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*Himantopus himantopus* Linnaeus, 1758 - Italy, Sicily, Vendicari

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Nature Reserve of Vendicari (Italy, Sicily), landscape (photo by G. Iuvara).



Pendolino, *Remiz pendulinus* (Linnaeus, 1758) (Seidlitz, 1896) on the nest (photo by G. Iuvara). Cover: photo by Iuvara.

**The Vendicari Nature Reserve (Italy, Sicily).** The Oriented Natural Reserve (O.N.R.) “Oasi faunistica di Vendicari”, in the territory of Noto (Sicily, Italy), UNESCO World Heritage City, was established in March 14<sup>th</sup> 1984. Despite its small size (total of 1335.62 acres), within the reserve there is a concentration of environments hardly observable in other parts of Sicily. In particular, there have been identified as habitats of interest to the European Community: Intermittently flowing Mediterranean rivers of the *Paspalo-Agrostidion* (Habitat code 3290); Vegetated sea cliffs of the Mediterranean coasts with endemic *Limonium* spp. (code 1240); Endemic phryganas of the *Euphorbio-Verbascion* (code 5430); Thermo-Mediterranean and pre-desert scrubs (code 5330); embryonic shifting dunes (code 2110); Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes) (code 2120); Coastal dunes with *Juniperus* spp. (code 2250, priority habitat); Coastal lagoons (code 1150, priority habitat); Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetia fruticosi*) (code 1420); *Salicornia* and other annuals colonizing mud and sand (code 1310); Mediterranean salt meadows (*Juncetalia maritimi*) (code 1410). A highly rich biodiversity was therefore already reported for the reserve: data are contained in a compendium published in 2010 [Petralia A. (a cura di) 2010. *L'area protetta di Vendicari*. ©Ente Fauna Siciliana, Noto, Italy ([www.entefaunasiciliana.it](http://www.entefaunasiciliana.it))]. The plant list includes 486 species (48.4% therophytes, 22.0% hemicryptophytes, 13.7% geophytes, 6.2% chamaephytes, 6.0% phanerophytes, 2.7% nanophanerophytes, 0.8% hydrophytes). There are 7 species of mammals, 251 bird species (79 of which are included in the Directive 2009/147/EEC), 4 species of Amphibians, and 10 of Reptiles; moreover, after decades of absence, in 2013 and 2014, *Caretta caretta* returned to the reserve for nesting. 237 are the species of Macrolepidoptera present (24.0% of the species known for Sicily, 10.82% for Italy). Among orthopteroids there are 32 species (including the Ensifer *Brachytrupes megacephalus*, species of Community interest). As concerns the fauna of the marshes of the reserve, 22 species of molluscs, 3 of crustaceans, 2 of bristleworms (Polychaetes) and 7 of fish have been reported. More generally, further faunistic data may be derived from a larger survey [Pilato et al., 2007. *La fauna della regione iblea*. In “L'uomo negli Iblei” (a cura di A. Petralia). ©Ente Fauna Siciliana, Noto, Italy ([www.entefaunasiciliana.it](http://www.entefaunasiciliana.it))] that lists 2914 species and subspecies referring to the entire iblean area including Vendicari; of course the knowledge of fauna is periodically refreshed by new acquisitions such as the recent discovery of the presence of the relevant beetle *Buprestis cupressi* (Buprestidae). Finally, a project for the establishment of the Protected Marine Area of Vendicari aims to extend protection also to the sea off the reserve, with its seabed equally rich in biodiversity.

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## Global biodiversity gain is concurrent with declining population sizes

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### ABSTRACT

Many authorities believe that the world's foremost conservation problem is biodiversity loss caused by the extinctions of thousands of species per year. Estimates of huge losses are based on indirect evidence such as the amount of habitat destroyed, pollution, or overexploitation. But, we now have documented records of species extinctions that provide direct instead of indirect information about diversity loss. By using extinction records for well-known animal groups plus surrogate data, I show there is no evidence for an unusually high rate of extinction, a mass extinction is not yet underway, and there are indications of a continued biodiversity gain. On the other hand, there is ample evidence to demonstrate the persistence of numerous small populations that are the remnants of once widespread and productive species. These populations represent an extinction debt that will be paid unless they are rescued through present day conservation activity. They constitute the world's true biodiversity problem.

