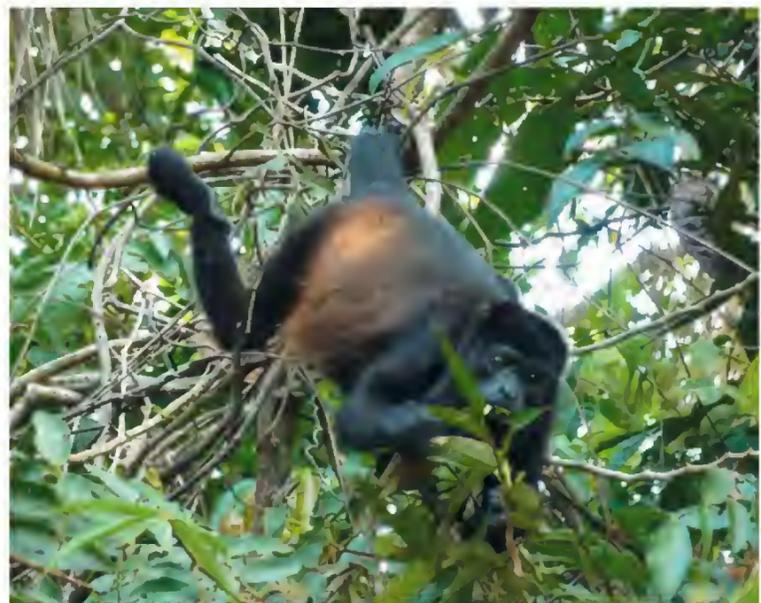
Habitat and Conservation for Primates at Caño Palma

Factors such as variable body size and feeding specializations may help New world primate species to mitigate interspecific competition. Additionally, each species' social structure can alleviate pressure from intraspecific competition and resource scarcity (Rosenberger, 1992). This self-regulating behaviour among and within species of primate highlights the importance of protecting areas that contain preferred food plants, especially in connected habitats like Caño Palma that buffer national reserves.

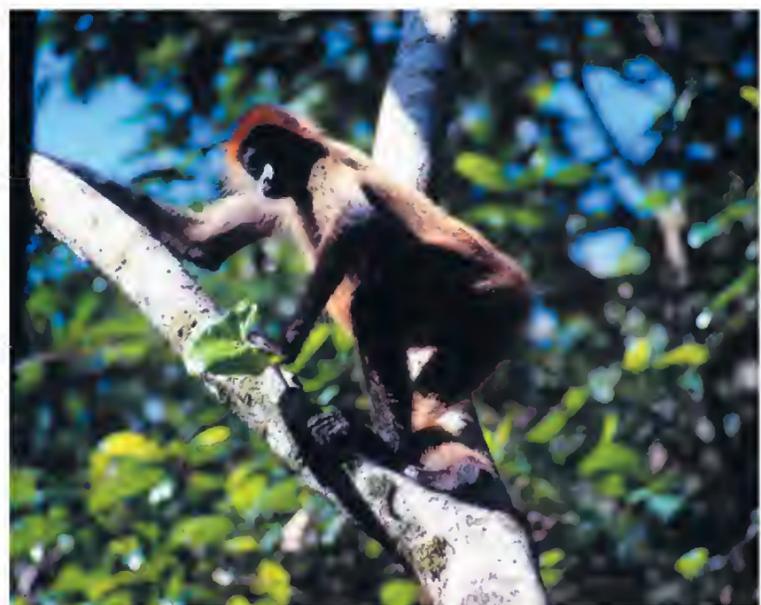
However, despite laws to regulate selective logging within the Barra del Colorado Refuge, unmonitored logging still occurs (Lewis et al., 2010; R. Ballard, pers. comm.). We recommend that any selective logging should avoid plant families and communities of local provenance to maintain the integrity of food resources for primates. Notwithstanding, regulation of selective logging on the vast Barra del Colorado Refuge is not always pragmatic. By studying and considering local foraging by primates, a strategy to conserve connected areas around Caño Palma could be realised, and is suggested. Further study of territory and distribution combined with disseminating information, and involvement of local communities, support this recommendation.



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Figure 4. White faced capuchin. Copyright Jamie Bowkett. Figure 5. Mantled Howler Monkey. Copyright Michelle Haines. Fig. 6 Black-handed Spider Monkey. Copyright Paul Grant.

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REFERENCES

- Blanck Achard F., Eva H.D., Stibig H.-J., Mayaux P., Gallego J., Richards T. & Malingreau J.-P., 2002. Determination of deforestation rates of the world's humid tropical forests. *Science*, 297: 999-1002.
- Canet-Desanti L. & Finegan B., 2010. Bases de conocimiento para la gestión de corredores biológicos en Costa Rica, Foundations of knowledge for the management of biological corridors in Costa Rica. *Mesoamericana*, 14: 11-24.
- Chapman C.A. & Fedigan L.M., 1990. Dietary differences between neighboring *Cebus capucinus* groups: local traditions, food availability or responses to food profitability. *Folia Primatologica*, 54: 177-186.
- Crockett C.M. & Eisenberg J.F., 1987. Howlers: variations in group size and demography. In: Smuts B.B., Cheney D.L., Seyfarth R.M., Wrangham R.W. & Struhsaker T.T. (Eds.), *Primate societies*. University of Chicago Press, Chicago, pp. 54-68.
- Dasilva G.L., 1992. The western black-and-white *Colobus* as a low-energy strategist: activity budgets, energy expenditure and energy intake. *Journal of Animal Ecology*, 61: 79-9.
- Di Fiore A. & Campbell C.J., 2007. The Atelines: variation in ecology, behavior, and social organization. In: Campbell C.J., Fuentes A., MacKinnon K.C., Panger M. & Bearder S. K. (Eds.), *Primates in perspective*. Oxford University Press, Oxford, pp. 155-185.
- Franceschi V.R. & Horner H.T., 1980. Calcium oxalate crystals in plants. *Botanical Review*, 46: 361-427.
- Freeland W.J. & Janzen D.H., 1974. Strategies in herbivory by mammals: the role of plant secondary compounds. *American Naturalist*, 108: 269-289.
- Genua J.M. & Hillson C.J., 1985. The occurrence, type and location of Calcium oxalate crystals in the leaves of fourteen species of Araceae. *Annals of Botany*, 56: 351-361.
- Glander K.E., 1994. Nonhuman primate self-medication with wild plant foods. In: Etkin N.L. (Ed.), *Eating on the wild side: The pharmacologic, ecologic, and social implications of using noncultigens*. University of Arizona Press, Tucson, pp. 239-256.
- Huffman M.A., 1997. Current evidence for self-medication in primates: a multidisciplinary perspective. *Yearbook of Physical Anthropology*, 40: 171-200.
- Jack K.M., 2007. The Cebines: toward an explanation of variable social structure. In: Campbell C.J., Fuentes A., MacKinnon K.C., Panger M. & Bearder S. K. (Eds.), *Primates in perspective*. Oxford University Press, Oxford, pp. 107-121.
- Janson C.H., 1988. Intra-Specific Food Competition and Primate Social Structure: A Synthesis. *Behaviour*, 105: 1-17.
- Lewis T.R., Grant P.B.C., Quesada M.G., Ryall C. & LaDuke T.C., 2010. A botanical survey of Caño Palma Biological Station (Estacion Biologica Caño Palma), Tortuguero, Costa Rica. *Brenesia*, 73-74: 73-84.
- Martin P. & Bateson P., 1993. *Measuring behaviour: An introductory guide*, second edition. Cambridge University Press, Cambridge, 176 pp.
- Massey L.K., Roman-Smith H. & Sutton R.A.L., 1993. Effect of dietary oxalate and calcium on urinary oxalate and risk of formation of calcium oxalate kidney stones. *Journal of the American Dietetic Association*, 93: 901-906.
- Milton K., 1979. Factors influencing leaf choice by howler monkeys: a test of some hypotheses of food selection by generalist herbivores. *American Naturalist*, 114: 362-378.
- Myers N., Mittermeier R.A., Mittermeier C.G., da Fonseca G.A.B. & Kent J., 2000. Biodiversity hotspots for conservation priorities. *Nature*, 40: 853-858.
- Pavelka M.S.M. & Knopff K.H., 2004. Diet and activity in black howler monkeys (*Alouatta pigra*) in southern Belize: does degree of frugivory influence activity level? *Primates*, 45: 105-111.
- Robinson J.G. & Janson C.H., 1987. Capuchins, squirrel monkeys, and Atelines: socio-ecological convergence with Old World primates. In: Smuts B.B., Cheney D.L., Seyfarth R.M., Wrangham R.W. & Struhsaker T.T. (Eds.), *Primate societies*. University of Chicago Press, Chicago, pp. 69-82.
- Rosenberger A.L., 1992. Evolution of feeding niches in new world monkeys. *American Journal of Physical Anthropology*, 88: 525-562.
- Sanchez-Azofeifa G.A., Harriss R.C. & Skole D.L., 2001. Deforestation in Costa Rica: a quantitative analysis using remote sensing imagery. *Biotropica*, 33: 378-384.
- Schoener T.W., 1971. Theory of feeding strategies. *Annual Review of Ecology and Systematics*, 2: 369-404.

Diversity of mosquitoes (Diptera Culicidae) in protected natural parks from Valencian Autonomous Region (Eastern Spain)

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ABSTRACT

Several larval samplings of mosquitoes (Diptera Culicidae) were carried out between 2008-2011, throughout very diverse larval biotopes located in thirteen protected natural parks from Eastern Spain, offering new information about the faunistic diversity of mosquitoes in these protected areas. Biodiversity was analyzed in terms of alpha, beta and gamma components, with the aim of comparing mosquito diversity according to the typology of the natural parks under study. A total of 15355 specimens belonging to 25 different mosquito species and 6 genera were collected and identified. Diversity analysis indicated higher diversity for Inland Mountainous Areas (IMAs) with a low degree of interspecific dominance in these communities, while Coastal Wetlands and Marshes registered the lowest observed diversity and a high degree of interspecific dominance. The cluster analysis revealed the relationship between the categories (IMA, CMA, CWM), while the Principal Components Analysis proved the relationship between larval abundance and the categories studied.

KEY WORDS

Mosquitoes; Culicidae; biodiversity; natural parks; Eastern Spain.

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INTRODUCTION

Mosquitoes (Diptera Culicidae) are considered one of the most relevant group of arthropods in the public health field (Schaffner et al., 2001; Becker et al., 2010) and, like other organisms, show a direct relation to different factors such as environmental and habitat heterogeneity or host preferences (Zhong et al., 2003). Unfortunately, since the eradication of malaria in Spain (Bueno Marí & Jiménez Peydró, 2008), there have been few scientific studies aimed to increase the knowledge about mosquito diversity and the factors that regulate its change and their populations in our country. From this point of view, the comparison of mosquito diversity (alpha diversity) and the

structure of the communities in which they are integrated (beta diversity) can provide us with a powerful tool for the implementation of more effective and efficient population control programs, according to the structure of the landscape (Wittaker, 1972; Magurran, 1988).

We can define alpha diversity (α) as the specific richness of a community that we consider homogeneous. Beta diversity (β) refers to the replacement degree in the specific composition between different communities of a landscape. And, finally, we can define gamma diversity (γ) as the specific richness of the grouped communities that form a landscape, resulting from both alpha and beta diversities interaction (Magurran, 1988). This method of biodiversity analysis is useful not

only to explore the climatic, physical or biological influences on biodiversity, but also to study the effects of human pressure on biodiversity (Halffter, 1998; Moreno, 2001). Taking into account these considerations, the aim of this study was to analyze the diversity of Culicidae present in the natural areas considered, as well as the differences on the faunistic composition of mosquito species in function of the climatic and ecological features of each natural park.

MATERIALS AND METHODS

Study area

To develop the study, we selected thirteen natural parks belonging to the Valencian Autonomous Region (Spain): eight of them belonging to inland mountainous areas, two belonging to coastal mountainous areas and, finally, three belonging to coastal wetlands and marshes (Fig. 1). Due to the climatic variability recorded in the Valencian Autonomous Region, it is possible to observe large differences in the average temperatures and precipitations registered between the different categories of the natural parks here studied. According to this, we can define our study area as follows (GVA, 2003):

- Inland Mountainous Areas (IMA). Characterized by a typical Mediterranean climate, but influ-

enced by continental climate, these are the only areas where it is possible to find Supramediterranean (mean temperature range between 13-8 °C) and Oromediterranean (mean temperature range between 8-4 °C) termotypes. During the study period, maximum average temperatures of 26.5 °C and minimum average temperatures of 2.5 °C were recorded, with an average precipitation of 36.7 l (Fig. 2).

- Coastal Mountainous Areas (CMA). Very similar to the IMA, are characterized by being classified as Termomediterranean (mean temperature range between 19-17 °C) and Lower Mesomediterranean (mean temperature range between 17-13 °C) termotypes, which is why the average temperature is higher than in the previous class. During the study period, maximum average temperatures of 27.8 °C and minimum average temperatures of 5.0 °C were recorded, with an average precipitation of 29.2 l (Fig. 3).

- Coastal Wetlands and Marshes (CWM). CWM are the most common coastal environments of the Valencian territory, registering the highest average values of temperature (Inframediterranean termotype, mean temperature >19 °C). Rainfall is strongly influenced by seasonality, characterized by a severe drought time during the summer months. During the study period, maximum average temperatures of 29.1 °C and minimum average temperatures of 5.5 °C were recorded, with an average rainfall of 27.8 l (Fig. 4).



Figure 1. Study area and the classification of each natural park studied by category. IMA (Inland Mountainous Areas), CMA (Coastal Mountainous Areas) and CWM (Coastal Wetlands and Marshes).

Sampling methods and taxonomic identification

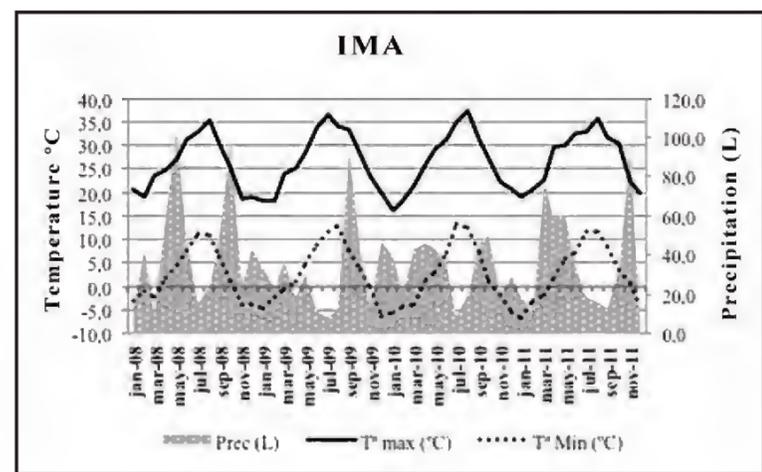
A simple random sampling method was carried out across the study area by selecting all suitable biotopes to accommodate immature forms of mosquitoes. In this way, many different points were sampled by using “dipping” technique (Service, 1993) over 4 consecutive years (2008-2011). Mosquito species were identified according to the keys of Encinas Grandes (1982), Darsie & Saminadou Voyadjoglou (1997) and Schaffner et al. (2001).

Diversity studies and statistical analysis

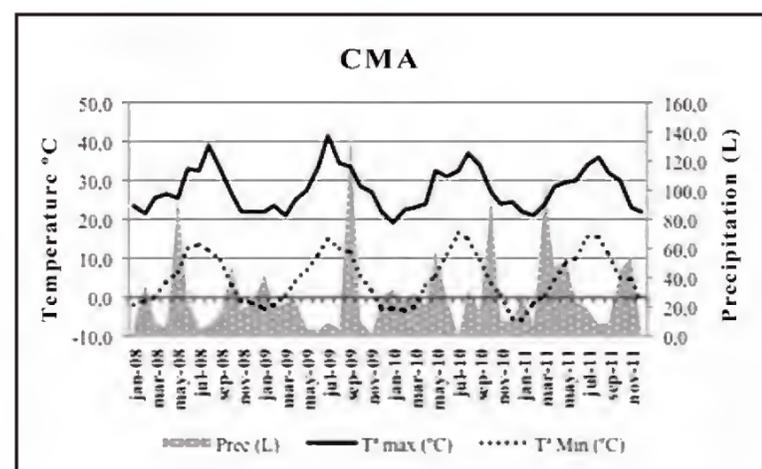
Diversity studies (alpha diversity) were conducted separately for each natural park category (IMA, CMA and CWM) by calculating classic diversity indexes like Margalef's ($D_{Mg} = (S-1)/\ln N$) (Simpson, 1949; Magurran, 1988; Moreno, 2001) and Simpson's Indexes ($\lambda = \sum p_i^2$, where $p_i = n_i/N$ [n_i , relative abundance of the species calculated as the proportion of individuals of a given species against the total number of individuals of a community, N]). Shannon diversity index ($H' = -[\sum(p_i \cdot \ln p_i)]$) is commonly used to characterize species diversity in a community, accounting for both abundance and evenness of the species present (Shannon & Weaver, 1949). Species richness (S) is the number of species present in a community while species evenness (J') indicates the distribution of individuals within the species and it's calculated by using Pielou's Index formula ($J' = H'/H'_{max}$, where $H'_{max} = \ln(S)$) (Magurran, 1988; Moreno, 2001).

On the other hand, to calculate beta diversity, a variety of similarity/dissimilarity indexes were used, both qualitative (Jaccard's Index, $I_j = c/[a+b-c]$) and quantitative (Sorensen's Index, $I_s = [2pN]/[aN+bN]$), as well as Whittaker's (which calculates the species replacement according to the expression $\beta_W = S/[(2a+b+c)-1]$) and Complementarity Index ($C_{AB} = [S_A + S_B - 2V_{AB}]/[S_A + S_B - V_{AB}]$, where V_{AB} represents the number of common species to both sites A and B) (Magurran, 1988; Moreno, 2001).

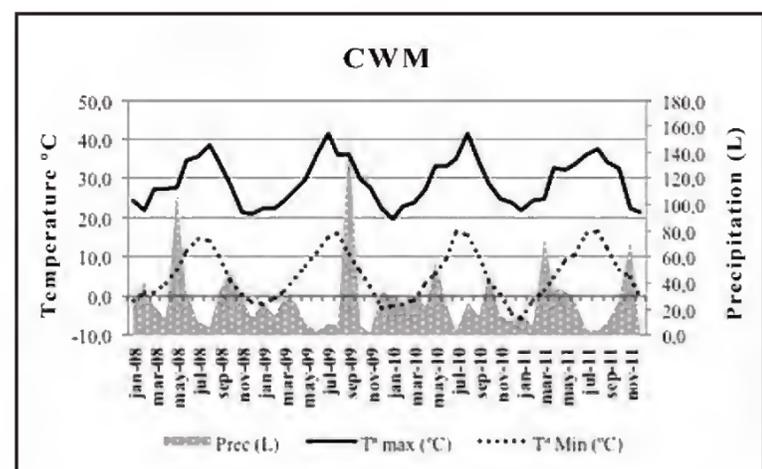
The calculation of gamma diversity, was carried out by using the classic proposal of Schluter and Ricklefs (Schluter & Ricklefs, 1993) ([average α diversity][average β diversity][sample size(N')]), as well as the modification made by Lande (1996) ([average α diversity][β diversity], where



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Figure 2. Characteristic climogram (average maximum and minimum temperatures and precipitations) of IMAs natural parks for the study period (2008-2011). Figure 3. Characteristic climogram (average maximum and minimum temperatures and precipitations) of CMAs natural parks for the study period (2008-2011). Figure 4. Characteristic climogram (average maximum and minimum temperatures and precipitations) of CWMs natural parks for the study period (2008-2011).

$\beta = \sum q_j [S_T - S_j]$) to calculate the contribution made by alpha and beta diversity to gamma (Moreno, 2001). Finally, to calculate the ecological distance between different environments, a cluster (based on

	IMA	Relative abundance	CMA	Relative abundance	CWM	Relative abundance
<i>Aedes</i>						
<i>Aedes vexans</i>	15	0.16	0	0.00	0	0.00
<i>Aedes vittatus</i>	0	0.00	49	1.37	0	0.00
<i>Anopheles</i>						
<i>Anopheles atroparvus</i>	22	0.23	0	0.00	0	0.00
<i>Anopheles claviger</i>	30	0.32	0	0.00	0	0.00
<i>Anopheles maculipennis s.s.</i>	34	0.36	0	0.00	0	0.00
<i>Anopheles marteri</i>	19	0.20	0	0.00	0	0.00
<i>Anopheles petragrani</i>	1069	11.23	63	1.77	0	0.00
<i>Culex</i>						
<i>Culex hortensis hortensis</i>	1216	12.77	7	0.20	0	0.00
<i>Culex impudicus</i>	697	7.32	44	1.23	0	0.00
<i>Culex laticinctus</i>	1265	13.29	1462	40.96	0	0.00
<i>Culex mimeticus</i>	583	6.12	41	1.15	0	0.00
<i>Culex modestus</i>	17	0.18	0	0.00	47	2.08
<i>Culex pipiens</i>	1935	20.32	708	19.84	1138	50.24
<i>Culex territans</i>	246	2.58	0	0.00	0	0.00
<i>Culex theileri</i>	2	0.02	0	0.00	0	0.00
<i>Culiseta</i>						
<i>Culiseta annulata</i>	62	0.65	0	0.00	11	0.49
<i>Culiseta longiareolata</i>	2151	22.59	1195	33.48	168	7.42
<i>Ochlerotatus</i>						
<i>Ochlerotatus berlandi</i>	14	0.15	0	0.00	0	0.00
<i>Ochlerotatus caspius</i>	0	0.00	0	0.00	658	29.05
<i>Ochlerotatus detritus</i>	0	0.00	0	0.00	223	9.85
<i>Ochlerotatus echinus</i>	93	0.98	0	0.00	0	0.00
<i>Ochlerotatus geniculatus</i>	33	0.35	0	0.00	0	0.00
<i>Ochlerotatus gilcolladoi</i>	11	0.12	0	0.00	0	0.00
<i>Ochlerotatus pulcritarsis</i>	7	0.07	0	0.00	0	0.00
<i>Uranotaenia</i>						
<i>Uranotaenia unguiculata</i>	0	0.00	0	0.00	20	0.88
TOTAL COUNT	9521	62.00%	3569	23.24%	2265	14.75%

Table 1. Number of specimens captured for each environmental category (IMA, CMA and CWM).

Jaccard's Index) and a principal components analyses (PCA) were made, offering the cophenetic correlation value for the Jaccard cluster to calculate the degree of reliability of the classification system used. PAST software (Paleontological Statistics Software Package) was used to carry out all calculations developed (Hammer et al., 2001).

RESULTS AND DISCUSSION

Faunistic and systematic results

A total of 15,355 mosquito larvae were collected from 285 sampling points, obtaining a total of 900 samples. The systematic study showed a total of 25 species belonging to 6 different genera (Table 1) which represents an 86.21% of the maximum specific richness calculated for the Valencian Autonomous Region (Bueno Mari, 2011). The complete catalogue of species collected is listed below: *Aedes vexans* (Meigen, 1830); *Aedes vittatus* (Bigot, 1861); *Anopheles atroparvus* Van Thiel, 1927; *Ano-*

pheles claviger (Meigen, 1804); *Anopheles maculipennis* s.s. Meigen, 1818; *Anopheles marteri* Senevet et Prunelle, 1927; *Anopheles petragrani* De Vecchio, 1939; *Culex hortensis hortensis* Ficalbi, 1889; *Culex impudicus* Ficalbi, 1890; *Culex laticinctus* Edwards, 1913; *Culex mimeticus* Noe, 1899; *Culex modestus* Ficalbi, 1889; *Culex pipiens* Linnaeus, 1758; *Culex territans* Walker, 1856; *Culex theileri* Theobald, 1903; *Culiseta annulata* (Schrank, 1776); *Culiseta longiareolata* (Macquart, 1838); *Ochlerotatus berlandi* (Séguy, 1921); *Ochlerotatus caspius* (Pallas, 1771); *Ochlerotatus detritus* (Haldy, 1833); *Ochlerotatus echinus* (Edwards, 1830); *Ochlerotatus geniculatus* (Olivier, 1791); *Ochlerotatus gilcolladoi* (Sánchez-Covisa, Rodríguez et Guillén, 1985); *Ochlerotatus pulcritarsis* (Rondani, 1872) and *Uranotaenia unguiculata* Edwards, 1913.