### KEY WORDS

biodiversity gain; biodiversity loss; conservation; extinction debt; speciation.

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### INTRODUCTION

As new portions of terrestrial wilderness continue to be utilized or modified by human activity, wildlife has less territory, individual species are crowded into smaller spaces, and many of them lose population size until their existence becomes precarious. Overexploitation by hunting and trapping directly affect populations of birds and mammals. In the oceans, there is loss of natural habitat over large areas of sea bottom through the action of commercial trawlers, and by the degradation of coral reefs by human use and global warming. Along shorelines, construction and pollution have impacted much of the shallow marine habitat. The direct effect of overfishing has resulted in hundreds

of species being reduced to remnants of their original population sizes. These kinds of impacts are assumed to have contributed to a global biodiversity loss of several thousand species each year, an apparent crisis that has been called the world's greatest conservation problem.

The reactions of conservation societies and government agencies to the foregoing problems have tended in two directions: (1) trying to stem the perceived loss of biodiversity due to species extinction, and (2) paying attention to the plight of species that are threatened by extinction. This brings up the question, should we continue to concentrate on overall biodiversity loss or should we devote more resources to the needs of individual species? One might say that both conservation approaches are im-

portant, but is this really true? Let us first consider biodiversity loss.

### **BIODIVERSITY LOSS?**

Global and local losses of biodiversity have been a major focus of conservation action for 40 years. Anguish over the apparent, continuing extinction of large numbers of species has been expressed in numerous scientific papers, newspaper and magazine articles, and on the internet. As E.O. Wilson (1993) has noted, biodiversity, as a term and a concept, has been a remarkable event in recent cultural history. It was born as “BioDiversity” during the National Forum on BioDiversity held in Washington, D.C., in September, 1986. Prior to that time, Norman Myer’s (1979) book had caused considerable excitement when it predicted the extinction of one million species between 1975 and 2000.

By the 1990s, numerous books and articles had described biodiversity loss in terms of thousands of species that disappeared each year. Among the most notable, were Al Gore’s (1992) book which estimated that 40,000 species were disappearing each year, and E.O. Wilson’s (1993) prediction of about 27,000 rain forest extinctions per year. Other huge species loss estimations (Briggs, 2014) were soon followed by declarations that the Earth had started to undergo its sixth great mass extinction (Ceballos et al., 2010; Kolbert, 2014).

In retrospect, biodiversity loss became rapidly established as a scientific revelation and there were few questions about sources of the information. But, such concepts or theories need to be supported by facts and, in this case, the facts were few and the theory was so captivating that it survived even with little support for 40 years. The beginning can be traced back to an influential work on island biogeography by MacArthur & Wilson (1967). The authors found that on small islands, species diversity was determined by island size, i.e., the larger the size, the greater the diversity. Also, they found a constant turnover whereby the numbers of invading species were balanced by the native species that were lost. In subsequent years, more research was done on islands and other small habitats and these two discoveries were generally substantiated.

The relationship between area size and species diversity became important to many ecologists who were convinced that, if a given amount of habitat was destroyed, a certain number of species must be lost. That idea was converted to a “rule of thumb” which stated that when a habitat is reduced to one tenth its original size, the number of species eventually drops to one half (Wilson, 1993). This species-area rule (SAR) became well accepted and began to be applied to locations ranging from small islands to large continental areas. However, prohibitive difficulties became apparent when the SAR was applied to areas larger than small, isolated islands. As noted by Whittaker et al. (2001), the problem with such data is one of scale. When small scale data are applied to very large scale areas, the results are apt to become meaningless. Furthermore, there has been constructive criticism about the usefulness of the SAR (He & Hubbell, 2011). To avoid the SAR problem, as well as to depend on direct instead of theoretical data, it is preferable to utilize information from documented extinctions. More recently, various statistical methods have been used to manipulate the theoretical extinction data in order to prove large annual losses (for example Pimm et al., 2014), but they unnecessarily complicate what is actually a simple problem. By utilizing information from recorded extinctions, together with data from well-known surrogate taxa, I show that rate of recent extinctions has been very low.