Mosquito species richness and evenness

According to the analysis of α biodiversity indexes (Table 2), it is possible to observe that IMA environments are the most diverse ($S=21$; $D_{Mg}=2.183$),

	IMA	CMA	CWM
Abundance	9521	3569	2265
Specific richness (S)	21	8	7
Margalef index (D_{Mg})	2.183	0.856	0.777
Simpson index (λ)	0.149	0.320	0.353
Shannon index (H')	2.101	1.301	1.274
Evenness of Pielou index (J)	0.690	0.626	0.655

Table 2. Alpha biodiversity estimators for each environmental category (IMA, CMA and CWM).

	IMA-CMA	IMA-CWM	CMA-CWM
Jaccard index (I_j)	0.32	0.17	0.15
Sorensen index (I_{Squant})	0.51	0.23	0.30
Whittaker index (β_W)	0.52	0.71	0.73
Complementarity ($C_{AB}\%$)	68.18	83.33	84.62

Table 3. Beta biodiversity estimators for each environmental category (IMA, CMA and CWM)

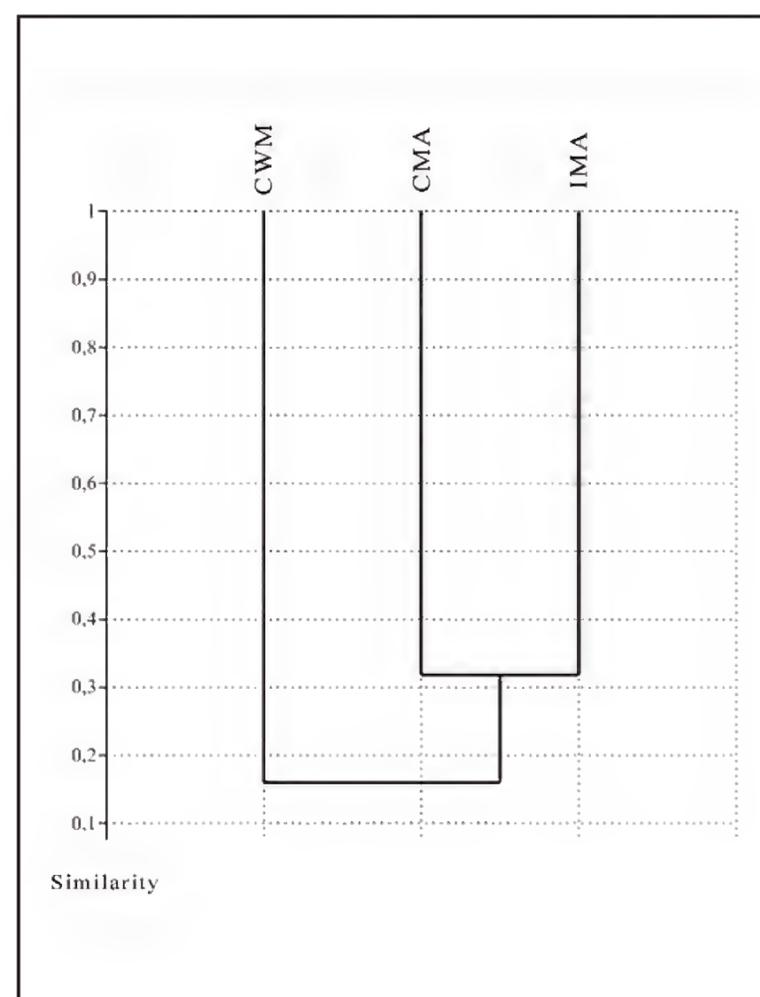


Figure 5. Cluster analysis based on Jaccard's distance; cophenetic correlation $rc=0.9975$.

while CWM are the least diverse ($S = 7$; $D_{Mg} = 0.777$). Simpson and Shannon indexes highlight that in CWMs ($\lambda = 0.353$; $H' = 1.274$) species such as *Cx. pipiens* (50.24%) and *O. caspius* (29.05%) strongly dominate the rest of species present in the community. Something similar occurs in the case of CMAs ($\lambda = 0.320$; $H' = 1.301$), where *Cx. laticinctus* (40.96%), *Cs. longiareolata* (33.48%) and *Cx. pipiens* (19.84%) develop a strong influence. Finally, IMAs ($\lambda = 0.149$; $H' = 2.101$) are the category of natural park where a greater evenness degree can be observed, because the most dominant species do not show such a strong influence as in the two other cases.

These observations can be explained according to the bioclimatic characteristics of each natural park category. The IMAs record a greater rainfall abundance (Fig. 2) as well as a higher variety of environments that are able to be colonized by mosquitoes than in other categories of natural parks. That means a greater amount of larval biotopes available to be exploited by different communities of culicids along the year. The CMAs, can be defined as transitional environments between IMAs and CWMs categories since rainfall regime is more heterogeneous, focusing on specific periods throughout the year (Fig. 3). This factor, in combination with times of severe drought during the summer months, determines a population dynamics feature which is reflected in the diversity observed in the natural parks grouped in this category. Finally, CWMs represent the most extreme type of environment analyzed, being the driest (Fig. 4) and most homogeneous in terms of water bodies typology, which acts as limiting factor in the diversity observed in that category.

Similarity and dissimilarity analysis

The analysis of β biodiversity (Table 3), indicates that IMAs and CMAs are the closest categories in their specific composition ($I_j = 0.32$; $I_{Squant} = 0.51$), showing the lower replacement degree ($\beta_W = 0.52$) between pairs analyzed, observations also supported by the complementarity index ($C_{IMA-CMA} = 68.18\%$). With the aim of representing the information provided by the Jaccard index, a cluster analysis based on Jaccard's distance was carried out, corroborating the same conclusions already given before (Fig. 5). The high value of Jaccard distance cophenetic correlation ($r_c = 0.9975$) indicates a high correlation level between the ecological distance ob-

served in the study and the distance predicted by the hierarchical configuration of the cluster.

As a result of the PCA, two principal components were extracted explaining a 93.06% of the total variability observed ($PC_1 = 83.55\%$; $PC_2 = 9.51\%$) (Fig. 6). It is worth pointing out the large dispersion exhibited by *Cx. pipiens*, *Cs. longiareolata* and *Cx. laticinctus*, which are the most abundant and dominant species in all studied communities. It is also interesting to mention the close relationship existing between IMAs (the most diverse and heterogeneous) and species such as *Cx. mimeticus*, *Cx. impudicus* and *An. petragrani*, which define perfectly the main vector of this natural park category. Specially significant is the case of *Cx. hortensis hortensis*, which has been described as one of the regular members of the most biodiverse Culicidae communities in our region (Bueno Marí & Jiménez Peydró, 2011).

In the case of CWMs, note the relationship with typical halophilic species, being *O. caspius* and *O. detritus* the ones that best define the axis of this category, despite the fact that *Cx. pipiens* was the most common and dominant species in CWMs.

Integrated landscape biodiversity

As mentioned above, gamma (γ) diversity was calculated following Schluter & Ricklefs (1993) and Lande (1996) criteria. As a result, $\gamma_{(Schluter \text{ and } Ricklefs)}$ was 25.71, virtually identical to the value of the total specific richness ($S = 25$) evidenced in the study area. On the other hand, $\gamma_{(Lande)}$ was 19.99 with an α contribution of 60.05% and a β contribution of 39.95%, demonstrating that the alpha diversity of the richest community (IMAs) contributes to a greater extent of the gamma diversity (60.05%), which implies a low level of complementarity between categories and a high proportion of exclusive species in each category studied.

CONCLUSIONS

Due to the limited existence of studies based on mosquito diversity in Spain (Demba et al., 2005; Bueno Marí, 2011; Bueno Marí & Jiménez Peydró, 2011), the results of our study represent an interesting contribution to the general knowledge about Culicidae diversity in our country. According to

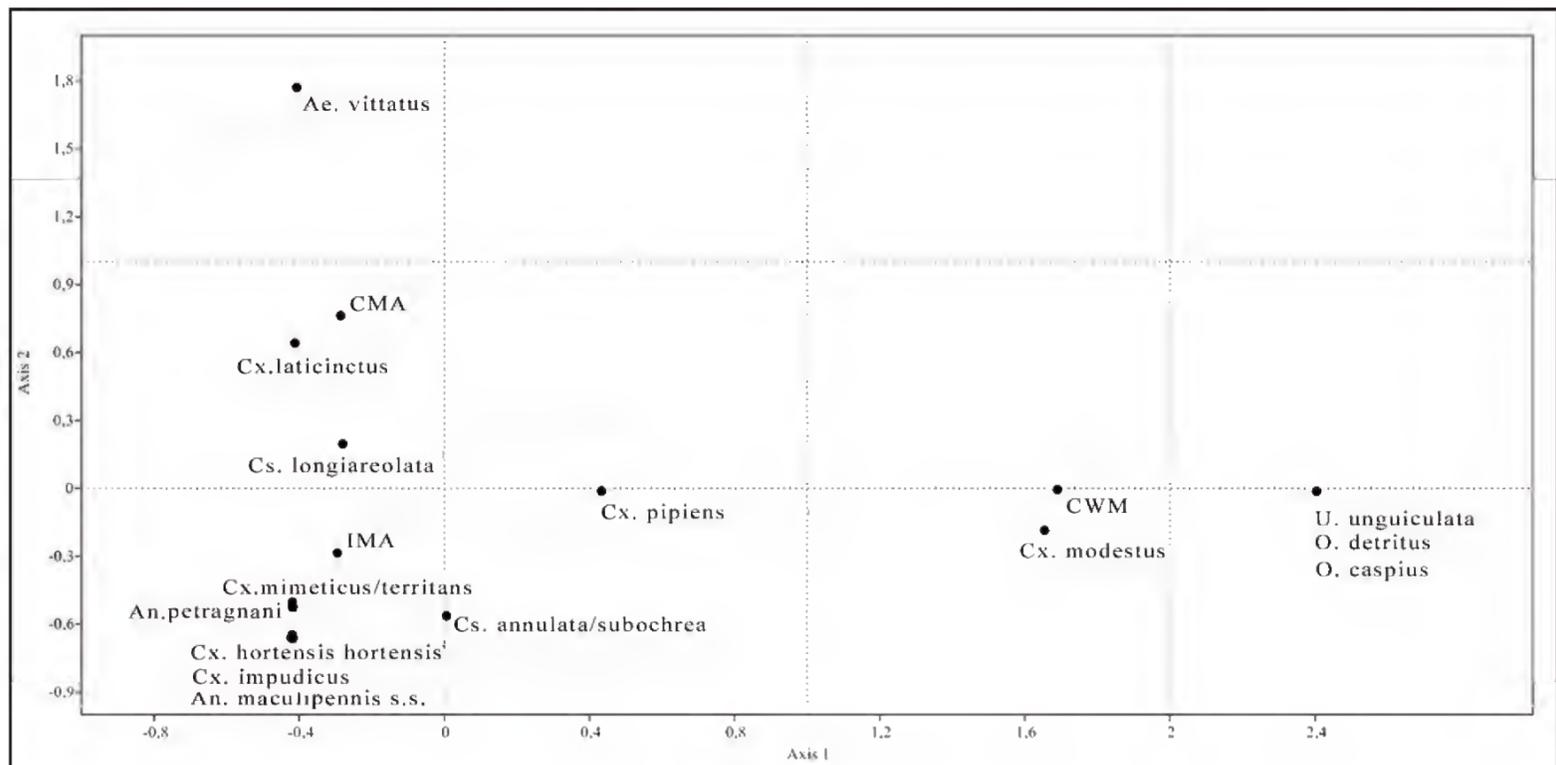


Figure 6. Principal Components Analysis (PCA) based on the larval abundance within each natural park category.

Margalef Index and specific richness, IMAs show the highest diversity observed in the Valencian Autonomous Region's natural parks, probably due to various factors that should be taken into account. In first place, these are the most extensive areas, facilitating landscape heterogeneity and larval biotopes diversity present within their limits. These conditions favor their colonization and increase the likelihood of the presence of suitable host on which to feed. Another aspect to consider is the water quality sampled (low levels of eutrophy), the high level of replacement and longer periods of stay (higher precipitation regimes favor both aspects) (Rivas Martínez, 2004), aspects strongly related with the presence of species such as *Cx. hortensis hortensis* and *An. petragrani*. CMAs recorded a lower level of diversity, a fact that relates to their lower surface and larger coastline influence. These conditions lead to a decrease in turnover rate and retention of water (high drought times) (Rivas Martínez, 2004), favoring an ecological filter toward less sensitive species and better adapted to strong changes such as *Cs. longiareolata* and *Cx. laticinctus* (Becker et al., 2010).

CWMs are the natural parks that suffer from the stronger influence by the closeness of the sea, showing a greater homogeneity of larval habitats, a lower level of replacement and water permanence (Rivas Martínez, 2004), promoting the presence of heavily adapted species (such as *O. caspius*, *O. detritus* and

U. unguiculata) or highly plastic ones (such as *Cx. pipiens*). On the other hand, the concentration of human population in coastal zones (INE, 2011) and the higher level of anthropogenic influence has been linked to the decline of diversity in other areas of our territory (Bueno Marí et al., 2010). In this case, it has been observed a pattern of loss of diversity from inland areas (IMAs) toward coastal ones (CWMs), coinciding with the assessments of Bueno Marí & Jiménez Peydró (2011), who maintain that a high level of anthropization does not imply a reduction of mosquito populations in urban environment, but rather an ecological selection filter that is only surpassed by a few species.

Finally, it is particularly interesting to note the high level of correlation observed between IMAs and a small group of species (*An. petragrani*, *Cx. hortensis hortensis*, *Cx. impudicus* and *Cx. mimeticus*), which behave as indicators of this category and, therefore, can be related to a high degree of conservation of the environment for future studies on bioindicator species (Dorvillé, 1996, Montes, 2005).

To conclude, IMAs have a higher diversity of Culicidae with a lesser degree of dominance and a greater intraspecific evenness. On the other hand, CWMs represent the less diverse and uniform communities, with a greater degree of interspecific dominance. These communities are composed of a few abundant and a high number of rare species,

establishing a clear relationship between Culicidae abundance and the prevailing climatic conditions.

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REFERENCES

- Becker N., Petric D., Zgomba M., Boase C., Madon M., Dahl C. & Kaiser, A., 2010. Mosquitoes and their control. Springer, London, 577 pp.
- Bueno Marí R., 2011. Bioecología, diversidad e interés epidemiológico de los culícidos mediterráneos (Diptera: Culicidae). Servei de Publicacions de la Universitat de València, Valencia, 423 pp. Available online at: <http://hdl.handle.net/10803/52158>.
- Bueno Marí R. & Jiménez Peydró R., 2008 Malaria en España: Aspectos entomológicos y perspectivas de futuro. *Revista Española de Salud Pública*, 82: 161-163.
- Bueno Marí R. & Jiménez Peydró R., 2011. Differences in mosquito (Diptera: Culicidae) biodiversity across varying climates and land-use categories in Eastern Spain. *Entomologica Fennica*, 22: 190-198.
- Bueno Marí R., Corella López E. & Jiménez Peydró R., 2010. Culicidofauna (Diptera: Culicidae) presente en los distintos enclaves hídricos de la ciudad de Valencia (España). *Revista Colombiana de Entomología*, 36: 235-241.
- Darsie R.F. & Saminadou Voyadjoglou A., 1997. Keys for the identification of the mosquitoes of Greece. *Journal of the American Mosquito Control Association*, 13: 247-254.
- Demba Sy M., Remus Zamfirescu S., Thiam N. & Palanca Soler A., 2005. Diversity of mosquitoes in a semiarid environment from San Juan del Flumen (Los Monegros, Huesca, Spain) (Diptera, Culicidae). *Boletín de la Asociación Española de Entomología*, 29: 23-33.
- Dorvillé L.F.M., 1996. Mosquitoes as bioindicators of forest degradation in southeastern Brazil, a statistical evaluation of published data in the literature. *Studies on Neotropical Fauna and Environment*, 31: 68-78.
- Generalitat Valenciana (GVA), 2003. Hábitats prioritarios de la Comunidad Valenciana. Conselleria de Territori i Habitatge, Valencia, 222 pp.
- Halffter G., 1998. A strategy for measuring landscape biodiversity. *Biology International*, 36: 3-17.
- Hammer Ø., Harper D.A.T. & Ryan P.D., 2001. PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica*, 4: 9. Available online in: http://palaeo-electronica.org/2001_1/past/issue1_01.htm.
- Instituto Nacional de Estadística (INE), 2011. Cifras oficiales de población resultantes de la revisión del padrón municipal (01/01/2011). Available online at: <http://www.ine.es/jaxi/tabla.do>. Accessed 3 March 2013.
- Lande R., 1996. Statistics and partitioning of species diversity and similarity among multiple communities. *Oikos* 76: 5-13.
- Magurran A.E., 1988. Ecological diversity and its measurement. Princeton University Press, New Jersey, 179 pp.
- Montes J., 2005. Culicidae fauna of Serra da Cantareira, Sao Paulo, Brazil. *Revista de Saude Publica Sao Paulo*, 29: 578-584.
- Moreno C., 2001. Métodos para medir la biodiversidad. Manuales & Tesis de la SEA. Editorial Cyted, Orcyt-Unesco & SEA, Zaragoza, 84 pp.
- Rivas Martínez S., 2004. Centro de Investigaciones Fitosociológicas. Global Bioclimatics Org. Available online at: <http://www.ucm.es/info/cif>. Accessed 3 March 2013.
- Schaffner F., Angel G., Geoffroy B., Hervy J.O. & Rhaeim A., 2001. The mosquitoes of Europe/Les moustiques d'Europe [computer program]. France: IRD Éditions and EID Méditerranée, Montpellier.
- Schluter R.E. & Ricklefs R.E., 1994. Species diversity: an introduction to the problem, in: Ricklefs, R.E. & Schluter, R.E. (Eds.), *Species diversity in ecological communities: historical and geographical perspectives*. The University of Chicago Press, Chicago, pp. 1-10.
- Service M.W., 1993. Mosquito Ecology. Field Sampling Methods. Elsevier Science Publishers, London, 988 pp.
- Shannon C.E. & Weaver W., 1949. *The Mathematical Theory of Communication*. The University of Illinois Press, Urbana, Ill, 144 pp.
- Simpson E.H., 1949. Measurement of diversity. *Nature*, 163: 688-688.
- Wittaker R.H., 1972. Evolution and measurement of species diversity. *Taxon*, 21: 213-251.
- Zhong H., Yan Z., Jones F. & Brock C., 2003. Ecological analysis of mosquito light trap collections from West Central Florida. *Environmental Entomology*, 32: 807-815.

Phenotypic diversity, taxonomic remarks and updated distribution of the Mediterranean *Jujubinus baudoni* (Monterosato, 1891) (Gastropoda Trochidae)

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ABSTRACT

Jujubinus baudoni (Monterosato, 1891) shows highly diverse chromatic and morphological patterns. Based on the examination of the type material and series of specimens from private collections, and of recent findings from Sardinia, we reviewed and updated the distribution of this species, and figured the three representative shell colour morphs which are constant in local populations. A comparative SEM analysis did not outline significant differences among shells with greatly different colour patterns, thus justifying their belonging to a single specific entity. The survey of the material of *J. baudoni* did not show a strict correspondence between Corse and Sardinian shell colour morphs and their geographical distribution, not allowing to clearly state trends and relationships among island populations. On the contrary the colour pattern of the continental shells of *J. baudoni* seems to be constant and different from the ones of the island shells, indicating a well separated colour morph. This study confirmed that the distribution of *J. baudoni* is limited to the north-western Mediterranean Sea, with its eastern range widened to the La Maddalena Archipelago (Sardinia). The record of this species from Azores is due to a misidentification with *J. pseudogravinae* Nordsieck, 1973, which is also figured for comparison. A lectotype and paralectotypes of *Trochus baudoni* are herein designated.

KEY WORDS

Trochidae; *Jujubinus baudoni*; Monterosato collection; colour morph; Mediterranean Sea.

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INTRODUCTION

The genus *Jujubinus* Monterosato, 1884 was nominally based on *Trochus matoni* Montagu, 1803 and it is represented by a small group of marine gastropods living mostly in the intertidal zone down to about 80 m, invariably associated with photophilic algal vegetation and/or marine phanerogames. The alpha-taxonomy of this genus still has to be completely solved, but it is currently accepted that sev-

eral different species occur worldwide albeit, mainly on European waters, the exact number at the moment amounts to 29 according to WoRMS (World Register of Marine Species available at <http://www.marinespecies.org/index.php>; Appeltans et al., 2012). In particular, 18 taxa are listed by CLEMAM (at <http://www.somali.asso.fr/clemam/index.php>; Gofas & Le Renard, 2013) as European species, most of them restricted to the Mediterranean basin. Among the Mediterranean taxa be-

longing to this genus, *Jujubinus baudoni* (Monterosato, 1891) was reevaluated as bona species by Curini Galletti (1982). *J. baudoni* was described under the genus *Trochus* Linnaeus, 1758 by Monterosato (1891) with a very scanty description: “Il T. Baudoni, H. Martin mss., è una piccola forma grosse-sculpta, vivente in abbondanza sulle coste di Provenza” (“The T. Baudoni, H. Martin mss., is a small form heavily sculptured, abundant and living along the coast of Provence”). Since the paper of Curini Galletti (1982), only two further reports were recently published dealing with this species: by Scaperrotta et al. (2011), who figured shells from Corse, and by Spanu (2011) who reported specimens from the northwestern Sardinian coast. *J. baudoni* is present on the infralittoral zone and is considered locally common of the Catalan coast, Gulf of Lion, Corse and North-Western Sardinia (Curini Galletti, 1982; Scaperrotta et al., 2011; Spanu, 2011). The Azores Islands cannot be considered in the *J. baudoni* distribution, since the material examined in the Monterosato collection and labelled as *Calliostoma baudoni* coming from these islands, tentatively identified as *J. pseudogravinae* Nordsieck, 1973 by Curini Galletti (1982), has been confirmed to belong to this latter taxon. We have analyzed the type material of *Trochus baudoni* Monterosato, 1891 and *J. baudoni* var. *incomparabilis* Locard et Caziot (1901) (reported by CLEMAM as *J. baudoni incomparabilis* Ghisotti et Melone, 1975), and series of specimens of *J. baudoni* from private collections. A lectotype of *J. baudoni* is herein designated. We found that this species shows a great morphological variability, mainly concerning its colour pattern, which is very constant within the different population examined. A survey of colour morphs from different localities is here presented and, as far as to our knowledge, this study confirmed that the distribution of *J. baudoni* is limited to a restricted area of the North-Western Mediterranean basin, being slightly enlarged to east with the sampling of shells from the La Maddalena Archipelago (Sardinia). Shells from Monterosato’s collection labelled as *J. baudoni* and *J. pseudogravinae* from the Azores are figured for comparison.

ACRONYMS AND ABBREVIATIONS. Carlo Smriglio and Paolo Mariottini collections, Rome, Italy (CS-PM); Monterosato (MTS); Museo Civico di Zoologia, Rome, Italy (MCZR); Scanning Electron Microscopy (SEM).

MATERIALS AND METHODS

EXAMINED MATERIAL. We could examine the type material of *Trochus baudoni* in the Monterosato collection at the MCZR, consisting of empty shells: 134 exx from Paulilles (France); 30 exx from Roussillon (France); 12 exx from Département de l’Aude, Pyrénées Orientales (France); 20 exx *J. baudoni* var. *incomparabilis* from Pietranera, (Corse). A lectotype from the Paulille lot has been designated with the number MCZR00218 and the remaining material have been designed as paralectotypes MCZR00219/1-195. Furthermore, 18 exx from Azores (Portugal) MCZR 11761, named as *Calliostoma baudoni* but not related to this species, have been examined.

Other empty shells of *J. baudoni* examined: 2 exx from Cadaques (Spain), collected at a depth of 4 m; 3 exx from Capo Caccia, Sardinia (Italy), depth of 25 m. From La Maddalena Archipelago, Sardinia (Italy) further empty material was gathered among the shell grit collected handily by SCUBA diving: 59 exx from Caprera Is., depth of 25 m; 91 exx from La Maddalena Is., depth of 25 m; 62 exx of Spargi Is., depth of 20 m. Material referring to *J. pseudogravinae*: 8 exx from Azores (Portugal), dealer source. SEM photographs were carried out at the Interdepartmental Laboratory of Electron Microscopy (LIME), Università Roma Tre, Rome, Italy.

RESULTS AND DISCUSSION

We analysed the type material of *T. baudoni*, including the *J. baudoni* var. *incomparabilis* shells, stored at the MCZR and we figured some shells and original labels (Figs. 1a-12b). The shells of *J. baudoni* var. *incomparabilis* well fit the description given by Locard and Caziot (1901): “Nous revelon une très belle var. incomparabilis (M tr.), d’une coloration verte et rouge”. A lectotype and paralectotypes of *T. baudoni* have been herein designated. From the examination of these shells, and the accompanying labels, as well as of shells from private collections, we could confirm the systematic status of this species and derived its distribution. In fact, Monterosato’s material labelled as *T. baudoni* from Azores (Figs. 13-15d) resulted to be *J. pseudogravinae* Nordsieck, 1973 after a literature research (Ávila et al., 2004; Ávila et al., 2007;

Ávila et al., 2011) and a direct comparison with shells of this endemic species (Figs. 16a-d, 29a-n). Most probably the bad conservation of the shells (sent by Dautzenberg, see handwriting label of Fig. 14) has induced Monterosato to identify wrongly these specimens, as already suggested by Curini Galletti who examined this material (1982). As far as we know, there are no reliable records of *J. baudoni* from Alboran Sea or Atlantic Ocean, including Azores islands. On the contrary, from literature and personal sampling (Figs. 17a-24b) the distribution of this species seems to be rather confined to the north-western Mediterranean basin (Ghisotti & Melone, 1975; Curini Galletti, 1982; Scaperrotta et al., 2011; Spanu, 2011).

The distribution of *J. baudoni* has been slightly enlarged to east with the shells collected by SCUBA diving in the La Maddalena Archipelago (Sardinia); in particular material was collected in the infralittoral zone from three islands of the Archipelago (Caprera, La Maddalena, Spargi) (Figs. 22a-24b; Table 1).

Regarding the morphological variability of this taxon, interestingly we found different phenotypes, being the shells (colour morph A) from the continental coast stouter, slightly more coarsely sculptured, showing prosocline reddish-brown and milky-white flammules, higher in number on the basal cordlet (Figs. 1a-8c; 17a-18c), in respect to the specimens from Corse and Sardinia. In turn, these latter can be divided in two different colour patterns regarding the teleoconch coloration: 1) the typical *J. baudoni* var. *incomparabilis* coloration (colour morph B), which consists in an emerald green background interrupted by bright orange and/or red flammules and milky-white prosocline stripes, with white spots on the basal cordlet (Figs. 9a, 12b, 19a-20b); 2) colour morph C, almost entirely brownish-green or with prosocline faint whitish flammules (Figs. 22a, 24b).

We recall that all *J. baudoni* shells invariantly show protoconch and initial teleoconch whorls of red colour. It is worth to mention that this feature has induced several authors in the past to erroneously identify *J. baudoni* as *J. exasperatus corallinus* (Monterosato, 1884) (Figs. 21a-c-30a-e), as recalled by Curini Galletti (1982) and Spanu (2011). Since it is possible to easily separate the three colour patterns, as well as the continental shells from the Corse and Sardinian ones, due to their slight dif-

ferences in the teleoconch sculpture, a comparative SEM analysis was carried out. The examination of the SEM photographs did not reveal any significant protoconch and teleoconch sculpture differences among all the shells analysed (Figs. 25a-28g), in spite of their diverse colour patterns, thus indicating that we are probably facing a single specific entity. It is a matter of fact, the colour pattern of the continental shells of *J. baudoni* seems to be constant and different from the ones of the island shells, indicating a well separated phenotype. On the contrary, shells of *J. baudoni* from Corse and Sardinia did not show a strict correspondence between colour morphs and their geographical distribution, not allowing to clearly state trends and relationships among island populations. In many marine gastropods a direct genetic control of shell coloration has been demonstrated, and in several cases variation in shell colour has been considered to be an adaptive value related to environmental variables such as climate, diet, habitat choice, insolation, salinity, visual predation and wave exposure (Terreni, 1981; Byers, 1989; Sokolova & Berger, 2000 and references therein; Miura et al., 2007). Shell colour may have three functions: communication, crypsis and thermoregulation, and it has been suggested that correlation between individual physiology and shell colour polymorphism is a result of pleiotropic effects of genes responsible for the shell colour or a linkage between them and genes determining certain physiological features (Sokolova & Berger, 2000 and references therein; Miura et al., 2007). The factors that maintain the color polymorphism, and those that contribute to among-site variation in color frequencies, remain unknown. Although the color polymorphism may have an underlying genetic component, the regional-scale variation in color frequency observed in *J. baudoni* could be ecologically controlled.

Interestingly, another member of the genus *Jujubinus*, *J. geographicus* Poppe, Tagaro et Dekker, 2006 shows a parallel shell colour variability (Figs. 31a, 32), including one very similar to the morph B (red-green pattern, Figs. 31a-c) and one entirely red (Fig. 32). In particular, green is a rare colour occurring in marine shell coloration and the occurrence of this colour in two different species so distantly geographically separated (Mediterranean and Philippines) could be due to a common genetic background the phenotype of which is selected by similar ecological constraints.

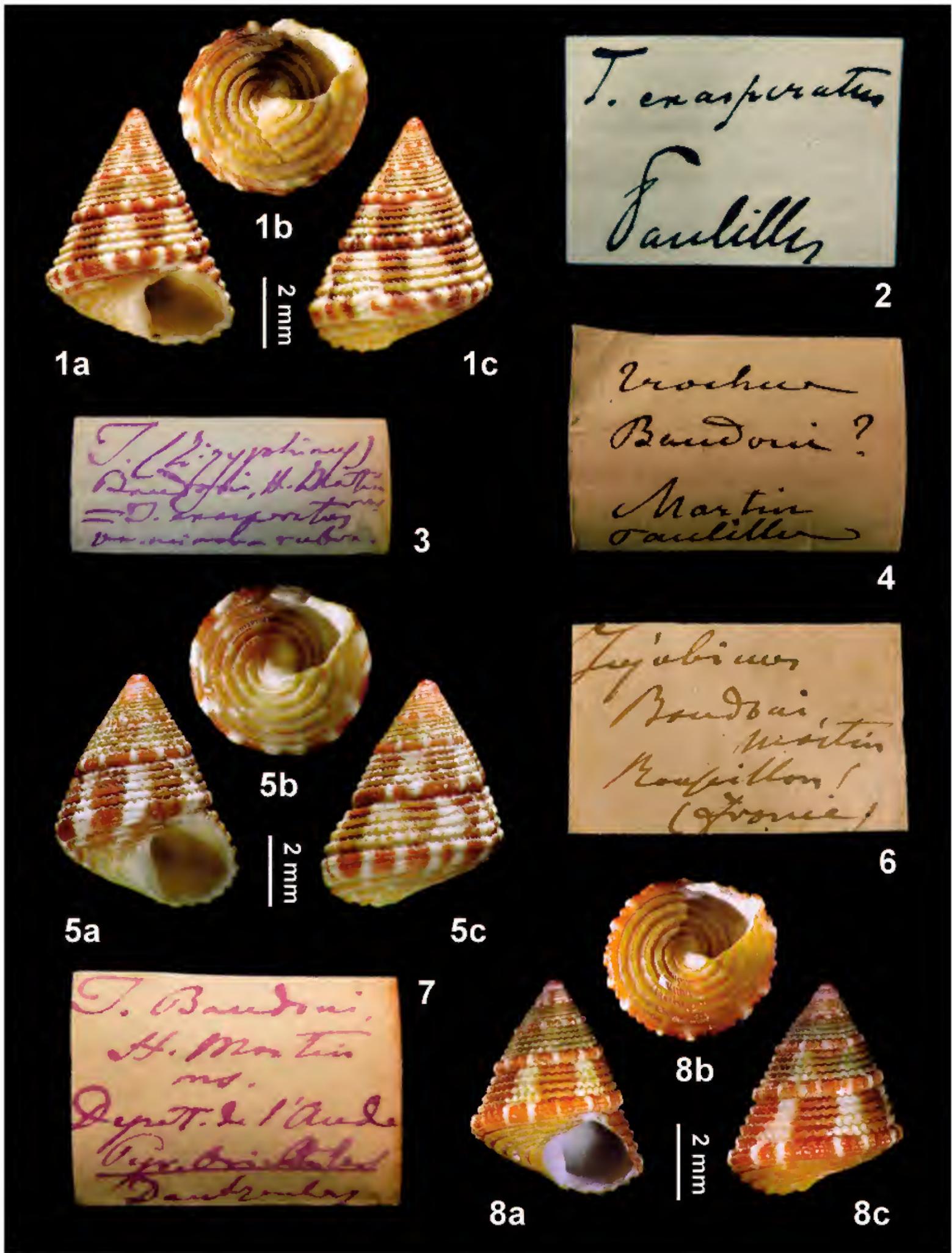


Figure 1. *Trochus baudoni*. MTS collection, lectotype MCZR00218, H = 6.5 x D = 5.2 mm, Paulilles (France). Figures 2-4. MTS collection, original labels. Figure 5. *T. baudoni*. MTS collection, 6.3 x 5.0 mm, Roussillons (France). Figures 6, 7. MTS collection, original labels. Figure 8. *T. baudoni*. MTS collection, 5.7 x 4.7 mm, Department de l'Aude (France).

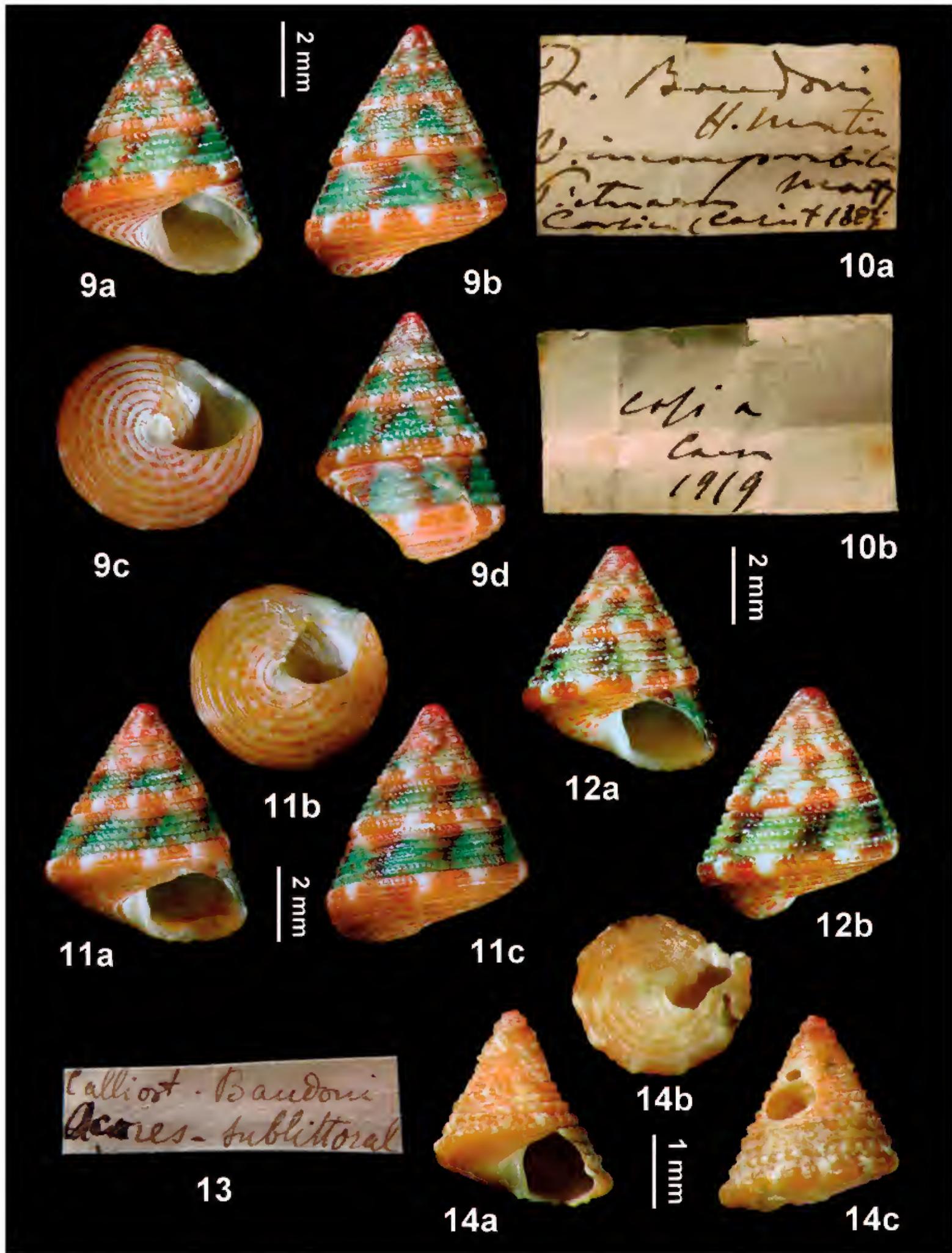


Figure 9. *Jujubinus baudoni* var. *incomparabilis*. MTS collection, H = 6.0 x D = 4.9 mm, Pietranera (Corse). Figure 10. MTS collection, original label. Figure 11. *J. baudoni* var. *incomparabilis*. MTS collection, 6.1 x 5.0 mm, Pietranera (Corse). Figure 12. *J. baudoni* var. *incomparabilis*. MTS collection, 5.4 x 4.8 mm, Pietranera (Corse). Figure 13. MTS collection, original label. Figure 14. *J. pseudogravinae*. MTS collection, 2.8 x 2.6 mm, Azores Islands.

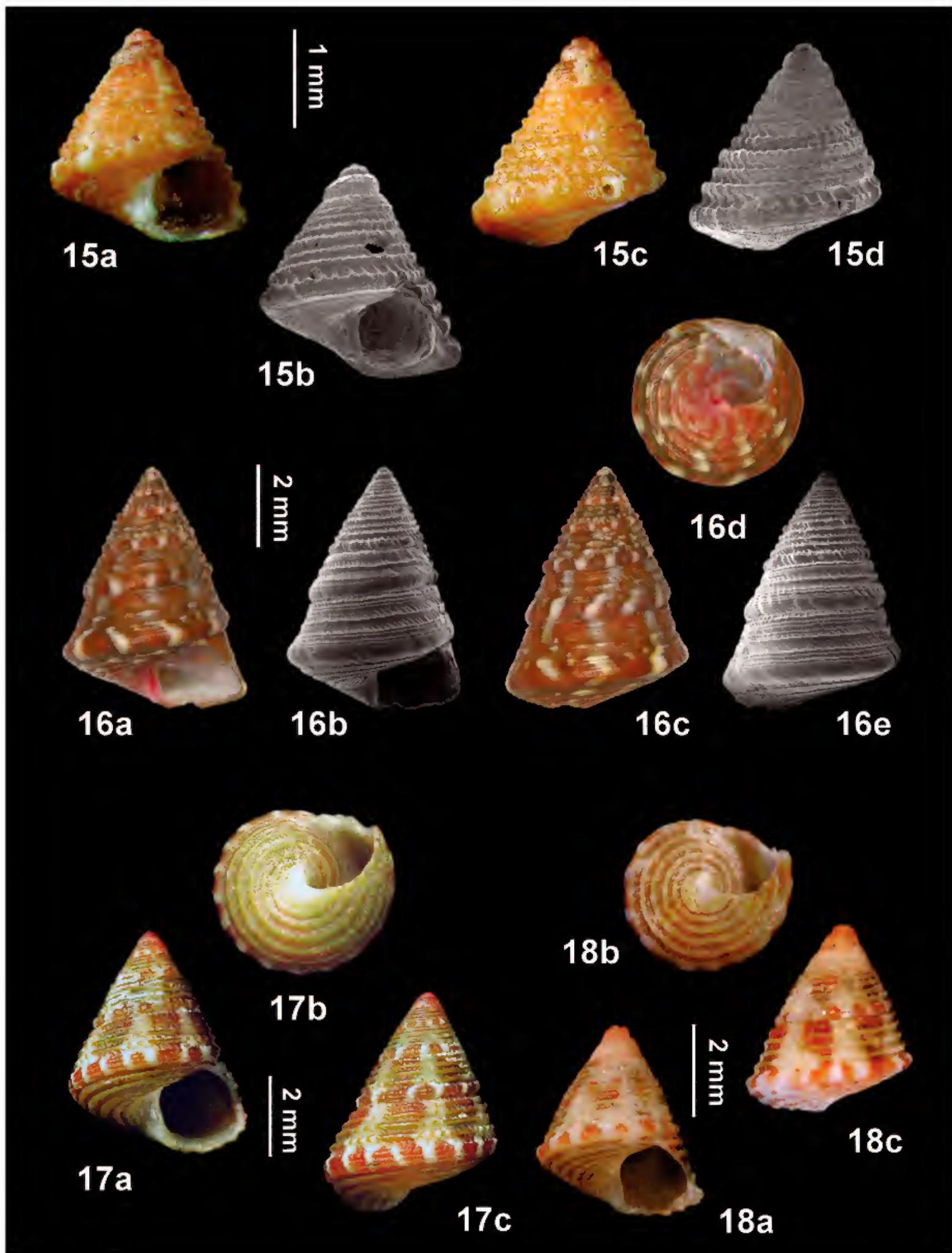


Figure 15. *Jujubinus pseudogravinae*. MTS collection, H = 2.7 x D = 2.6 mm, Azores Islands, MTS collection. Figure 16. *J. pseudogravinae*. CS-PM collection, 6.9 x 4.8 mm, Cais da Ribeirinha, S. Miguel Is. (Azores Islands), on stones, 10 m depth. Figure 17. *Jujubinus baudoni*. CS-PM collection, 5.5 x 4.4 mm, Cadaques (Spain), 4 m depth. Figure 18. *J. Baudoni*. CS-PM collection, 3.9 x 3.1 mm, Cadaques (Spain), 5 m depth.

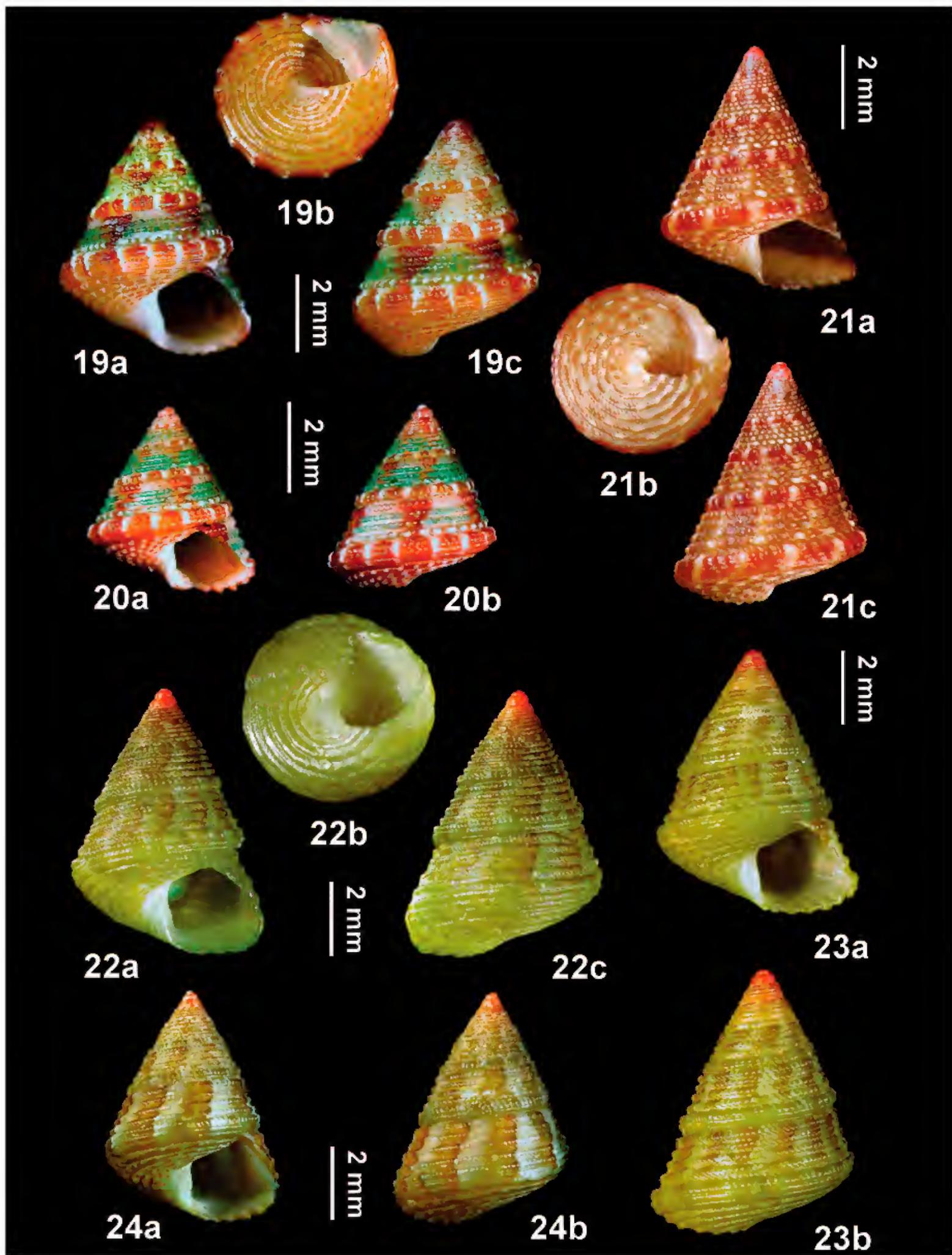


Figure 19. *Jujubinus baudoni* var. *incomparabilis*. CS-PM collection, H = 5.9 mm x D = 4.6 mm, Capo Caccia (Sardinia), 15 m depth. Figure 20. *idem*, 4.1 mm x 3.7 mm. Figure 21. *J. exasperatus corallinus*. CS-PM collection, 6.2 x 4.9 mm, La Maddalena Is. (Sardinia), 25 m depth. Figure 22. *J. baudoni*. CS-PM collection, 7.1 x 4.8 mm, La Maddalena Is., Sardinia, 25 m depth. Figure 23. *idem*, 7.1 x 4.9 mm, Caprera Is. (Sardinia), 30 m depth. Figure 24. *idem*, 6.0 x 4.2 mm.

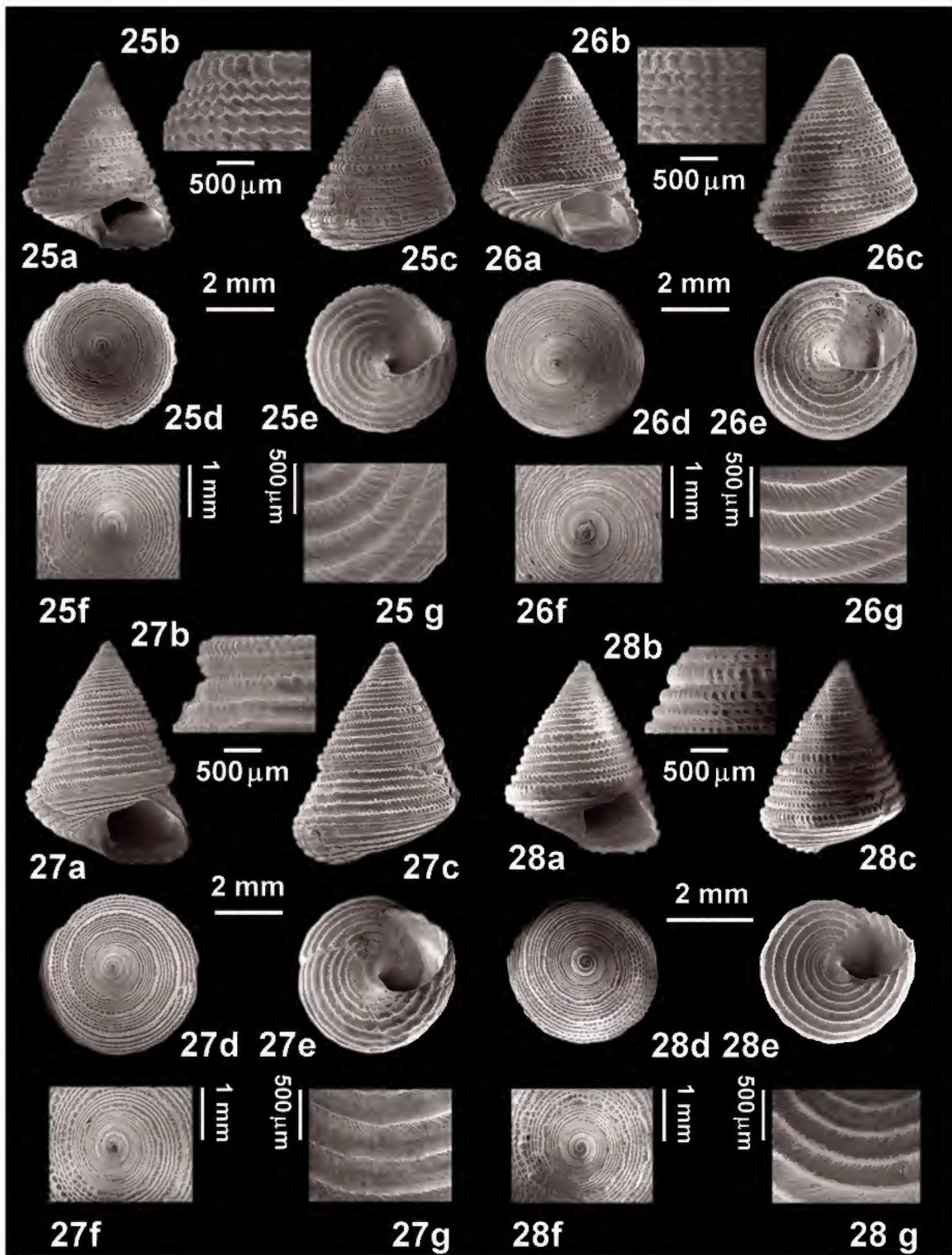


Figure 25. *Trochus baudoni*. MTS collection, H = 4.7 x D = 4.2 mm, Paulilles (France). Figure 26. *Jujubinus baudoni* var. *incomparabilis*. MTS collection, 6.1 x 4.8 mm, Pietranera (Corse). Figure 27. *J. baudoni* (Monterosato, 1891); specimen of figure 22. Figure 28. *J. baudoni*. CS-PM collection, 4.6 x 3.4 mm, Caprera Is. (Sardinia), 30 m depth.

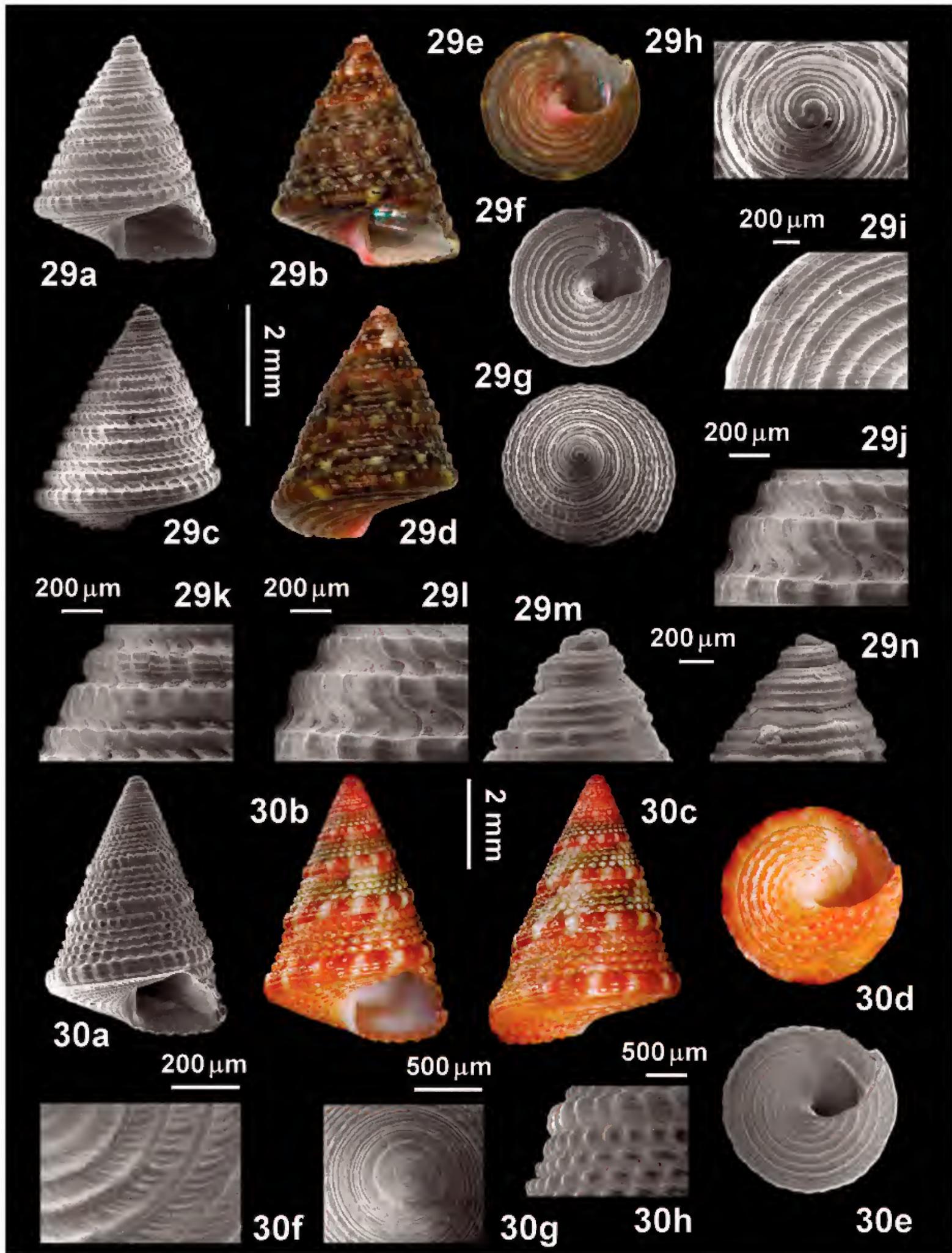


Figure 29. *Jujubinus pseudogravinae* Nordsieck, 1973. CS-PM collection, H = 4.5 x D = 3.0 mm, Cais da Ribeirinha, S. Miguel Is. (Azores Islands), on stones, 10 m depth. Figure 30. *J. exasperatus corallinus*. CS-PM collection, 6.8 x 4.6 mm, Bosa Marina (Sardinia), 30 m depth.

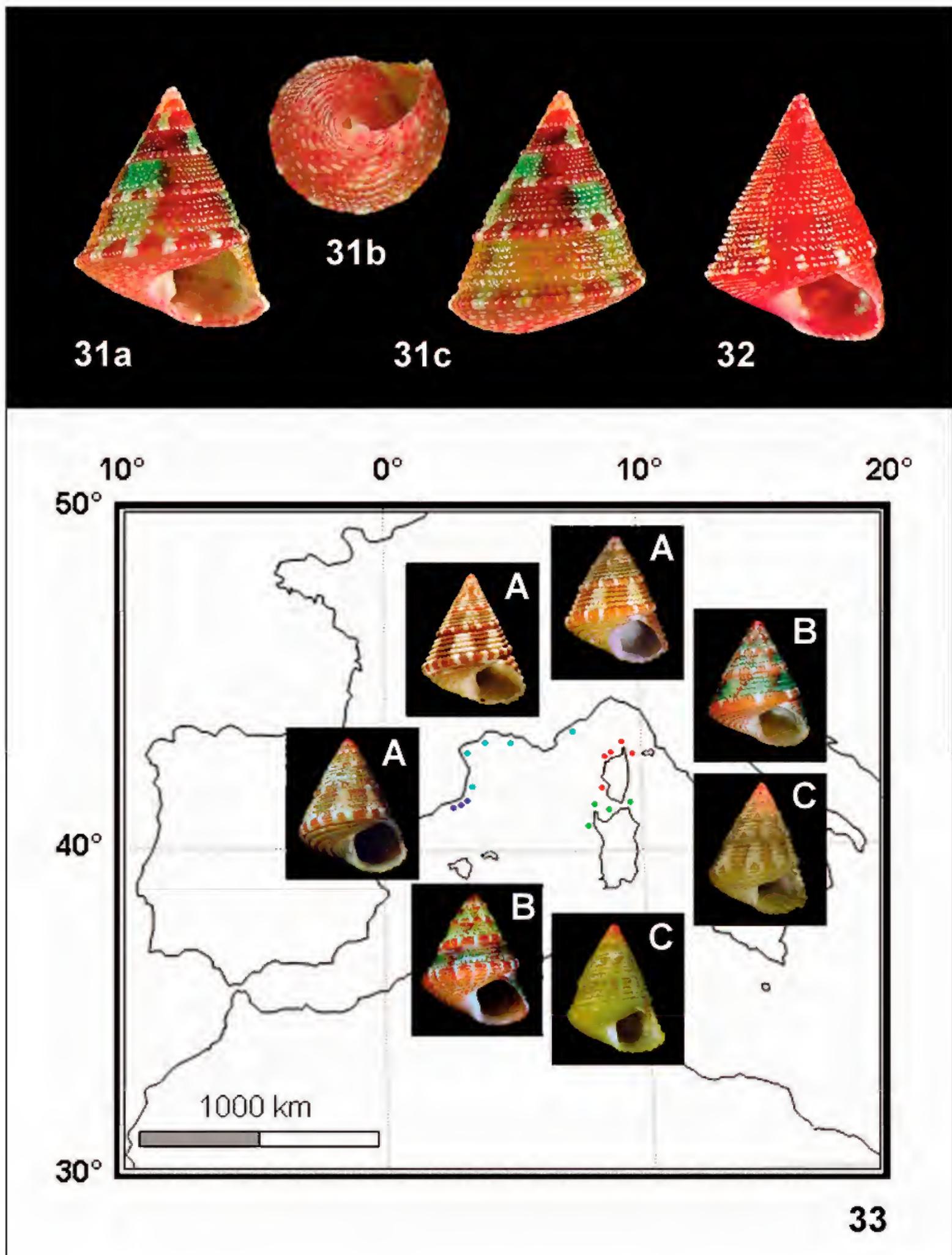


Figure 31. *Jujubinus geographicus*. Holotype, H = 4.9 x D = 3.9 mm, Punta Engano, Mactan Island (Philippines), 80-150 m depth. Figure 32. *J. geographicus*. Topotype, 4.8 x 3.3 mm, Punta Engano, Mactan Island (Philippines), 80-150 m depth. Fig. 33. *J. baudoni*. Morphotypes A-C distribution.

COAST	LOCALITY	REFERENCES
SPAIN	La Escala, Girona, Palamòs	Curini Galletti, 1982; Giannuzzi-Savelli et al., 1994
	Port Lligat, Cadaques	Spanu, 2011; this work
FRANCE	Paulilles, Roussillon; Dupott de l'Aude, Pyrénées Orientales	Monterosato, 1891
	Lérin Islands, Provence	Spanu, 2011
CORSE	Pietranera	Monterosato, 1891
	Ajaccio; Ile-Rousse; Barcaggio; Bastia	Locard & Caziot, 1901
	Revellata	Scaperrotta et al., 2011
SARDINIA	Capo Caccia, Alghero (Sassari); Asinara Island, Punta Aguada (Sassari); Costa Paradiso, Trinità d'Agultu (Olbia-Tempio)	Spanu, 2011; this work
	La Maddalena Archipelago (Olbia-Tempio)	This work

Table 1. Records of *Jujubinus baudoni* from the North-Western Mediterranean area (from literature and this work).

CONCLUSIONS

Type material of *Trochus baudoni* and *Jujubinus baudoni* var. *incomparabilis*, together with other shells of this species have been analysed and figured in the present work. A lectotype and paralectotypes of *T. baudoni* have been designated. *J. baudoni* resulted to be represented by highly diverse chromatic shells, and three distinct colour morphs (A-C) have been recognized and figured, but comparative SEM analyses demonstrated that there are no significant differences in the shell sculpture, suggesting that they belong to a single specific entity. Since members of genus *Jujubinus* graze on a variety of micro-algal food sources, such as diatoms and green algal epiphytes (Peduzzi, 1987), we can infer that the different colour patterns observed in *J. baudoni* are influenced by diverse environmental factors. This could explain the occurrence of the same colour pattern in disjointed populations of the same geographical area, like the case of the colour morph B of Pietranera (Corse) and Capo Caccia (Sardinia), which are separated by the colour morph C (Fig. 33 and Table 1). However, we cannot rule out a different scenario, where those phenotypes correspond to a mosaic of sibling species. In the present study, we prefer to be con-

servative in non-assigning a taxonomic status to these different chromatic patterns. Genetic analyses are required to verify our current interpretation and further studies are necessary to reveal mechanisms maintaining shell colour polymorphism among populations of *J. baudoni* and understand if there is a physiological selection as a driving force shaping the pheno-(geno-)typic structure of these populations along the continental and island coasts. As far as we know, the distribution of *J. baudoni* is limited to the North-Western Mediterranean Sea, with its eastern range widened to the La Maddalena Archipelago (Sardinia) (Fig. 33). On the contrary, this species does not occur in the Azores, having been misidentified with *J. pseudogravinae*.

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Philippines) for the permission to use a *J. baudoni* and *J. geographicus* photographs, respectively.

REFERENCES

- Appeltans W., Bouchet P., Boxshall G.A., De Broyer C., de Voogd N.J., Gordon D.P., Hoeksema B.W., Horton T., Kennedy M., Mees J., Poore G.C.B., Read G., Stöhr S., Walter T.C. & Costello M.J., 2012. World Register of Marine Species. Available at <http://www.marinespecies.org> (accessed 8 May 2013).
- Ávila S.P., Cardigos F. & Santos R.S., 2004. D. João de Castro Bank, a shallow water hydrothermal-vent in the Azores: checklist of the marine molluscs. *Arquipélago. Life and Marine Sciences*, 21A: 75-80.
- Ávila S.P., Cardigos F. & Santos R.S., 2007. Comparison of the community structure of the marine molluscs of the "Banco D. João de Castro" seamount (Azores, Portugal) with that of typical inshore habitats on the Azores archipelago. *Helgol Marine Research*, 61: 43-53.
- Ávila S.P., Borges J.P. & De Frias Martins A.M., 2011. The littoral Trochoidea (Mollusca: Gastropoda) of the Azores. *Journal of Conchology*, 40: 408-427.
- Byers B.A., 1989. Habitat-choice polymorphism associated with cryptic shell-color polymorphism in the limpet *Lottia digitalis*. *The Veliger*, 32: 394-402.
- Curini Galletti M., 1982. Note ai Trochidae, VI. *Jujubinus Baudoni* H. Martin in Monterosato, 1891. *Atti della Società Toscana di Scienze Naturali, Memorie, serie B*, 89: 75-85.
- Giannuzzi-Savelli R., Pusateri F., Palmeri A. & Ebreo C., 1994. Atlas of the Mediterranean Sea Shells. "La Conchiglia" Ed., Roma, 125 pp.
- Ghisotti F. & Melone G., 1975. Catalogo illustrato delle conchiglie marine del Mediterraneo, 5. *Conchiglie*, 11, suppl. 5: 147-208.
- Gofas S. & Le Renard J., 2013. CLEMAM: Check List of European Marine Mollusca. Available at <http://www.somali.asso.fr/clemam/index.clemam.html> (accessed 8 May 2012).
- Locard A. & Caziot E., 1901. Les coquilles marines des cotes de Corse. *Annales de la Société Linnéenne de Lyon*, 47: 158-294.
- Miura O., Nishi S. & Chiba S., 2007. Temperature-related diversity of shell colour in the intertidal gastropod *Battillaria*. *Journal of Molluscan Studies*, 73: 235-240.
- Monterosato T. di Maria di, 1891. Molluschi fossili quaternari di S. Flavia. *Il Naturalista siciliano*, 10: 96-104.
- Peduzzi P., 1987. Dietary preferences and carbon absorption by two grazing gastropods *Gibbula umbilicaris* (Linne') and *Jujubinus striatus*. *Marine Ecology*, 8: 359-370.
- Scaperrotta M., Bartolini S. & Bogi C., 2011. Stages of growth of marine molluscs of the Mediterranean Sea. Vol. III. L'Informatore Piceno Ed., Ancona, 184 pp.
- Sokolova I.M. & Berger V.Ja., 2000. Physiological variation related to shell colour polymorphism in White Sea *Littorina saxatilis*. *Journal of Experimental Marine Biology and Ecology*, 245: 1-23.
- Spanu M.T., 2011. Prima segnalazione di *Jujubinus baudoni* (Monterosato, 1891 ex H. Martin ms) (Gastropoda: Trochidae) per la Sardegna e le acque italiane. *Bollettino Malacologico*, 47: 135-137.
- Terreni G., 1981. Molluschi conchiferi del mare antistante la costa toscana (Gastropoda, Scaphopoda, Amphineura, Bivalvia, Cephalopoda). Livorno, 106 pp.

New and poorly-known harvestmen (Opiliones) from Sardinia (Italy). Part I: *Lacinius horridus* (Panzer, 1794), new to Sardinia (Phalangiidae Oligolophinae)

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ABSTRACT The first occurrence of *Lacinius horridus* (Panzer, 1794) (Phalangiidae Oligolophinae) on Sardinia is described and the general biogeographical distribution of Opiliones in Italy is discussed.

KEY WORDS Opiliones; Sardinia; *Lacinius horridus*; biogeography.

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INTRODUCTION

Lacinius horridus (Panzer, 1794) (Phalangiidae Oligolophinae) is a well-known species found in nearly all areas of Southern, Central and Northern Europe (Martens, 1978; Blick & Komposch, 2004) with the exception of Spain (Prieto, 2008), the Netherlands (Wijnhoven, 2009) and Norway (Stol, 2007). In Italy *L. horridus* has been found on the mainland and also in Sicily (Stoch, 2003), but not undisputedly in Sardinia.

ABBREVIATIONS. S-Fri = sardinian specimen; G-Fri = german specimen; Fe = femur; Pt = patella; Ti = tibia; Mt = metatarsus; Ta = tarsus;

Lacinius horridus (Panzer, 1794) from Sardinia

EXAMINED MATERIAL. Coordinates in WGS84. Usini, Sassari, 31.04.2012, subadult female, 40°39'49" / 08°29'49", 78 m a.s.l., legit S. Canu (S-Fri 01-099 Rif 71/8). Usini, Sassari, 05.04 2012, subadult female, 40°39'46" / 08°32'41", 206 m a.s.l.

legit S. Canu (S-Fri 02-010 Rif 81/2). Usini, Sassari, 29.04.2012, juvenile female, 40°39'44" / 08°32'44", 206 m a.s.l., legit S. Canu (coll. "Schönhofer"). Usini, Sassari, 04.06.2012, subadult female, 40°39'46" / 08°32'43", 206 m a.s.l., legit S. Canu (coll. "Schönhofer") (Fig. 1).

REMARKS. For this first reliable record of the thermophile *L. horridus* all specimens were collected by hand. The localities where *L. horridus* was found, can be described as typical "mediterranean semi-natural dry open grasslands", mostly on calcareous substrates (Fig. 1; Martens 1978:325; Komposch & Gruber, 2004: 516). Two of the specimens (Nr. Rif71/8, = Fri 01-099 and Nr. Rif 81/2, = Fri 02-010) were selected for further examination and have been retained as voucher specimens in collections of Department of Agriculture, Plant Pathology and Entomology Section, University of Sassari (Italy). In Table 1 (measurements) we have added 4 reference-specimens, 3 from Germany/Brandenburg (G) and 1 from Martens (1978, lit.).

Without any evidence other than the ominous citation in Costa (1885:11, but as *Acantholophus hor-*

Specimens-nrs.	body length/breadth(l/b)	leg II (Fe, Pt, Ti, Mt, Ta)	Fe I / Fe II / Fe III / Fe IV
S-Fri 01-099 Rif 71/8	2.8 / 2.0 l/b = 1.4	1.6 / 0.5 / 1.6 / 0.8 / 3.5 = 7.4	0.5 / 1.7 / 0.5 / 1.3
S-Fri 02-010 Rif 81/2	2.8 / 1.9 l/b = 1.5	1.4 / 0.5 / 1.2 / 0.7 / 2.2 = 6.0	0.4 / 1.4 / 0.4 / 1.2
G-Fri 03-030	2.0 / 1.5 l/b = 1.3	1.3 / 0.5 / 1.2 / 0.5 / 2.0 = 5.5	0.3 / 1.3 / 0.3 / 1.2
G-Fri 03-031	5.5 / 3.5 l/b = 1.6	4.5 / 1.0 / 3.7 / 1.9 / 5.8 = 16.9	1.5 / 4.5 / 1.4 / 2.9
G-Fri 03-053	6.0 / 4.6 l/b = 1.3	4.8 / 1.0 / 3.7 / 2.4 / 6.0 = 17.9	1.7 / 4.8 / 1.9 / 3.7
Martens (1978) ad. females	6.0 / 3.5 l/b = 1.7	5.2 / 1.5 / 4.1 / 3.1 / 7.3 = 21.2	- / 5.2 / -- / --

Table 1. Measurements of specimens in mm. G-Fri 03-030, Bad Belzig, 03.09.2010, juvenile female, 52°13'21" 12°34'57", 98 m a.s.l. G-Fri 03-031, Bad Belzig, 29.10.2012, subadult female, 52°13'25" 12°34'57", 98 msm. G-Fri 03-053, Bad Belzig, 21.08.2009, adult females, 52°13'22" 12°35'03", 98 msm.

ridus Bosc, not Panzer, 1794), Marcellino (e.g. 1973: Tab. 1. as "sistema sardo-corso", p. 7, 1975:163 and 1980: 337, Tab. 1) includes the species *Lacinius horridus* as known for Sardinia (contra Roewer, 1924, 1957 and Trossarelli, 1943; Stoch 2003). Consequently, this unverified statement by Marcellino (e.g. 1980:337: "Non ho trovato specifiche menzioni per la Sardegna, salvo l'unica citazione di Costa ...") was not followed by Chemini (1995) or Stoch (2003).

It is nonetheless worth mentioning that Sardinia plays an important role in the biogeographical distribution of Opiliones in Italy. Chemini (1996) already observed that Italy can be divided into five faunal territorial regions: northern, middle, and southern peninsula; Sicily and Sardinia. Furthermore (Chemini, 1996) there is a strong latitudinal effect (North-South-Island) that can be seen in the increasing number of Mediterranean species from 11% (Northern Italy) to 63% in Sardinia and the decreasing number of European species from 59% (Northern Italy) to 0% in Sardinia. A similar tendency can be observed in the increasing number of endemic species from the north (25%) to 41% in Sicily (Chemini, 1996).

In contrast, the so-called widespread species (Chemini, 1996, but not Marcellino, 1973: "geonomia europea"), which include *L. horridus*, *Mitopus morio* (Fabricius, 1799), *Trogulus nepaeformis* (Scopoli, 1763), *Phalangium opilio* Linnaeus, 1761 and *Odiellus spinosus* (Bosc, 1792) are also wide-

spread in Italy and make up about 4-5% of all opilionid species in all regions of Italy.

Marcellino (1980: 325, Tab. 1) listed 29 species of Opiliones for Sardinia, of which 16 species were recognized as valid by Stoch (2003). Now with the new species *L. horridus* and the long "overseen" *Mitostoma sabbadinii* (Tedeschi et Sciaky, 1997, indicated with *) the number of Opiliones on Sardinia increases to 18.

Family SIRONIDAE

Parasiro minor Juberthie, 1958

Family TRAVUNIIDAE

Buemarinoa patrizii Roewer, 1956

Family PHALANGODIDAE

Ptychosoma vitellinum Soerensen, 1873

Scotolemon terricola Simon, 1872

Family NEMASTOMATIDAE

Histicostoma argenteolunulatum (Canestrini, 1875)

Mitostoma patrizii Roewer, 1953

Mitostoma sabbadinii Tedeschi et Scia, 1997 *

Family DICRANOLASMATIDAE

Dicranolasma soerenseni Thorell, 1876



Figure 1. *Lacinius horridus* (coll. “Schönhöfer”, subadult female; Usini, 04.06.2012) and its habitat (Photo S. Canu).

Family TROGULIDAE

Anelasmacephalus brignolii Martens et Chemini, 1988

Family ISCHYROPSALIDIDAE

Ischyropsalis adamii Canestrini, 1873

Family PHALANGIIDAE

Metaphalangium propinquum (Lucas, 1847)
Dasylobus argentatus argentatus (Canestrini, 1871)
Dasylobus gestroi (Thorell, 1876)
Phalangium opilio Linnaeus, 1758

Phalangium targionii (Canestrini, 1871)
Lacinius horridus (Panzer, 1794)

Family SCLEROSOMATIDAE

Metasclerosoma sardum (Thorell, 1876)
Nelima doriae (Canestrini, 1871)

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REFERENCES

- Barnabé Blick T. & Komposch C., 2004. Checkliste der Weberknechte Mittel- und nord-europas (Checklist of the harvestmen of Central and Northern Europe). Arachnida: Opiliones. Version 27. http://www.arages.de/checklist/checklist04_opiliones.html
- Chemini C., 1995. Arachnida, Scorpiones, Palpigradi, Solifugae, Opiliones, Fascicolo 21. In: Minelli, A., Ruffo, S. et La Posta, S. (Ed.). Checklist delle Specie della Fauna Italiana. Ministero dell'Ambiente e Comitato Scientifico per la Fauna d'Italia, pp. 1-8.
- Chemini C., 1996. Biogeographic patterns in the opilionids of Italy. (Arachnida: Opiliones). Bollettino del Museo Civico di Storia Naturale di Verona, 30: 531-538.
- Costa A., 1885. Notizie ed osservazioni sulla Geo-Fauna sarda. Memoria Quinta. Risultamento delle ricerche fatte nel mese di maggio. Rendiconti della Reale Accademia delle Scienze Fisiche e Matematiche di Napoli, Vol. 1, Ser. 2, 1-31.
- Komposch C. & Gruber J., 2004. Weberknechte österreichs. Denisia 12 (Neue Serie), 14: 485-534.
- Marcellino I., 1973. Opilioni (Arachnida) delle Isole Eolie ed Egadi. Lavori della Società Italiana di Biogeografia; Nuova Serie, 3: 329-339.
- Marcellino I., 1975. Opilioni Italiani del genere *Lacinius* THORELL, 1876, (Arachnida, Opiliones, Phalangiiidae). Fragmenta entomologica, 11: 149-168.
- Marcellino I., 1980. Opilioni di Sardegna (Arachnida, Opiliones). Lavori della Società Italiana di Biogeografia, Nuova Serie, 8: 323-345.
- Martens J., 1978. Die Tierwelt Deutschlands 64. Teil, Weberknechte, Opiliones. VEB Gustav Fischer Verlag, Jena, 464 pp.
- Prieto C. E., 2008. Updating the checklist of the Iberian opiliofauna: corrections, suppressions and additions. Revista Ibérica de Aracnología, 16: 49-65.
- Roewer F., 1924. Opilioniden von der Insel Rhodos, Italien und Sardinien sowie der Cyrenaica. Bollettino dei Musei di Zoologia e di Anatomia Comparata della Reale Università di Torino, 39: 1-7.
- Roewer C.F., 1957. Über Oligolophinae, Caddoinae, Sclerosomatinae, Leiobuninae, Neopilioninae und Leptobuninae (Phalangiidae, Opiliones Palpatores). (Weitere Weberknechte XX). Senckenbergiana biologica, 38: 323-358.
- Trossarelli F., 1943. Contributo allo studio degli Opilioni Italiani. Bollettino della Società Entomologica Italiana, 5: 49-54.
- Stoch F., 2003. In: Zuklat P., (Ed.), Checklist of the species of the Italian fauna. Italian Ministry of Environment - Direction for Nature Protection (online version 2.0). <http://www.faunaitalia.it/checklist/introduction.html>
- Stol I., 2007. Checklist of Nordic Opiliones. Norwegian Journal of Entomology, 54: 23-26.
- Wijnhoven H., 2009. De Nederlandse hooiwagens (Opiliones). Entomologische Tabellen, Nr. 23.

The potentially invasive opisthobranch *Polycera hedgpethi* Er. Marcus, 1964 (Gastropoda Nudibranchia), introduced in a Mediterranean coastal lagoon

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ABSTRACT

The non-native opisthobranch *Polycera hedgpethi* Er. Marcus, 1964 is reported from the coastal lagoon of Capo Peloro (Central Mediterranean Sea) with notes on its habitat typology and feeding behavior. The recently published opinion that *P. hedgpethi* established in the Mediterranean Sea is disputed, since records of adult specimens and egg laying were not accompanied by the presence of juveniles and/or larvae. Mussels imported from Atlantic and North-Adriatic lagoons are hypothesized to be the source of incoming populations in the Peloro Lagoon.

KEY WORDS

Opisthobranchs; Alien species; Sicily; Biopollution; Transitional waters.

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INTRODUCTION

Human activities are responsible of increasing introductions of non-indigenous species (NIS) worldwide. The rate of NIS introductions is notably high in the Mediterranean Sea due to the strong anthropogenic pressure, but also favoured by the marked longitudinal and latitudinal gradients in physical factors, and highly diversified habitat typologies. Since investigation efforts are mainly focused on those organisms having a potential impact on the human economy, taxa with indirect or weak interaction with anthropogenic activities are less known. The opisthobranchs, as highly diversified taxa including both generalist and specialized species, which may display invasive behaviors, constitute an ideal model to study colonization processes. Some examples are *Aplysia*

dactilomela (Rang, 1828), *Bursatella leachii leachii* (Blainville, 1817), and *Melibe viridis* (Kelaart, 1858), whose spread throughout the Mediterranean was carefully monitored (Cinar et al., 2006; Daskos & Zenetos, 2007; Borg et al., 2009).

Polycera hedgpethi is a small sized nudibranch, which has been considered an invasive species because of its worldwide distribution (Wilson, 2006). This species, that is known from the Mediterranean since 1988, has recently colonized transitional and coastal environments in the northern Adriatic (Keppel et al., 2012) and south Tyrrhenian Sea.

In this note, the occurrence of *P. hedgpethi* in the Lago Faro, coastal lagoon of Capo Peloro, Sicily, is reported. The aim of this paper is to contribute to the knowledge of the spread of *P. hedgpethi* in the Mediterranean, as an example of a species that could potentially become invasive.

METHODS

Study area

The Lago Faro (38°16'07"N, 15°38'13"E), north-eastern Sicily, is a temperate body of water (average temperature of shallow waters 20.4°C) characterized by a meromictic regime which determines anoxic conditions below 10 m depth. Faro is a mesotrophic lagoon (Saccà et al., 2008) with high levels of microbial productivity (Leonardi et al., 2009). A moderate anthropogenic contamination was attributed to the extensive shoreline urbanization (Giacalone et al., 2004; Minutoli et al., 2008), but the impact of molluscan farms has not been evaluated to date.

Molluscan assemblages have been scarcely investigated in the past (Spada, 1969; Parenzan, 1979), but recent data suggest the anthropogenic introduction of some extra-Mediterranean species, together with the progressive rarefaction of endemic taxa (Giacobbe, 2012). Alien molluscs, crustaceans and annelids from the Faro Lagoon were also reported by Cosentino et al. (2011), Cosentino & Giacobbe (2011), Crocetta (2012) and Giangrande et al. (2012).

Sampling

This research has been carried out in the framework of the PRA 2008/2009 program: "Settlement dynamics and colonization of allochthonous assemblages in the Capo Peloro lagoon". Qualitative surveys were carried out monthly since March 2009, along the oxygenated shallower lake-floors (0-4 m depth). Quantitative samples were collected in 16 stations in Spring 2012, and replicated in Autumn 2012 and Spring 2013. Each station, covering a 100 m² surface, was explored by means of a 5x5 m grid (four replicates). The most easily recognizable opisthobranchs were identified in situ, photographed and counted. Some specimens were also collected to confirm their identification, and preserved in ethanol 95%, or formaldehyde 4%, or frozen at -24°C, according to the different analytical requirements. Collected specimens are currently deposited at the Department of Biological and Environmental Sciences, Messina, Italy.

RESULTS AND DISCUSSION

A total of eight *P. hedgpethi* specimens were found between April 2012 and May 2013 inside the Faro Lagoon and adjacent channels. The specimens were recorded in the stations shown in figure 1, and the data are summarized in table 1. Four specimens were found along the channel that connects the Messina Strait with the lagoon (stations K14, K15, K16). A mussel farm is located close to the inner mouth. Mussel farming is currently practiced in the proximity of the K4 station, whereas stations K5 and K3 are not located near aquaculture farms.

All specimens were recorded on fouled hard substrata, less than 1 m depth, except for the first specimen, found at 1.5 m depth and the fourth specimen, which was sampled on floating green algae, *Ulva rigida* C. Agardh 1823 (Fig. 2). All the specimens were found in association with bryozoans, *Bugula neritina* (L., 1758), 3 specimens, and *Zoobotryon verticillatum* (Delle Chiaje, 1822), 5 specimens. All the specimens, whose size was comprised between 15 mm and 35 mm, showed the characteristic chromatic pattern consisting in a whitish background color, largely covered by dense grey dots, with yellow-orange bands on propodial, tentacles, rhinophores, branchial plumes and related lateral processes, as accurately described by Keppel et al. (2012) for Mediterranean specimens. A description of anatomical features was provided by Cervera et al. (1988), who comprehensively confirmed previous records, except for some details in the reproductive system.

Wilson (2006) indicated that *P. hedgpethi* is native to California, where it is widely distributed and common, and it was also recorded in several localities both in Pacific and Atlantic oceans. The species, that might be cryptogenic in the Caribbean, was introduced to South Africa (Gosliner, 1982), Australia (Wilson, 2006), New Zealand (Miller, 2001), Japan (Keiu, 2000), the Atlantic coasts of the Iberian Peninsula (Caballer & Ortea, 2002), and the Mediterranean Sea, where it was first reported from the Fusaro Lake, south Tyrrhenian Sea (Cervera et al., 1988). Subsequently, the species was found in the coastal lagoon of Thau, Southern France (<http://www.seaslugforum.net/find.cfm?id=10791>), and more recently, in the North-Western Adriatic Sea and the Venice Lagoon (Keppel et al., 2012), the northernmost limit of its range.

P. hedgpethi has a planktotrophic development which favours natural dispersal (Goddard, 2004). However, natural larval fluxes between the small and sparsely situated Italian lagoons are difficult, whilst human-mediated connections are frequent.

Because of the disjunct distribution of this species, ship fouling was suggested as the most probable vector (Ryland et al. 2011) as its favourite prey, the bryozoan *Bugula neritina* and other congeneric species (McDonald & Nybakken, 1978; Gosliner,



1



2



3

Figure 1. Distribution of *P. hedgpethi* in Italian waters. Faro Lake location and related sampling stations are reported. Figure 2. On-field photo of *P. hedgpethi* on floating green algae. Figure 3. On-field photo of *P. hedgpethi* preying upon *Bugula neritina*, with egg ribs.

1982) often grow on ship hulls. Nevertheless, *P. hedgpethi* has been never reported from commercial harbors in Mediterranean, while it occurs in moderately polluted water bodies whose common trait is the presence of mussel and oyster farms (Sacchi & Renzoni, 1962; Ceccherelli & Barboni, 1983; Malet et al., 2012; Giacobbe, 2012). (Fig. 1). The regular occurrence in the Faro Lagoon of *B. neritina* on mussels and oysters imported from both Atlantic and Adriatic Sea, together with the Adriatic record of *P. hedgpethi* “on a mussel bed” (Keppel et al., 2012), support the hypothesis of a mussel-mediated spreading in the Mediterranean lagoons.

Spawning is documented in Spring (May 2012) for the Faro Lagoon (Fig. 3), whilst in the Venice Lagoon, Keppel et al. (2012) found egg masses in Autumn, as reported by Gosliner, (1982) for South hemisphere. Keppel et al. (2012) also found a juvenile specimen “which did not survive” and documented egg laying in the laboratory, followed by larval hatch seven days later. Nevertheless, egg laying is a common stress-induced response in opisthobranchs, which does not necessarily involve reproductive success. The low number of specimens recorded in the Faro Lagoon confirms that *P. hedgpethi* introductions do not result in dense populations outside its native range (Cervera et al., 1988; Caballer & Ortea, 2002; Cervera et al., 2010), contrary to typical invasive behavior. Moreover, *P. hedgpethi* was recently considered as casual in the Mediterranean (Gofas & Zenetos, 2003; Zenetos et

al., 2010; Cervera et al., 2010; Occhipinti-Ambrogi et al., 2011; Crocetta, 2012) until the recent records from the Venice Lagoon, that were considered consistent to an established population (Keppel et al., 2012). Keppel et al. (2012) opinion was accepted in the most recent revision by Crocetta et al. (2013), because of the increased frequency of specimens and egg depositions in different areas of the Mediterranean, despite the fact that it was not supported by the detection of a planktonic larvae supply for self-sustaining populations. For a species to be considered established, it is necessary to provide evidence of “self-maintaining and self-perpetuating populations” (European Commission, 2004). In the case of *P. hedgpethi* such evidence is lacking since no generation replacement has been observed. On the contrary, the hypothesis of recurrent pseudo-populations supported by external supplies appears to agree with both the spatial-temporal discontinuity of records and disappearance of the species from early-colonized areas (Villani, pers. comm.).

CONCLUSIONS

The present record of *P. hedgpethi* increases the number of NIS that have recorded in the Faro Lagoon, which might be considered a Mediterranean hotspot for species introductions, similarly to the larger and better known Venice Lagoon (Keppel et al., 2012). The Mediterranean range of *P. hedgpethi*

Specimen	n° 1	n° 2	n° 3	n° 4	n° 5	n° 6	n° 7	n° 8
Date	04/12/2012	05/16/2012	05/24/2012	05/24/2012	05/24/2012	05/24/2012	02/09/2013	05/15/2013
Station	K5	K13	K14	K14	K15	K16	K4	K16
Lat. N	38°16'12.2"	38°16'15"	38°15'59.78"	38°15'59.78"	38°15'57.40"	38°15'54.39"	30°16'9.4"	38°15'54.39"
Long. E	15°38'2.9"	15°38'10"	15°38'22.24"	15°38'22.24"	15°38'28.04"	15°38'35.01"	15°38'2.1"	15°38'35.01"
Depth	1.5 m	0.5 m	0.5 m	0.5 m	0.5 m	0.5 m	0.5 m	0.5 m
Substratum	iron	builders	beton	green algae	builders	builders	builders	green algae
Association	<i>Zoo. vert.</i>	<i>Zoo. vert.</i>	<i>Bug. nerit.</i>	<i>Zoo. vert.</i>	<i>Zoo. vert.</i>	<i>Bug. nerit.</i>	<i>Bug. nerit.</i>	<i>Zoo. vert.</i>

Table 1. Sampling data for the eight collected specimens. The associated preys, *Zoobothryon verticillatum* (*Zoo. vert.*) and *Bugula neritina* (*Bug. ner.*), are indicated.

suggests that its introduction in the Faro Lagoon might be mediated by mussel and oyster fouling, confirming the role of aquaculture as an important pathway for introduction and/or secondary spread into Mediterranean semi-enclosed water bodies. Similarly to other non-indigenous and introduced species, *P. hedgpethi* needs to be carefully monitored for a better management and spread prevention. Nevertheless, this species does not appear to show invasive characteristics despite its rapid worldwide spread. *P. hedgpethi* might be recently established in the Venice Lagoon, but this needs to be confirmed with further evidence of the existence of self-maintaining and self-perpetuating populations. The Venice Lagoon might be the source of incoming populations in the Faro Lagoon by mussel trade, but a direct introduction from Atlantic farms cannot be discarded.

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REFERENCES

- Borg J.A., Evans J. & Schembri P.J., 2009. Occurrence of the alien nudibranch *Melibe viridis* (Kelaart, 1858) (Opisthobranchia, Tethydidae), in the Maltese Islands. *Mediterranean Marine Science*, 10: 131-136.
- Caballer M. & Ortea J.A., 2002. Primera cita de *Polycera hedgpethi* Marcus, 1964 (Mollusca: Opisthobranchia) para la Península Ibérica. *Noticiario SEM*, 37: 55-56.
- Ceccherelli V.U. & Barboni A., 1983. Growth, survival and yield of *Mytilus galloprovincialis* Lamk. on fixed suspended culture in a bay of the Po River Delta. *Aquaculture*, 34: 101-114.
- Cervera J.L., Garcia-Gomez J.C., Toscano F. & Garcia F.J., 1988. *Polycera hedgpethi* Marcus, 1964 (Gastropoda: Nudibranchia), an Indo-Pacific species discovered in the Mediterranean Sea. *Iberus*, 8: 225-231.
- Cervera J.L., Tamsouri N., Moukrim A. & Villani G., 2010. New records of two alien opisthobranch molluscs from the north-eastern Atlantic: *Polycera hedgpethi* and *Godiva quadricolor*. *Marine Biodiversity Records*, 3; e51: 4 pp.
- Cinar M.E., Bilecenoglu M., Öztürk B. & Can A., 2006. New records of alien species on the Levantine coast of Turkey. *Aquatic Invasions*, 1: 84-90.
- Cosentino A., Giacobbe S. & Potoschi A., 2011. The CSI of the Faro Lake (Messina): a natural observatory for the incoming of marine alien species. *Biologia Marina Mediterranea*, 16: 132-133.
- Cosentino A. & Giacobbe S., 2011. The new potential invader *Linopherus canariensis* (Polychaeta: Amphinomididae) in a Mediterranean coastal lake: Colonization dynamics and morphological remarks. *Marine Pollution Bulletin*, 62: 236-245.
- Crocetta F., 2012. Marine alien Mollusca in Italy: a critical review and state of the knowledge. *Journal of the Marine Biological Association*, 92: 1357-1365.
- Crocetta F., Macali A., Furfaro G., Cooke S., Villani G. & Valdes A., 2013. Alien molluscan established along the Italian shores: an update, with discussions on some Mediterranean “alien species” categories. *ZooKeys*, 277: 91-108.
- Daskos A. & Zenetos A., 2007. Additions to the knowledge of alien Opisthobranchia of Greece. *Aquatic Invasions*, 2: 258-260.
- European Commission, 2004. Environment Directorate-General LIFE Focus I Alien species and nature conservation in the EU. The role of the LIFE program. Luxembourg: Office for Official Publications of the European Communities, 55 pp.
- Giacalone A., Gianguzza A., Mannino M.R., Orecchio S. & Piazzese D., 2004. Polycyclic aromatic hydrocarbons in sediments of marine coastal lagoons in Messina, Italy: extraction and GC/MS analysis, distribution and sources. *Polycyclic Aromatic Compounds*, 24: 135-149.
- Giacobbe S., 2012. Biodiversity loss in Sicilian transitional waters: the molluscs of Faro Lake. *Biodiversity Journal*, 3: 501-510.
- Giangrande A., Cosentino A., Lo Presti C. & Licciano M., 2012. Sabellidae (Annelida) from the Faro coastal lake (Messina, Ionian Sea), with the first record of the invasive species *Branchiomma bairdi* along the Italian coasts. *Mediterranean Marine Science*, 13: 283-293.
- Goddard J.H.R., 2004. Developmental mode in benthic opisthobranch molluscs from the northeast Pacific Ocean: feeding in a sea of plenty. *Canadian Journal of Zoology*, 82: 1954-1968.
- Gofas S. & Zenetos A., 2003. Exotic molluscs in the Mediterranean basin: current status and perspectives. *Oceanography and Marine Biology: an Annual Review*, 41: 237-277.
- Gosliner T.M., 1982. A new record of the nudibranch gastropod *Polycera hedgpethi* Marcus, from the Indian Ocean of South Africa. *Journal of Molluscan Studies*, 48: 30-35.
- Keppel E., Sigovini M. & Tagliapietra D., 2012. A new geographical record of *Polycera hedgpethi* Er. Marcus, 1964 (Nudibranchia: Polyceridae) and evidence

- of its established presence in the Mediterranean Sea, with a review of its geographical distribution. *Marine Biology Research*, 8: 969-981.
- Keiu S., 2000. *Opisthobranchs of Izu Peninsula*, TBS-Britannica Co., Ltd, Tokyo. 184 pp.
- Leonardi M., Azzaro F., Azzaro M., Caruso G., Mancuso M., Monticelli L.S., Maimone G., La Ferla R., Raffa F. & Zaccone R., 2009. A multidisciplinary study of Cape Peloro brackish area (Messina, Italy): characterization of trophic conditions, microbial abundances and activities. *Marine Ecology*, 30: 32-42.
- Malet N., Pastoureaud A., Vaquer A., Quéré C. & Dubroca L., 2012. Marine diatoms sustain growth of bivalves in a Mediterranean lagoon. *Journal of Sea Research*, 68: 20-32.
- McDonald G.R., & Nybakken J.W., 1978. Additional notes on the food of some California nudibranchs with a summary of known food habits of California species. *Veliger*, 21:110-118.
- Miller M.C., 2001. Descriptions of the dorid nudibranchs *Polycera hedgpethi* Marcus, 1964 and *P. fujitai* Baba, 1937 in New Zealand. *Journal of Molluscan Studies*, 67: 491-499.
- Minutoli R., Fossi M.C., Zagami G., Granata A. & Guglielmo L., 2008. First application of biomarkers approach in the zooplanktonic copepod *Acartia latisetosa* for the early management and conservation of transitional waters ecosystem. *Transitional Water Bulletin*, 1: 45-52.
- Occhipinti-Ambrogi A., Marchini A., Cantone G., Castelli A., Chimenz C., Cormaci M., Froglija C., Furnari G., Gambi M.C., Giaccone G., Giangrande A., Gravilli C., Mastrototaro F., Mazziotti C., Orsi-Relini L. & Piraino S., 2011. Alien species along the Italian coasts: An overview. *Biological Invasions*, 13: 215-237.
- Parenzan P., 1979. Fauna malacologica dei laghi di Ganzirri e del Faro (Messina). *Thalassia Salentina*, 9: 67-78.
- Ryland J.S., Bishop J.D.D., De Blauwe H., El Nagar A., Minchin D., Wood C.A. & Yunnice A.L.E., 2011. Alien species of *Bugula* (Bryozoa) along the Atlantic coasts of Europe. *Aquatic Invasions*, 6: 17-31.
- Saccà A., Guglielmo L. & Bruni, V., 2008. Vertical and temporal microbial community patterns in a meromictic coastal lake influenced by the Straits of Messina upwelling system. *Hydrobiologia*, 600: 89-104.
- Sacchi C.F. & Renzoni A., 1962. L'ecologie de *Mytilus galloprovincialis* (Lam.) dans l'étang littoral du Fusaro et les rythmes annuels et nyctéméraux des facteurs environnants. *Pubblicazioni della Stazione Zoologica di Napoli*, 32 (Suppl.): 255-293.
- Spada A., 1969. Breve esplorazione malacologica del lago di Ganzirri e del Pantano di Torre del Faro presso Messina. *Conchiglie*, 5: 60-65.
- Terrence M.G., 1982. A new record of the nudibranch gastropod *Polycera hedgpethi* Marcus, from the Indian Ocean of South Africa. *Journal of Molluscan Studies*, 48: 30-35.
- Wilson N., 2006. New record of the nudibranch *Polycera hedgpethi* Er. Marcus, 1964, in South Australia, with a discussion on its occurrence in Australia. *Records of the Western Australian Museum*, Suppl. 69:137-140.
- Zenetos A., Gofas S., Verlaque M., Çinar M.E., García-Raso J.E., Bianchi C.N., Morri C., Azzurro E., Bilecenoglu M., Froglija C., Siokou I., Violanti D., Sfriso A., San Martín G., Giangrande A., Katağan T., Balasteros E., Ramos-Esplá A., Mastrototaro F., Ocaña O., Zingone A., Gambi M.C. & Streftaris N., 2010. Alien species in the Mediterranean by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. *Mediterranean Marine Science*, 11: 381-493.

Fossil starfishes (Echinodermata Asteroiidae) and paleontological analysis of the Pliocene of Cherasco, Piedmont region (NW Italy)

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ABSTRACT

The remarkable discovery of two fossil starfishes in the Pliocene clay of Cherasco (NW Italy), allowed to analyze in detail the sediment and paleontological material associated (malacofauna and foraminifers assemblages), aiming at reconstructing paleoenvironmental conditions in which these organisms lived. Furthermore biostratigraphic analysis based on planktonic foraminiferal assemblages, allowed the recognition of the MPI2 biozone of lower Pliocene.

KEY WORDS

Astropecten; malacofauna; Foraminifera; paleoenvironmental reconstruction; Pliocene.

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INTRODUCTION

The structure of starfish bodies is maintained by soft tissues that rapidly disaggregate after death and the discovery of remains relies on exceptional conditions of preservation. In the Pliocene clay of Cherasco (Cuneo, Piedmont region, NW Italy), these exceptional conditions allowed the discovery of two fossil starfishes, attributed to Asteroidea. The fossil record of starfishes is very sparse in Piedmont region. In the literature only two other discoveries of Asteroidea are known in the area albese-braidese: *Astropecten bispinosus* (Otto, 1823), reported by Sacco (1893) for the Pliocene of Bra, and a print, unfortunately devoid of significant details, illustrated by Cavallo et al. (1986), found in the Tortonian marls at Alba.

The remarkable discovery allowed to be analyzed in detail the sediment and paleontological material associated. The analysis focused first on the paleontological study of fossil starfish, and in a second step

on malacofauna and foraminiferal assemblages in order to characterize these clays of Cherasco from paleocologic and biostratigraphic points of view, for which no specific data exist in the literature.

MATERIAL AND METHODS

Cherasco (Cuneo, Piedmont region, NW Italy) (Fig. 1) is located in a plain extending towards the South West, bordered in the North West by the Stura of Demonte river and in the East by the Tanaro river. In the western part of Cherasco, the plain is strongly incised by “Rii di San Giovanni” (30-40 meters depth). The fossil starfishes have been discovered on the left side of the Rio Crosio, one of the “Rii di San Giovanni” (3.5 km long). The outcrop (20 m long) is located at 240 m a.s.l. (44°38'48" N; 7°51'7" E), and it is composed of grey-blue muddy clays which are continuous and homogenous, 15 m thick (Figs. 2, 3). The Pliocene

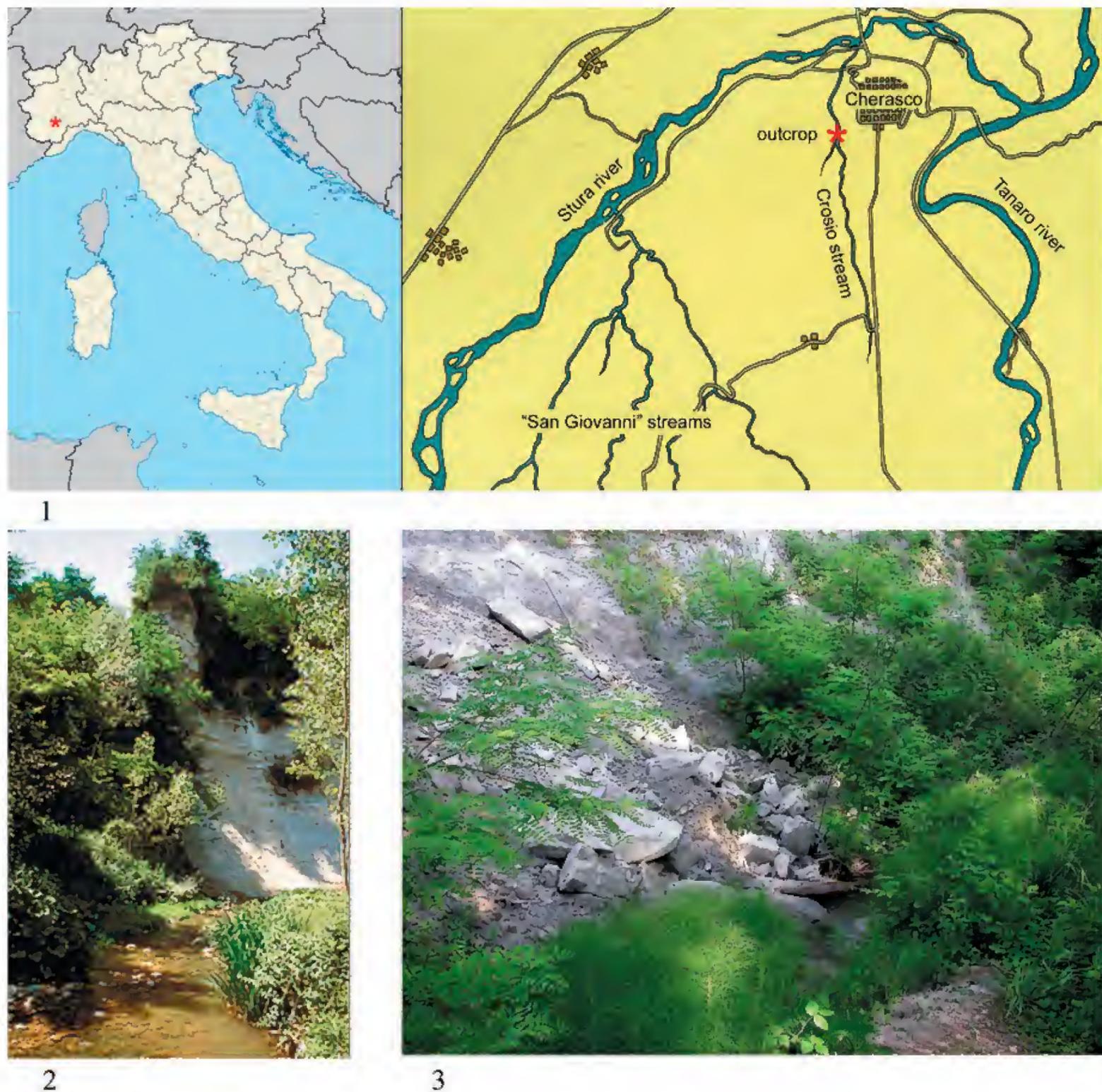


Figure 1. Location of Pliocene outcrop near Cherasco (Piedmont region, NW Italy). Figures 2, 3. Outcrop view of the Pliocene clays.

muddy clays are outcropped by quaternary alluvions (see geological map of Italy, foglio 80 Cuneo).

The two fossils were found in the upper meter of the outcrop. The oral ventral sides of the two specimens were visible and in discrete preservation. The better preserved specimen has a diameter of 60 mm (Fig. 4), while the other one is 55 mm (Fig. 5). The muddy clay matrix, including specimens, was disaggregated and observed under a microscope to analyze the malacofauna and

foraminiferal assemblages. For the malacofauna, 3 liters of sediment were observed after being water sieved.

For foraminiferal assemblages, a sample of 300 g was previously disaggregated in hydrogen peroxide (120% by volume), for about 1 hour. Later it was divided into four size fractions: $>315 \mu\text{m}$, 150-315 μm , 125-150 μm , 63-125 μm . For the $>315 \mu\text{m}$, 150-315 μm , 125-150 μm fractions, a quantitative study was performed on a volume of residue after drying, split with an Otto microsplitter (Scott

et al., 1980) in order to obtain a representative quantity of the particle size fraction. This allowed to be evaluated the abundance of the residue, the state of preservation of tests of foraminifera and the presence of any other organogenic and inorganic components. The foraminiferal assemblages were subsequently the subject of specific determination and quantitative analysis. For the fraction 63-125 μm , which consists almost exclusively of biogenic fragments and minute foraminifera shells, that only in rare cases allow attribution of precise species (Schönfeld et al., 2012), specific determinations were not performed.

RESULTS

ECHINODERMATA ASTERIIDAE

Astropecten cf. *irregularis pentacanthus* (Delle Chiaje, 1825)

The starfish, belonging to the same species, were attributed without doubt to the genus *Astropecten* Gray, 1840; this systematic group currently includes, worldwide, more than a hundred species living in muddy and sandy bottoms of the littoral system, with the exception of some species which are bathyfile (Tortonese, 1965).

The comparison, as far as possible, with the species of *Astropecten* currently present in the Mediterranean, is particularly difficult in the absence of the clear visibility of anatomical structures useful for this purpose. Nevertheless the *Astropecten* analyzed can be attributed to the species *A. irregularis* (Pennant, 1777) and more precisely to the subspecies *A. irregularis pentacanthus* (Delle Chiaje, 1825). Fossil specimens from Cherasco, in addition to the general morphological characteristics, showed strong similarities with the subspecies mentioned in: a) the apices of the arms, more or less rounded; b) the size of the individuals close to the dimension of individuals currently living in the Mediterranean, which generally have a diameter of 80-120 mm; c) the ratio R/r 4.4 to 4.7 which seems consistent with their stage of growth, considering that it tends to be greater in the larger specimens (Borghi & Bajo Campos, 2008); and finally, d) because this subspecies, which in the Mediterranean appears to be the most frequent Asteroidea, is present on the muddy or sandy-clay seabed at depths from 2 to 200 m (Riedl, 1991). The brick-red color of the fossil specimens is probably due to the processes of oxidation of organic tissues.

Unfortunately, the clay investigated did not return ossicles of Asteroidea which, if present, could possibly provide additional information for a more exact specific determination.

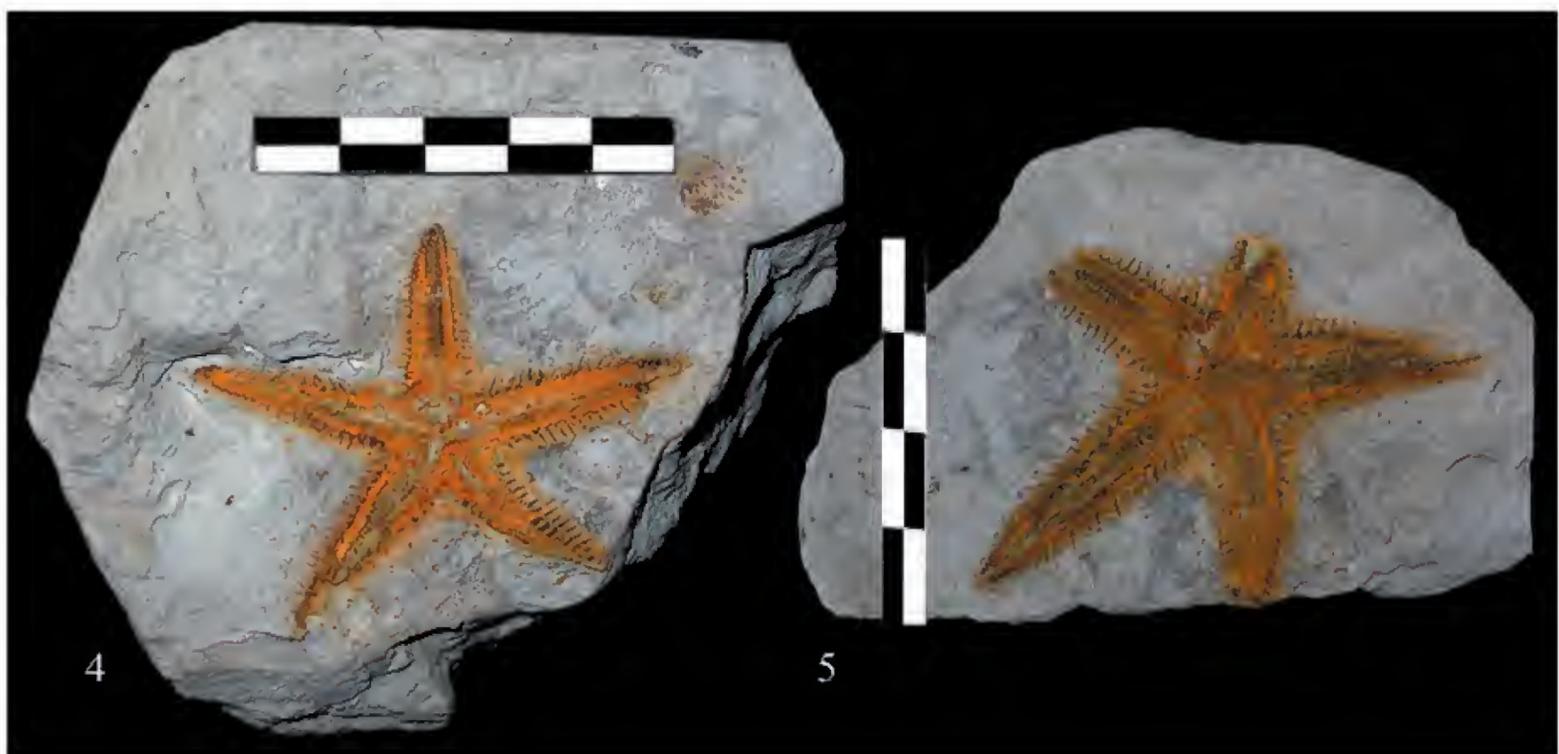


Figure 4. *Astropecten* cf. *irregularis pentacanthus*, D 60 mm, from Cherasco, ventral side. Figure 5. Other specimen of *A. cf. irregularis pentacanthus*, D 55 mm, from Cherasco, ventral side.

MALACOFAUNA

Given the extreme fragility of the shells, it was hardly possible to isolate whole shells: even the species of a few millimeters not resisted to the usual treatments of water clay filtration, so it can be retrieved only in fragments. In association with bivalve fragments, have been found carbon wood, parts of claws and fragments of crustaceans decapods arts and a dozen calcareous tubes of *Ditrupa* sp. A list in systematic order of the species is found below (Figs. 6-19)

Turritella spirata (Brocchi, 1814)

EXAMINED MATERIAL. 1 specimen (teleoconch almost complete) (Fig. 14).

REMARKS. Although it is sometimes present in shallower environments and not in pelitic facies, generally outcrops where the species is found indicate a muddy circalittoral-bathyal environment (Borghi & Vecchi, 2005). This species, in fact, is characteristic of shale and marl facies of the Miocene and Pliocene (Malatesta, 1974).

Aporrhais uttingerianus peraraneosus (Sacco, 1893)

EXAMINED MATERIAL. 2 specimens (fragments).

REMARKS. The fragments of *Aporrhais* Da Costa, 1778 found, show long and thin digits, which allow to assign them to the subspecies *peraraneosus*. The presence of this subspecies in the Rio Crosio is already mentioned by Charrier (1953). Probably the long and thin digits are an adaptive character that promotes the activities of these animals in the particular seabed in which they live. In fact, the large surface area between the coil and the digits tips line, and the thinness of digits in proportion to their very low weight, allows the bivalve, during their reptation (movements), to "float" more smoothly on the soft mud of seabed (Damarco, 1994). The ecological niche of *A. uttingerianus peraraneosus* is now occupied by *A. serresianus* (Michaud, 1828), species originating from the Atlantic Ocean and which occasionally penetrated into the Mediterranean during the Pliocene (Forli, 1989). This species developed and proliferated later in the Quaternary (Ruggieri, 1971), and it is currently living in the mud-detritic

bottoms of the circalittoral zone also deep (Terreni, 1981; Brunetti & Forli, 2013).

Euspira sp.

EXAMINED MATERIAL. 1 specimen, in poor preservation.

REMARKS. The specimen found was too deteriorated and specific determination was impossible.

Phalium saburon (Bruguière, 1792)

EXAMINED MATERIAL. 1 specimen (protoconch more than 3 whorls of teleoconch).

REMARKS. It is a euribate species, being correlated to the deep muddy bottoms, in the circalittoral and in the bathyal zones (settings) (Pères & Picard, 1964). In fact it lives in the Mediterranean Sea on sandy muddy bottoms of the circalittoral zone (Chirli, 2008).

Nassarius elatus (Gould, 1845)

EXAMINED MATERIAL. 2 specimens (1 juvenile) (Figs. 6, 7). In the protoconch of the figure 7, the slight rib characterizes the first whorls of teleoconch.

REMARKS. The species has been reported by Adam & Glibert (1975) for a dozen Italian fossil localities, both of the Lower and Upper Pliocene and it can be confused with *N. semistriatus* (Brocchi, 1814). It still lives in the Mediterranean sandy-muddy infra-circalittoral seabed.

Bela nitida Pavia, 1976

EXAMINED MATERIAL. 2 specimens (1 juvenile) (Fig. 8).

REMARKS. According to Pavia (1976) this species is present in the lower and middle Pliocene of the Piedmont (Monteu Roero, Valle Botto-Asti) and of the Liguria (Rio Torsero-Ceriale).

Raphitoma leufroyi (Michaud, 1828)

EXAMINED MATERIAL. 2 specimens (1 juvenile). (Figs. 9, 10). In figure 10 is illustrated planktotrophic multispiral with 3 whorls, the first decorated by microgranules arranged in spirals, while the subsequent whorls show sculpture canceled trending sigmoidal.

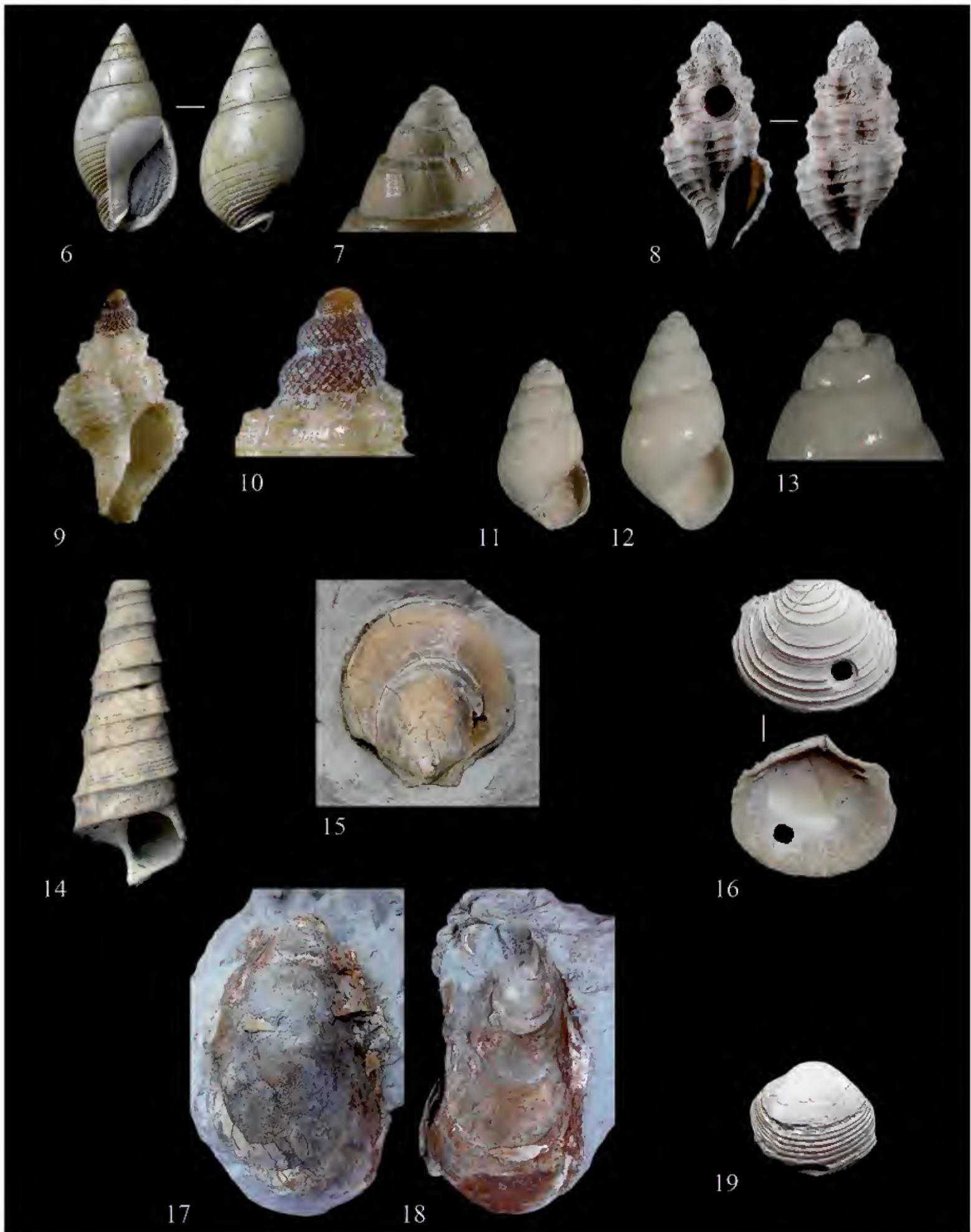


Figure 6. *Nassarius elatus*, h 11.2 mm. Figure 7. Protoconch of *N. elatus*, magnification 9x. Figure 8. *Bela nitida*, h 3 mm, predation hole on the penultimate whorl. Figure 9. *Raphitoma leufroyi*, h 2.3 mm. Figure 10. Protoconch of *R. leufroyi*, magnification 37x. Figure 11. *Odostomia conoidea*, h 1.4, Figure 12. *Idem*, h 1.8 mm. Figure 13. Protoconch of *O. conoidea*, magnification 29x. Figure 14. *Turritella spirata*, h 23 mm. Figure 15. *Korobkovia oblonga*, right valve, D 24.6 mm. Figure 16. *Myrtea spinifera*, D 6.9 mm, external and internal view of left valve, with predation hole. Figure 17. *Neopycnodonte navicularis*, external view of left valve D 62.8 mm. Figure 18. *Idem*, right valve D 45.4 mm. Figure 19. *Corbula gibba*, D 4.4 mm, external view of right valve.

REMARKS. The specimen sampled, with two whorls of teleoconch, is rather young, but its preservation is excellent. This species lives on all types of bottoms, from a few meters to about 150 m in depth (Poppe & Goto, 1991).

Odostomia conoidea (Brocchi, 1814)

EXAMINED MATERIAL. 2 specimens (Figs. 11-13). The protoconch of the figure 13 consists of 2 whorls, the first of which is wound in a spiral with the axis approximately at right angles to the axis of the shell, well represents the protoconch of "type A", according to van Aartsen (1987).

REMARKS. According to Scaperrotta et al. (2011) and Chirli & Micali (2011), this species lives in the Mediterranean sea on the muddy-sandy bottoms of the infra-circalittoral zone.

Philine* cf. *scabra (Müller O.F., 1784)

EXAMINED MATERIAL. 1 specimen (fragments).

REMARKS. Living on sandy and mud-sandy bottoms at lower depths (Thompson, 1976).

Roxania utriculus (Brocchi, 1814)

EXAMINED MATERIAL. 1 specimen (juvenile).

REMARKS. Living on the mud bottoms of the circalittoral zone (150 m depth) (Ardovini & Cossignani, 1999).

Yoldia nitida (Brocchi, 1814)

EXAMINED MATERIAL. 1 specimen: fragments of the right valve.

REMARKS. The genus *Yoldia* is found on the muddy-sandy bottoms of the infralittoral zone.

Aequipecten angelonii (De Stefani et Pantanelli, 1878)

EXAMINED MATERIAL. 1 specimen: fragments of the left valve.

REMARKS. It seems that this species was found exclusively in clay-marl outcrops attributed to the Pliocene: in the "turquoise clays" of Colle Melamenda of coralligenous area (De Stefani & Pantanelli, 1878); in clays of Castelnuovo d'Asti, in Fornaci di Savona and in Piacenza area (Sacco,

1897); in the marl of Rio Torsero in Savona (Andri et al., 2005).

Flabellipecten bosniasckii (De Stefani et Pantanelli, 1880)

EXAMINED MATERIAL. 1 specimen: fragments of left and right valves.

REMARKS. The *Flabellipecten* Sacco, 1897 constitute a group adapted to live on soft bottoms, therefore characterize all sandy-clayey facies of the Upper Miocene and Pliocene (Malatesta, 1974).

Mimachlamys* cf. *varia (Linnaeus, 1758)

EXAMINED MATERIAL. 3 partials valves, 1 right.

REMARKS. The species is ubiquitous: it lives on rocky-gravelly-muddy bottoms, often with fine bissus attached to the sponges (Malatesta, 1974). Some authors (Tebble, 1966; Poppe & Goto, 1993), referring especially to the Atlantic Ocean, reported *M. varia* at 83 m maximum depth, and Terreni (1981) reported this species in Mediterranean area living on the muddy-sandy bottoms in the infra-circalittoral zone. Parenzan (1974) reports it from 1350 m deep, but adds that the normal environment does not exceed perhaps a hundred meters.

Korobkovia oblonga (Philippi, 1844)

EXAMINED MATERIAL. 1 specimen: right valve (Fig. 15).

REMARKS. This species is restricted to the silts and fine-grained calcarenites of the base of the Pliocene (Jiménez et al., 2009).

Neopycnodonte navicularis (Brocchi, 1814)

EXAMINED MATERIAL. 7 right valves (3 partials and 1 juvenile) and 2 left valves (only 1 with umbonal area) (Figs. 17, 18).

REMARKS. It seems certain, as reported by Malatesta (1974), that the actual *N. cochlear* (Poli, 1795) result from a genetic mutation of *Neopycnodonte navicularis* extinct in the late Pliocene; regarding *N. cochlear*, Parenzan (1974) and Terreni (1981) reported that it lives from a hundred feet to over 1000 m depth, on the muddy-debris bottoms of the deep circalittoral zone.

Myrtea spinifera (Montagu, 1803)

EXAMINED MATERIAL. 1 specimen: left valve (Fig. 16).

REMARKS. In the Mediterranean it has been found in the biocenosis of unstable bottom sediments (Malatesta, 1974); in the British Islands it has been found to a maximum depth of 110 m (Tebble, 1966), on the Tuscan coast (Italy); it lives in the detritic mud-bottom of infra-circalittoral zone (Terreni, 1981).

Clausinella fasciata (Da Costa, 1778)

EXAMINED MATERIAL. 1 specimen: fragments of the left valve.

REMARKS. The species lives burrowing into the gravelly, gravelly-stony, stony or sandy-muddy sediment, up to about 110 m depth (Tebble, 1966). According to Scaperrotta et al. (2009), it prefers waters with coarse gravel or gravel and mud, from a few meters to over 100 m in depth.

Timoclea ovata (Pennant, 1777)

EXAMINED MATERIAL. 3 valves (partials)

REMARKS. Euribathyal species, reported for the Mediterranean from a few meters up to 700 meters depth, on the muddy-debris bottoms (Malatesta, 1974).

Corbula gibba (Olivi, 1792)

EXAMINED MATERIAL. 1 right valve (partial) e 3 left (juveniles and partial). The external view of right valve (Fig. 19) is characterized by a large ventral rib concentric sculpture.

REMARKS. In the Mediterranean it is found in the biocenosis of the seabed debris (80-130 m) of the infralittoral zone; with the polychaete *Ditrupa arietina* (O.F. Müller, 1776) this species is characteristic of the biocenosis of instable bottoms (Malatesta, 1974). This species seems to prefer muddy or sandy-muddy bottoms (Scaperrotta et al., 2009).

The polychaete *Ditrupa* sp., of which we found a dozen specimens, also lives in sandy-muddy bottoms and constitutes an indicator of the depth range of substrate. It is a genus characteristic of biocoenosis of unstable bottom which Pérès & Picard (1964) placed at depths between 35 to just over 100 m.

FORAMINIFERA

The residue of the sample is quantitatively scarce. For the three fractions considered, the inorganic materials are predominantly made up of abundant particles of iron oxides, frequent angular particles of quartz and lamellae of muscovite, some rare granule mineralized with pyrite and glauconite. The percentage of the inorganic fraction constitutes 60% of the residue for the >315 µm fraction, it tends to decrease to about 40% in the 150-315 µm fraction, to increase up to 80% of the residue in the 125-150 µm fraction. This increase is marked by an abundance of muscovite flakes lamellae that become prevalent.

The organogenic residue consists mainly of abundant fragments of pyritized and partially oxidized plant frustules, frequent fragments of echinoderm spines and prevailing benthic foraminifera, generally very well preserved. Sometimes there are rare individuals mineralized with pyrite and glauconite. The planktonic foraminifera, in all fractions analyzed, were extremely rare.

Benthic foraminifera

The benthic foraminiferal assemblages (44 species, Table 1) were represented principally by hyaline species. Only two agglutinated species were present, but rare (*Bigenerina nodosaria* and *Textularia* sp.). The porcellanaceous species were absent. Species more abundant than 4% of the assemblage of at least one station were described and considered as dominant: *Bolivina anaeriensis*, *B. punctata*, *Bulimina aculeata*, *B. lappa*, *B. inflata*, *Stainforthia complanata*, *Uvigerina peregrina* and *Valvulineria bradyana* (Figs. 20-35; Fig. 36). In the coarser fraction (>315 µm) *Uvigerina peregrina* (~34%) and *Valvulineria bradyana* (~20%) prevailed. *Bulimina aculeata* was almost frequent (~11%), while the species of genus *Bolivina* d'Orbigny, 1839 and *Stainforthia complanata* were rare (<3%) (Fig. 36). In the 150-315 µm fraction the percentage of *Uvigerina peregrina* was similar to the coarser fraction, while the percentage of *Valvulineria bradyana* decreased considerably (~13.5%). The species of genus *Bulimina* d'Orbigny, 1826 showed a variable trend. *Bulimina aculeata* decreased (5%), while *Bulimina lappa* increased strongly (~8%). *Lenticulina calcar*, absent in the

Benthic foraminifera	>315μ	150-315μ	125-150μ	>315μ	150-315μ	125-150μ
Split	.1/2	.1/8	.1/8	%	%	%
Hyaline species						
<i>Ammonia tepida</i> (Cushman, 1926)			1	0.0	0.0	0.4
<i>Amphicoryna scalaris</i> (Batsch, 1791)		2		0.0	0.7	0.0
<i>Asterigerinata mammilla</i> (Williamson, 1848)			1	0.0	0.0	0.4
<i>Bolivina punctata</i> d'Orbigny, 1839 (Fig. 22)	8	27	6	2.9	9.7	2.3
<i>Bolivina albatrossi</i> Cushman, 1922 (Fig. 21)			6	0.0	0.0	2.3
<i>Bolivina alata</i> (Seguenza, 1862)			9	0.0	0.0	3.4
<i>Bolivina anaeriensis</i> (Costa, 1856) (Fig. 23)	4	8	11	1.4	2.9	4.1
<i>Bolivina dilatata</i> Reuss, 1850			7	0.0	0.0	2.6
<i>Bolivina spathulata</i> (Williamson, 1858) (Fig. 24)	1	2	7	0.4	0.7	2.6
<i>Bulimina aculeata</i> d'Orbigny, 1826 (Fig. 25)	30	15	4	10.8	5.4	1.5
<i>Bulimina lappa</i> Cushman et Parker, 1937 (Fig. 20)	4	23	20	1.4	8.2	7.5
<i>Bulimina inflata</i> Seguenza, 1862 (Fig. 26)	13	11	14	4.7	3.9	5.3
<i>Cassidulina carinata</i> Silvestri, 1896			1	0.0	0.0	0.4
<i>Chilostomella oolina</i> Schwager, 1878	3			1.1	0.0	0.0
<i>Cibicides kullenbergi</i> Parker, 1953	7			2.5	0.0	0.0
<i>Cibicides</i> sp.	1		9	0.4	0.0	3.4
<i>Dentalina leguminiformis</i> (Batsch, 1791)	1		1	0.4	0.0	0.4
<i>Florilus boueanum</i> (d'Orbigny, 1846)	1	3	1	0.4	1.1	0.4
<i>Globobulimina affinis</i> (d'Orbigny, 1839)	4	1		1.4	0.4	0.0
<i>Gyroidina altiformis</i> (R.E. et K.C. Stewart, 1930)	1			0.4	0.0	0.0
<i>Gyroidinoides umbonatus</i> (Silvestri, 1898)		5	8	0.0	1.8	3.0
<i>Heterolepa floridana</i> (Cushman, 1922)	5			1.8	0.0	0.0
<i>Lenticulina calcar</i> (Linnaeus, 1767) (Fig. 28)	1	19	2	0.4	6.8	0.8
<i>Marginulina hirsuta</i> d'Orbigny, 1826 (Fig. 31)		3		0.0	1.1	0.0
<i>Marginulina costata</i> (Batsch, 1791) (Fig. 32)	6			2.2	0.0	0.0
<i>Melonis padanum</i> (Perconig, 1952) (Fig. 29)	8			2.9	0.0	0.0
<i>Oridorsalis umbonatus</i> (Reuss, 1851)	4	4	3	1.4	1.4	1.1
<i>Pandaglandulina dinapolii</i> Loeblich et Tappan, 1955	2			0.7	0.0	0.0
<i>Planularia</i> sp.			1	0.0	0.0	0.4

<i>Pullenia bulloides</i> (d'Orbigny, 1846)	5	6	3	1.8	2.2	1.1
<i>Rectuvigerina bononiensis</i> (Fornasini, 1888)	1			0.4	0.0	0.0
<i>Rectuvigerina siphogenerinoides</i> (Lipparini, 1932)		1	1	0.0	0.4	0.4
<i>Saracenaria italica</i> Defrance, 1824		1		0.0	0.4	0.0
<i>Sphaeroidina bulloides</i> d'Orbigny, 1826	4			1.4	0.0	0.0
<i>Stainforthia complanata</i> (Egger, 1893) (Fig. 27)	1	3	13	0.4	1.1	4.9
<i>Stilostomella advena</i> (Cushman et Laiming, 1931)	6	5	2	2.2	1.8	0.8
<i>Stilostomella</i> sp.	1			0.4	0.0	0.0
<i>Trifarina angulosa</i> (Williamson, 1858)			1	0.0	0.0	0.4
<i>Uvigerina auberiana</i> d'Orbigny, 1839		1	3	0.0	0.4	1.1
<i>Uvigerina peregrina</i> Cushman, 1923 (Fig. 33)	95	98	27	34.3	35.1	10.2
<i>Valvulineria bradyana/complanata</i> (Fig. 30)	58	38	104	20.9	13.6	39.1
Agglutinated species						
<i>Bigenerina nodosaria</i> d'Orbigny, 1826		2		0.0	0.7	0.0
<i>Textularia</i> sp.	2	1		0.7	0.4	0.0
Total number of specimens	277	279	266	100.0	100.0	100.0

Table 1. Benthic foraminifera from Pliocene of Cherasco, Piedmont region (NW Italy).

Planktonic foraminifera	>315μ	150-315μ	125-150μ
Split	.1/2	.1/8	.1/8
<i>Globigerina bulloides</i> d'Orbigny, 1826	2	2	2
<i>Globigerina falconensis</i> Blow, 1959	2	2	2
<i>Globigerina glutinata</i> (Egger, 1893)			1
<i>Globigerinoides obliquus extremus</i> Bolli et Bermudez, 1965 (Fig. 35)	2		
<i>Globigerinoides elongatus</i> (d'Orbigny, 1826)	1		
<i>Globorotalia</i> cf. <i>magaritae</i> (Bolli et Bermudez, 1965)	1		
<i>Neogloboquadrina acostaensis</i> Blow, 1959	1		1
<i>Orbulina universa</i> d'Orbigny, 1839 (Fig. 34)	3	1	
<i>Sphaeroidinellopsis dehiscens</i> (Parker et Jones, 1865)		3	1
Total number of specimens	12	8	7

Table 2. Planktonic foraminifera from Pliocene of Cherasco, Piedmont region (NW Italy).

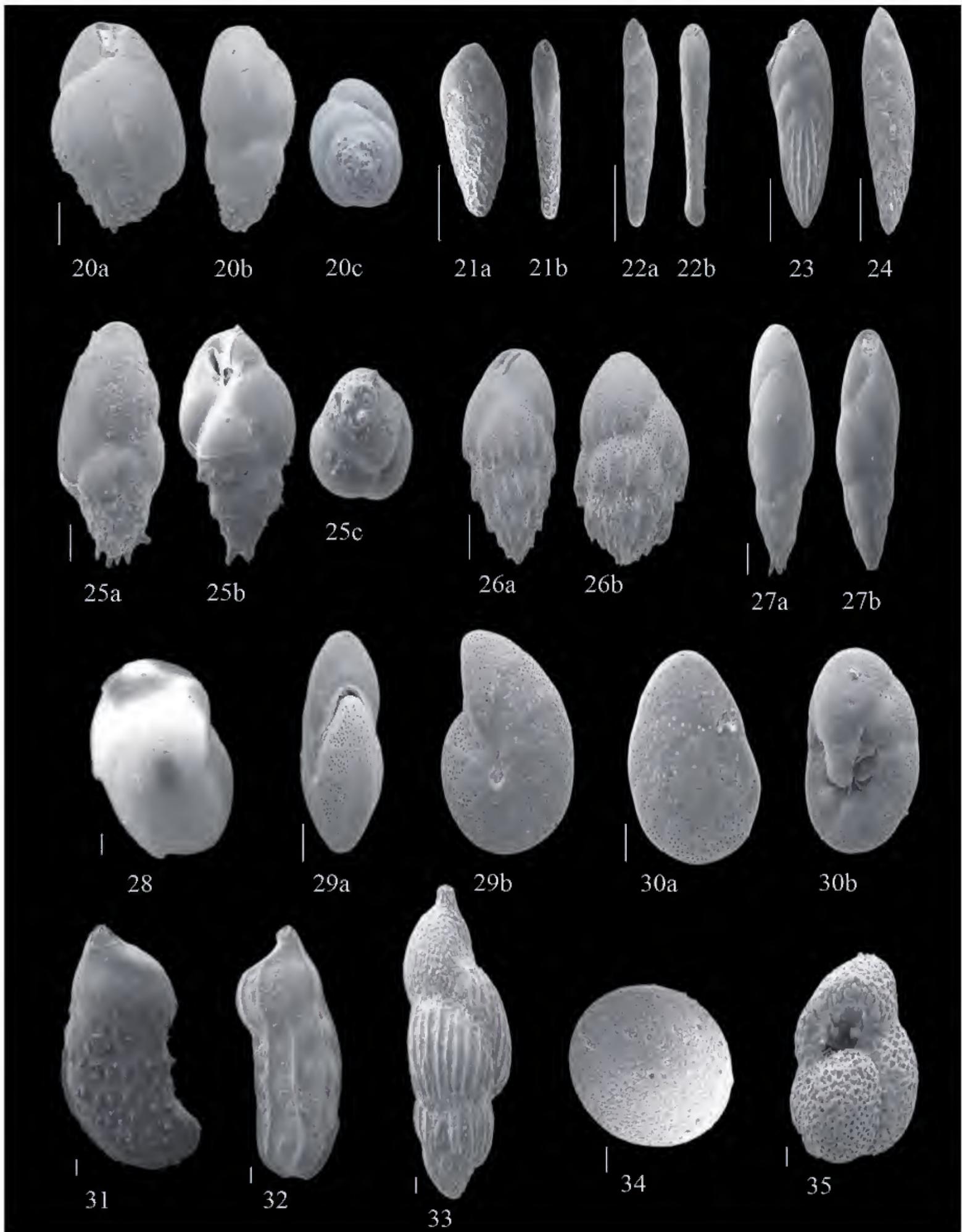


Figure 20. *Bulimina lappa*. Figure 21. *Bolivina albatrossi*. Figure 22. *Bolivina punctata*. Figure 23. *Bolivina anaeriensis*. Figure 24. *Bolivina spathulata*. Figure 25. *Bulimina aculeata*. Figure 26. *Bulimina inflata*. Figure 27. *Stainforthia complanata*. Figure 28. *Lenticulina calcar*. Figure 29. *Melonis padanum*. Figure 30. *Valvulineria bradyana*. Figure 31. *Marginulina hirsuta*. Figure 32. *Marginulina costata*. Figure 33. *Uvigerina peregrina*. Figure 34. *Orbulina universa*. Figure 35. *Globigerinoides obliquus extremus*. Each scale bar represents 100 μm .

coarser fraction, was present with a value of ~5%. The percentage of *Bulimina inflata* was constant in the three fractions considered (4-5%) (Fig. 37). In the 125-150 µm fraction *Uvigerina peregrina* decreased with a minimum of 10%, while *Valvulineria bradyana* increased with a maximum of 39%. *Bulimina aculeata* decreased strongly (~1%); *Bulimina lappa*, on the contrary, increased (5%). *Lenticulina calcar* was still present, but with an extremely low percentage (~0.5%). The genus *Bolivina* and *Stainforthia*, due to their natural small dimensions, were more frequent in the finer fraction (Fig. 37).

In the thanatocenosis the species allochthonous were rare. Among these *Ammonia tepida*, *Asterigerinata mammilla* have been recognized and individuals belonging to the genus *Cibicides* de Montfort, 1808, typical of infralittoral zone. It showed clearly signs of transport, highlighted by the poor preservation of the shell. The autochthonous fauna was represented by species typical of an outer continental shelf and an upper continental slope. For example the agglutinated *Bigenerina nodosaria*, *Uvigerina peregrina*, *Valvulineria bradyana*, *Bulimina* spp., *Lenticulina* and *Bolivina* spp. *Uvigerina peregrina*, a shallow infaunal species living close to the sediment-water interface, is characteristic of mesotrophic to eutrophic continental slope settings (Lutze & Coulbourn, 1984; Corliss, 1985, 1991; Lutze, 1986; Corliss & Emerson, 1990; Mackensen et al., 1995; Schmiedl & Mackensen, 1997; Jannik et al., 1998; Kuhnt et

al., 1999; De Rijk et al., 2000; Schmiedl et al., 2000; Morigi et al., 2001; Huang et al., 2002; Fontanier et al., 2003).

Valvulineria bradyana is a typical species of pelitic-sandy bottoms, characterized by low oxygen content and rich in organic matter (Bergamin et al., 1999). *B. aculeata* is generally also considered as a eutrophic species, typical of low-oxygen environments (Murray, 1991). The *Bolivina* species (ex. *B. aenariensis* and *B. punctata*), infaunals, are characteristics of muddy bottoms and they are particularly tolerant to reduced oxygenation levels, in environments such as meso-eutrophic (Blanc-Vernet, 1969; di Napoli Alliata et al., 1970; Van der Zwaan, 1983; Murray, 1991; Barmawidjaja et al., 1992; Sen Gupta & Machain-Castillo, 1993).

Planktonic foraminifera

Planktonic foraminiferal assemblages were extremely poor in the three fractions considered (9 species, Table 2). Individuals, sometimes strongly pyritized or glauconitized of *Orbulina universa* were found in association with rare *Globigerina bulloides*, *G. falconensis* and *G. glutinata*, as well as rare *Globigerinoides obliquus extremus*, *G. elongatus* e *Sphaeroidine-llopsis dehiscens*. Only one specimen of *Globorotalia* cf. *margaritae* was found in the coarser fraction. The genus *Neogloboquadrina* Frerichs et Vincent, 1967 was also extremely rare. Indeed only two specimens of *N. acostaensis* were identified. *Globigerinoides obliquus extremus* and *Orbulina universa* are represented in the figures 34, 35.

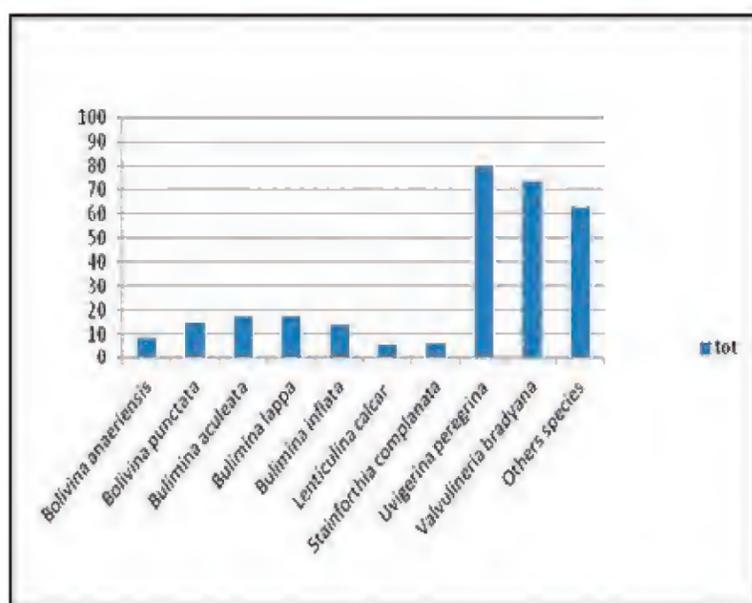


Figure 36. Total percentage of benthic foraminiferal dominant species.

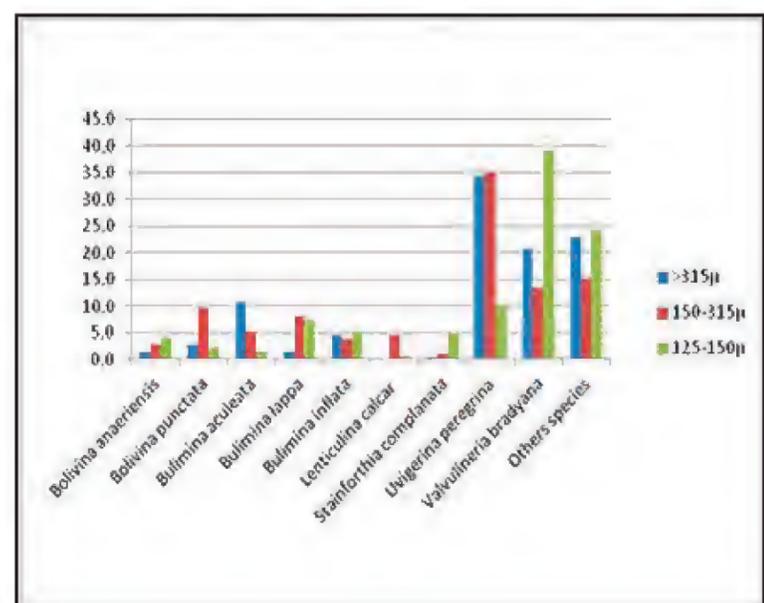


Figure 37. Percentage of benthic foraminifera dominant species for all studied fraction (>315 µm, 150-315 µm, 125-150 µm).

DISCUSSION AND CONCLUSION

In an outcrop of Pliocene clays near Rio Crosio (Cherasco, Piemonte, NW Italy) two specimens of fossil starfish were found, attributed to *Astropecten irregularis pentacanthus* (Delle Chiaje, 1825).

The analysis of the malacofauna and the benthic foraminiferal assemblages has provided paleoecological and paleoenvironmental data indicating a circalittoral deep environment, little more than 100 m depth and characterized by a muddy bottom; the trophic conditions were from meso to eutrophic, with a rather low level of oxygenation, which thus enabled the survival of upper and intermediate infaunals tolerant species, such as *Uvigerina peregrina*, *Valvulineria bradyana*, various species of the genus *Bulimina* and genus *Bolivina*. On the base of planktonic foraminiferal assemblages (*Globigerinoides obliquus extremus*, *G. elongatus*, genus *Sphaeroidinellopsis* Banner et Blow, 1959 and *Globorotalia margaritae*), the samples are attributed to biozone MP12 of lower Pliocene (Zanclean) which, according to Violanti (2012) in the NW Italy, correspond to 5.08 and 4.52 Ma. The absence of species such as *Globorotalia inflata* and *Bulimina marginata*, very frequent in the upper Pliocene (Lentini, 1969), allows to confirm this datation.

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REFERENCES

- Aartsen J.J. van, 1987. European Pyramidellidae: III. *Odostomia* and *Ondina*. Bollettino Malacologico, 23: 1-33.
- Adam W. & Glibert M., 1975. Contribution à la connaissance de *Nassarius semistriatus* (Brocchi, 1814) (Mollusca: Gastropoda). Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, 50: 1-78.
- Andri E., Tagliamacco A., Testa M. & Marchini A., 2005. Le malacofaune fossili del Rio Torsero. Regione Liguria, Catalogo dei beni naturali, 5. Nuova Editrice Genovese, Ceriale, 286 pp.
- Ardevini R. & Cossignani T., 1999. Atlante delle conchiglie di profondità del Mediterraneo. L'Informatore Piceno Ed., Ancona, 111 pp.
- Barmawidjaja D.M., Jorissen F.J., Puskaric S. & Van der Zwaan G.J., 1992. Microhabitat selection by benthic foraminifera in the northern Adriatic sea. Journal of Foraminiferal Research, 22: 297-317.
- Bergamin L., Di Bella L. & Carboni M.G., 1999. *Valvulineria bradyana* (Fornasini) in organig matter-enriched environment (Ombrone river mouth, Central Italy). Il Quaternario, Italian Journal of Quaternary Sciences, 12: 51-56.
- Blanc-Vernet L., 1969. Contribution à l'étude de foraminifères de Méditerranée. Recueil des Travaux de la Station Marine d'Endoume, 64: 1-315.
- Borghi E. & Bajo Campos I., 2008. Asteroidei fossili dell'Emilia. Notiziario della Società Reggiana di Scienze Naturali, 13-29.
- Borghi M. & Vecchi G., 2005. La malacofauna plio-pleistocenica del torrente Stirone (PR). Cerithiidae - Turritellidae. Parva Naturalia, 7: 3-46.
- Brunetti M.M. & Forli M., 2013. The genus *Aporrhais* Da Costa, 1778 (Gastropoda Aporrhaidae) in the Italian Plio-Pleistocene. Biodiversity Journal, 4: 183-208.
- Cavallo O., Macagno M. & Pavia G., 1986. Fossili dell'Albese: aspetti geologici, e paleontologici delle Langhe e del Roero. Famija Albeisa, Alba, 223 pp.
- Charrier G., 1953. Brevi note sulle forme del gen. *Aporrhais* (*Chenopus*) della fauna pliocenica di San Gaudenzio (Lessona) nel Biellese. Rivista Italiana di Paleontologia e Stratigrafia, Milano, 59: 195-202.
- Chirli C., 2008. Malacofauna pliocenica toscana. Neotaenioglossa. Vol. 6. Grafiche PDB, Tavernelle, 128 pp.
- Chirli C. & Micali P., 2011. Malacofauna pliocenica toscana. Pyramidelloidea. Vol. 8. Grafiche PDB, Tavernelle, 132 pp.
- Corliss B.H., 1985. Microhabitats of benthic foraminifera within deep-sea sediments. Nature, 314: 435-438.
- Corliss B.H., 1991. Morphology and microhabitat preferences of benthic foraminifera from the northwest Atlantic Ocean. Marine Micropaleontology, 17: 195-236.
- Corliss B.H. & Emerson S., 1990. Distribution of Rose Bengal stained deep-sea benthic foraminifera from the Nova Scotian continental margin and Gulf of Maine. Deep-Sea Research, 37: 381-400.
- Damarco P., 1994. Alcuni esemplari eccezionali di Aporrhaidae fossili del Pliocene piemontese. World Shells, 3: 28-30.

- De Rijk S., Jorissen F.J., Rohling E.J. & Troelstra S.R., 2000. Organic flux control on bathymetric zonation of Mediterranean benthic foraminifera. *Marine Micropaleontology*, 40: 151-166.
- De Stefani C. & Pantanelli D., 1878-80. Molluschi pliocenici dei dintorni di Siena. *Bullettino della Società malacologica italiana*, 4 (1-6): 5-48 [1878], 4 (7-14): 49-112 [1879], 4 (15-20): 113-160 [1879], 4 (21-30): 161-215 [1880].
- Di Napoli Alliata E., Stefanini S. & Fioramonti G., 1970. Étude de quelques carottes du plateau et du talus continental de la Sardaigne méridionale. *Bollettino della Società Geologica Italiana*, 89: 209-232.
- Fontanier C., Jorissen F.J., Chaillou G., David C., Anschutz P. & Lafon V., 2003. Seasonal and interannual variability of benthic foraminiferal faunas at 550 m depth in the Bay of Biscay. *Deep-Sea Research, Part I: Oceanographic Research Papers*, 50: 457-494.
- Forli M., 1989. Considerazioni filogenetiche su alcune specie del genere *Aporrhais* da Costa, 1778 (Mollusca: Gastropoda) (ultima parte). *Argonauta*, 5: 49-54.
- Huang B., Jian Z., Cheng X. & Wang P., 2002. Foraminiferal responses to upwelling variations in the South China Sea over the last 220000 years. *Marine Micropaleontology*, 47: 1-15.
- Jannik N.T., Zachariasse W.J. & Van der Zwaan G.J., 1998. Living (Rose Bengal stained) benthic foraminifera from the Pakistan continental margin (northern Arabian Sea). *Deep-Sea Research Part I. Oceanographic research Papers*, 45: 1483-1513.
- Jiménez A.P., Aguirre J. & Rivas P., 2009. Taxonomic study of scallops (Pectinidae: Mollusca, Bivalvia) from Pliocene deposits (Almería, SE Spain). *Revista Española de Paleontología*, 24: 1-30.
- Kuhnt W., Hess S. & Jian Z., 1999. Quantitative composition of benthic foraminiferal assemblages as a proxy indicator for organic carbon flux rates in the South China Sea. *Marine Geology*, 156: 123-157.
- Lentini F., 1969. Sezioni stratigrafiche plioceniche nella Val d'Agri presso Gannano (Matera). *Atti dell'Accademia Gioenia di Scienze Naturali di Catania*, 20 (Suppl. Sc. Geolog.): 19-79.
- Lutze G.F., 1986. *Uvigerina* species of the eastern North Atlantic. In: Van der Zwaan G.J., Jorissen F.J., Verhallen P.J.J.M. & von Daniels C.H. (Eds.), *Atlantic - European Oligocene to Recent Uvigerina*. *Utrecht Micropaleontological Bulletins*, 35: 21-46.
- Lutze G. & Coulbourn W., 1984. Recent benthic foraminifera from the continental margin off north-west Africa: community structure and distribution. *Marine Micropaleontology*, 8: 361-401.
- Mackensen A., Schmiedl G., Harloff J. & Giese M., 1995. Deep-sea foraminifera in the South Atlantic Ocean: ecology and assemblage generation. *Micropaleontology*, 41: 342-358.
- Malatesta A., 1974. Malacofauna pliocenica umbra. Memorie per servire alla descrizione della carta geologica d'Italia: 13: XI+498.
- Morigi C., Jorissen F.J., Gervais A., Guichard S. & Borsetti A.M., 2001. Benthic foraminiferal faunas in surface sediments off NW Africa: relationship with the organic flux to the ocean floor. *Journal of Foraminiferal Research*, 31: 350-368.
- Murray J.W., 1991. Ecology and distribution. *Benthos 90*, Tokai University Press, Sendai.
- Parenzan P., 1974. Carta d'identità delle conchiglie del Mediterraneo. Vol. II. Bivalvi (prima parte). Bios Taras Editrice, Taranto, 280 pp.
- Pavia G., 1976. I Molluschi del Pliocene inferiore di Monteu Roero (Alba, Italia NW). *Bollettino della Società Paleontologica Italiana*, 14: 99-175.
- Pérès J.M. & Picard J., 1964. Nouveau manuel de Biologie benthique de la Mer Méditerranée. *Recueil des Travaux de la Station Marine d'Endoume*, 31: 1-137.
- Poppe G.T. & Goto Y., 1991. *European Seashells*. Vol. 1 (Polyplacophora, Caudofoveata, Solenogastrea, Gastropoda). Verlag Christa Hemmen, Wiesbaden, 352 pp.
- Poppe G.T. & Goto Y., 1993. *European Seashells*. Vol. 2. (Scaphopoda, Bivalvia, Cephalopoda). Verlag Christa Hemmen, Wiesbaden, 221 pp.
- Riedl R., 1991. *Fauna e Flora del Mediterraneo*. Franco Muzzio Editore, Padova, 777 pp.
- Ruggieri G., 1972. Considerazioni su alcune *Aporrhais* del Neogene italiano e sul loro significato stratigrafico. *Rivista Mineraria Siciliana*, Palermo, 22: 14-20.
- Sacco F., 1893. Sopra alcuni Asteroidei fossili. *Atti Regia Accademia delle Scienze*, Torino, 28: 739-745.
- Sacco F., 1897. I Molluschi dei terreni terziarii del Piemonte e della Liguria. Parte XXIV. (Pectinidae). Carlo Clausen, Torino, 84 pp., 21 pls.
- Scaperrotta M., Bartolini S. & Bogi C., 2009. Accrescimenti. Stadi di accrescimento dei molluschi marini del Mediterraneo. Vol. I. L'Informatore Piceno Ed., Ancona, 167 pp.
- Scaperrotta M., Bartolini S. & Bogi C., 2011. Accrescimenti. Stadi di accrescimento dei molluschi marini del Mediterraneo. Vol. III. L'Informatore Piceno Ed., Ancona, 184 pp.
- Schmiedl G. & Mackensen A., 1997. Late Quaternary paleoproductivity and deep water circulation in the eastern South Atlantic Ocean: evidence from benthic foraminifera. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 130: 43-80.
- Schmiedl G., De Bovée F., Buscail R., Charrière B., Hemleben C., Medernach L. & Picon P., 2000. Trophic control of benthic foraminiferal abundances and microhabitat in the bathyal Gulf of Lions, western Mediterranean Sea. *Marine Micropaleontology*, 40: 167-188.

- Schönfeld J., Alve E., Geslin E., Jorissen F., Korsun S., Spezzaferri S. and members of the FOBIMO group, 2012. The FOBIMO (FORaminiferal BIO-MONitoring) initiative - Towards a standardised protocol for soft-bottom benthic foraminiferal monitoring studies. *Marine Micropaleontology*, 94-95: 1-13.
- Scott D.B., Schafer C.T. & Medioli F.S., 1980. Eastern Canadian estuarine foraminifera: a framework for comparison. *Journal of Foraminiferal Research*, 10: 205-234.
- Sen Gupta B.K. & Machain-Castillo M.L., 1993. Benthic foraminifera in oxygen-poor habitats. *Marine Micropaleontology*, 20: 183-201.
- Tebble N., 1966. *British Bivalve Seashells*. The British Museum of Natural History, London, 212 pp.
- Terreni G., 1981. Molluschi conchiferi del mare antistante la costa toscana (Gastropoda, Scaphopoda, Amphineura, Bivalvia, Cephalopoda). Tip. Benvenuti & Cavaciocchi, Livorno, 106 pp.
- Thompson T.E., 1976. *Biology of Opisthobranch Molluscs*. Vol. I. The Ray Society, London, 206 pp.
- Tortonese E., 1965. Echinodermata. *Fauna d'Italia*, Vol. VI. Calderini Ed., Bologna, 422 pp.
- Van der Zwaan G.J., 1983. Quantitative analyses and the reconstruction of benthic foraminiferal communities. *Utrecht Micropaleontological Bulletin*, 26: 49-69.
- Violanti D., 2012. Pliocene Mediterranean Foraminiferal Biostratigraphy: A Synthesis and Application to the Paleoenvironmental Evolution of Northwestern Italy, *Stratigraphic Analysis of Layered Deposits*. 123-160. Dr. Ömer Elitok (Ed.), InTech, Available from: http://cdn.intechopen.com/pdfs/36321/InTech-Pliocene_mediterranean_foraminiferal_biostratigraphy_a_synthesis_and_application_to_the_paleoenvironmental_evolution_of_northwestern_italy.pdf

A remarkable new flightless *Madrasostes* Paulian, 1975 from Vietnam (Coleoptera Scarabaeoidea Hybosoridae Ceratocanthinae)

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ABSTRACT

Madrasostes bartolozzii n. sp. is described from Vietnam (Ba Be National Park) on the basis of two females. Some remarks on this unusual flightless species are provided. Distinguishing characters between *Madrasostes* Paulian, 1975 and *Besuchestostes* Paulian, 1972 are briefly discussed.

KEY WORDS

Ba Be National Park; Ceratocanthinae; Flightlessness; *Madrasostes*; new species.

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INTRODUCTION

The last (and only) synopsis of Vietnamese Ceratocanthinae (Coleoptera Scarabaeoidea Hybosoridae) was the volume by Renaud Paulian (1945) on the Coleoptera Scarabaeoidea of French Indochina, which listed four species: *Madrasostes tonkinense* (Paulian, 1945), *Pterorthochaetes incertus* Gestro, 1899, *Pterorthochaetes coomani* Paulian, 1945 and *Pterorthochaetes armatus* Paulian, 1945. No additions have been recorded since then (Paulian, 1978; Ocampo & Ballerio, 2006). Paulian's work was based exclusively on material from Hoa Binh region (Northern Vietnam), and the country still awaits a proper exploration in order to inventory its Ceratocanthine fauna, which will probably score a final number several times larger than the four species listed above (for instance the study of the *P. incertus* from Hoa Binh kept in the Museum National d'Histoire Naturelle collection in Paris, in the course of an ongoing revision of the genus *Pterorthochaetes* Gestro, 1899, revealed that *P. incertus* does not occur in Vietnam and that the alleged *P. incertus* specimens actually represent three un-

described species). It is not surprising therefore that an expedition organized in 2011 by the team of the Museo Zoologico La Specola of Florence discovered a new species of the genus *Madrasostes* Paulian, 1975, remarkable by its unusual morphology, which is herein described.

METHODS

I refer to Ballerio et al. (2011) and references therein quoted for methods and terminological conventions. Habitus photographs were taken with a Canon Eos D5 MII with a macro objective MP 65 mm, all photos were then mounted with the Zerene Stacker software and cleaned and unmasked using a photo processing software.

ABBREVIATIONS. EL = maximum elytral length; EW = maximum total elytral width; HL = maximum head length; HW maximum head width; PL = maximum pronotal length at middle; PW = maximum pronotal width at middle; W/L = ratio width length.

Madrasostes bartolozzii n. sp.

EXAMINED MATERIAL. Holotypus, female, in Coll. Vietnam National Museum of Nature, Hanoi, Vietnam: Northern Vietnam, Bac Kan Province, Ba Be National Park (~350 m), 22°25'0.69"N 105°37'53.16"E, 3-8.VI.2011, L. Bartolozzi, S. Bambi, F. Fabiano & E. Orbach leg. Paratypus, female, in Coll. Museo Zoologico La Specola, Firenze: same data as holotypus.

DESCRIPTION OF HOLOTYPE. HL = 0.69 mm; HW = 1.44 mm; PL = 1.38 mm; PW = 2.33 mm; EL = 2.36 mm; EW = 2.27 mm.

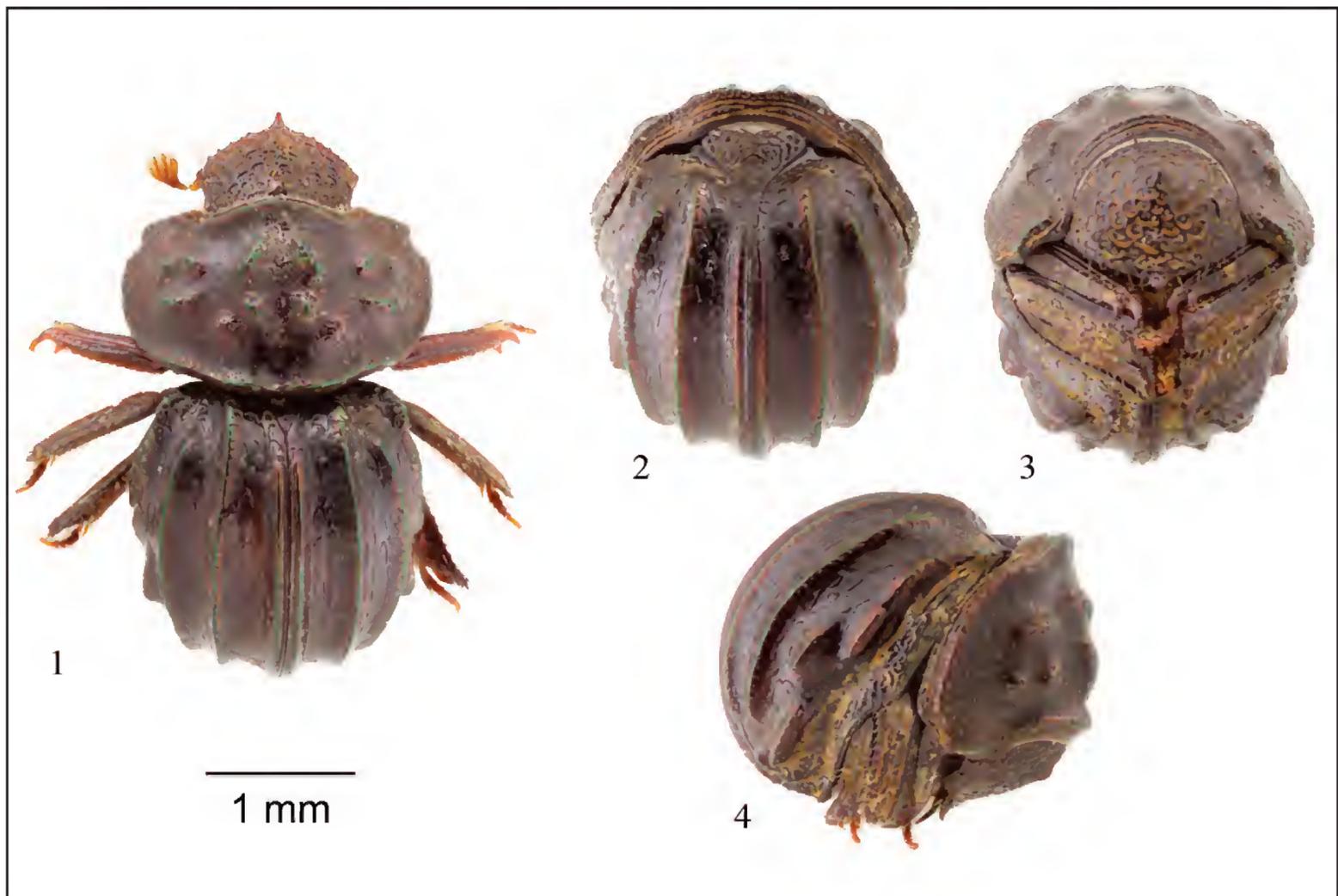
Small sized *Madrasostes* (Figs. 1-4), flightless, shiny dark-brown with green metallic sheen on reliefs, antennae, tarsi and sternum reddish-brown. Glabrous (45x). Head subpentagonal, wider than long (W/L ratio= 1.26). Clypeal extremity pointed, distinctly protruding forwards and apically slightly bent upwards (probably a sexually dimorphic character). Fore side of clypeus serrate, clypeopleuron short, genae slightly protruding outwards, genal canthus indistinct, dorsal ocular area absent. Head dorsal surface completely covered by dense impressed comma-shaped punctures, punctures larger on disc and frons and smaller on head base, centrifugally oriented, each one bearing a simple puncture next to inferior side, punctures dense, almost touching each other. Eyes small, longitudinally elongate. Antennae 10-segmented, scape long (about half the total length of antenna), slightly clavate distad, pedicellus cupuliform, flagellum short, made of short articles distinctly wider than long, antennal club three-segmented, uniformly hairy.

Mouthparts. Labrum wide and short, hemicircular, surface finely wrinkled, bearing medially a transverse row of about ten long erect fine setae and distally fringed by a dense fine setation directed forward. Distal epipharynx bisinuate, longitudinally divided by a strong anterior median process; median brush and corypha absent; apical fringe made of long, fine setae, absent in the middle. Mentum ventrally flat, widely emarginated in the middle, emargination regularly wide-U-shaped; labial palpi (including palpiger) four-segmented, first segment short and transverse, segment two short, segment three longer and plumper than preceding two together, segment four subconical, about as long as seg-

ment three, apically bearing some short sensilla, all segments, apart from the last one, fringed with long setae. Maxillae with an elongate single membranous lacinia, covered with fine long setae, monolobed galea proximally sclerotized and distally clothed with coarse long, fine setae with distinctive comb-like tip (galeal brush), maxillary palpi (including palpiger) four-segmented, palpiger small, segment two wide and short, segment three short, segment four long and subconical, about as long as preceding two together, apically bearing some short sensilla. Mandibles short, regularly curved, apicalis with pointed apical tooth very short and blunt, not protruding over mesal brush, lateral sclerite of apicalis bearing a distinct large pore, mesal brush wide and well developed, basalis with molar lobe strong.

Pronotum wider than long (W/L ratio= 1.6), fore angles truncate and sinuate externally, fore margin bisinuate, with visible bead, lateral and basal margin with a thick bead not visible from above, basal margin slightly swollen upwards, pronotal sculpturing as follows: whole surface, apart from area near fore angles, uniformly covered by very fine impressed simple punctures, their distance being one or two times their diameter. Area near fore angles covered by a mix of coarse shallow comma-shaped and ocellate punctures. Two large longitudinal irregular raised cariniform processes on disc, convergent anteriorly, basally, next to each cariniform process, there is a large blunt tubercle, and next to the tubercle there are two transversal processes subparallel to each other, the superior one is an irregular carina, while the inferior is a pair of tubercles; surface of carinae and tubercles smooth, apart from a few sparse large impressed simple punctures.

Scutellum wider than long (W/L ratio=1.4), sides proximally subparallel and distinctly notched by elytral articular process, then convergent to form a triangle with elongate acute apex and sides slightly curved inward. Surface slightly depressed in the middle, covered by irregular impressed comma-shaped punctures. Elytra slightly longer than wide (W/L ratio=0.98), sutural interstria raised and cariniform, another longitudinal strongly raised complete carina next to sutural carina, one further longitudinal complete raised carina, starting from the end of proximal third and ending at the beginning of the distal third, one fourth short raised carina occupying most of median third and finally a fifth longitudinal raised carina starting at humerus



Figures 1-4. *Madrasostes bartolozzii* n. sp. Fig. 1: Holotypus dorsal view. Fig. 2: rolled up holotypus dorsal view. Fig. 3: rolled up holotypus ventral view. Fig. 4: rolled up holotypus lateral view.

(and inglobating humeral callus) and ending near apex, interrupted medially in correspondence with the fourth carina. Surface of carinae smooth, surface between carinae covered by two irregular rows of longitudinally oriented elongate and narrow shallow horseshoe-shaped punctures, with opening backwards and having a simple puncture in the middle.

Pseudoepipleure absent, marginal area broad, expanded outwards, coarsely wrinkled, inferior sutural stria not present, articular area not visible. Fore tibiae ending with two outer teeth, outer margin coarsely serrate, apical spur long and broadly curved downwards. Meso- and metatibiae ending with two apical spurs.

VARIABILITY. The paratypus does not show any appreciable variation compared to the holotypus in size, colour, shape and sculpturing.

ETYMOLOGY. I am pleased to dedicate this remarkable new species to Dr. Luca Bartolozzi (Museo Zoologico La Specola, Firenze), who collected the type series.

DISTRIBUTION AND BIOLOGY. Known only from the type locality, Ba Be national Park in Northern Vietnam. The area falls within the South China-Vietnam Subtropical Evergreen Forest ecoregion (Wikramanayake et al., 2002). The type series was collected by sifting leaf litter collected in the rain-forest near the park headquarters (Bartolozzi, pers. comm.).

COMPARATIVE NOTES. *M. bartolozzii* n. sp. can be easily distinguished from all other *Madrasostes* because of the following combination of characters: head with serrate clypeal margin, genal canthus indistinct without any dorsal ocular area, pronotum with surface covered by a dense very fine puncturation, elytra with five strongly raised longitudinal carinae, flightless.

REMARKS. This new species strongly diverges morphologically from all other known *Madrasostes*. No other known *Madrasostes* displays such a combination of characters and at present it is not

possible even to find its closest relatives. The unusual puncturation pattern of pronotum, made of very fine simple punctures is not found in any other known *Madrasostes* and is unique even within Ceratocanthinae. The combination of flightlessness, indistinct eye canthus and dorsal ocular area absent and strong carinate elytra could lead to place this species in the genus *Besuchetostes* Paulian, 1972, according to the criteria set by Paulian (1978). However a redefinition of the genus *Besuchetostes* in preparation will soon circumscribe the genus to the Indian and Sri Lankan species ascribed to it (Ballerio, in prep.). *Madrasostes bartolozzi* n. sp. shares some characters typical of the *Perignamptus* genus group, as defined by Ballerio (2009), and absent in true *Besuchetostes*, such as the shape of epipharynx and the presence of a basal pore in the mandibles. Indistinct eye canthus and dorsal ocular area absent as well as strong carinate elytra and the pattern of distribution of tubercles on pronotum are probably the result of convergent evolution, due to flightlessness and strong adaptation to life in leaf litter.

Therefore the species is here attributed to *Madrasostes*, even if as previously highlighted in Ballerio (2009), this placement must be seen as provisional, due to the unsatisfactory current definition of the genus *Madrasostes* and its allies within the *Perignamptus* generic group.

REFERENCES

- Ballerio A., 2009. Unusual morphology in a new genus and species of Ceratocanthinae from New Guinea (Coleoptera: Scarabaeoidea: Hybosoridae). *The Coleopterists Bulletin*, 63: 44-53.
- Ballerio A., B.D. Gill & V. Grebennikov. 2011. Illustrated overview and identification key to Cameroonian Ceratocanthinae beetles (Coleoptera: Scarabaeoidea: Hybosoridae) with description of four new species. *Zootaxa* 2892: 1-24.
- Ocampo F.C. & Ballerio A., 2006. Catalog of the subfamilies Anaidinae, Ceratocanthinae, Hybosorinae, Liparochrinae, and Pachyplectrinae (Scarabaeoidea: Hybosoridae). In Ocampo F.C. (Ed.) *Phylogenetic analysis of the scarab family Hybosoridae and monographic revision of the New World subfamily Anaidinae* (Coleoptera: Scarabaeoidea). *Bulletin of the University of Nebraska State Museum*, 19: 178-209.
- Paulian R., 1945. Coléoptères Scarabaéides de l'Indochine. Première partie. Faune de l'Empire Français III. Librarie Larose, Paris, 228 pp.
- Paulian R., 1978. Révision des Ceratocanthidae [Col. Scarabaeoidea] II - Les espèces orientales et australiennes. *Annales de la Société Entomologique de France*, 14: 479-514.
- Wikramanayake E., Dinerstein E., Loucks C.J., Olson D.M., Morrison J., Lamoreux J., McKnight M. & Hedao P., 2002. *Terrestrial Ecoregions of the Indo-Pacific. A Conservation Assessment*. Island Press, Washington, 643 pp.