### ***Documented extinctions***

Until recent years, there had not been sufficient data on species extinctions to provide an overall estimate of biodiversity loss over the past 500 years or more. But now, the availability of more data, based on contemporary and fossil extinctions, has made possible a new analysis. It is important to note that previous estimates were made primarily on life in the terrestrial and freshwater environments. Obviously, global predictions should also depend on information from the sea which covers about 71% of the Earth’s surface. There is one significant difference between the data from land and sea. In the first instance, there have been, in the early years of island explorations by humans, thousands of extinctions of endemic species that were confined to very small spaces. But in the second case, recorded extinctions have been remarkably few.

Although attention has been called to marine biodiversity losses by Worm et al. (2006), that article was referring to decreases in population size rather than species extinction. The Holocene began about 12,000 years ago and a total of 20 marine extinctions were recorded by Dulvy et al. (2009). When the losses of the 20 marine species (4 mammals, 8 birds, 4 molluscs, 3 fishes, 1 alga) are compared to a total marine diversity of about 2.21 million eukaryotic species (Mora et al., 2011), the rate of extinction becomes vanishingly small. Although it is often assumed that invasive species are responsible for native extinctions, none of the 20 marine extinctions have been due to competition from exotic invaders (Briggs, 2007).

In fact, there is now good evidence that invasive species function to increase rather than decrease biodiversity. In locations where large numbers of exotic species are being introduced, such as the eastern Mediterranean Sea (Galil, 2007) and in many harbors and estuaries (Briggs, 2012), the invaders are accommodated by the native species resulting in local biodiversity increases. Information from Pliocene invasions demonstrates that a large fraction of invaders eventually speciate (Vermeij, 1991; 2005) thus adding to global biodiversity. It has been concluded that in the marine environment, invader species are a dynamic diversity-creation force with a circumglobal influence (Briggs & Bowen, 2013).

In the terrestrial environment, the birds and mammals are the best known vertebrates and their extinction rates have been recorded. The records and geographical locations of the extinctions, based on evidence in the IUCN Red List and the CREO List at the American Museum of Natural History, have been analyzed by Loehle & Eschenbach (2012). Extinctions during the past 500 years demonstrate an enormous difference between islands and continents. On all continents, only three mammals are recorded as having gone extinct. The remaining mammal extinctions (58 or 95%) took place on islands (Australia, due to its history of isolation, was classified as an island). Of 128 extinct bird species, 122 (95.3%) were island extinctions and only six were on continents. It has been observed that well-known surrogate taxa can be used as biodiversity indicators (Caro & O'Doherty, 1999). If we use the birds and mammals as surrogates for all the vertebrates, this suggests that

extinction rates among the vertebrate animals of the world's continents have been very low. Another discovery (Loehle & Eschenbach, 2012) was that none of the bird and mammal extinctions were known to have occurred solely because of habitat reduction. For many years, habitat reduction, especially tropical deforestation, had been regarded as the primary cause of species loss. A recent study of the vertebrate species in the Brazilian Amazon by Wearn et al. (2012) demonstrated that extinctions have been minimal (1%) and that 80% of the losses predicted by habitat decline were yet to come.

For invertebrates, the Zoological Society of London has published the world's first study of global invertebrate biodiversity (Collen et al., 2012). This report, produced in conjunction with the IUCN and its Species Survival Commission, concluded that about 80% of the world's species were invertebrates and about 20% of them were threatened with extinction. Of the world's terrestrial invertebrates, about 90% are insects. This suggests if dependable information on insect extinction rates were available, it might yield an approximate rate for terrestrial invertebrates as a whole. Three orders of insects: butterflies, tiger beetles, and Odonata (dragonflies and damselflies), have been studied to the extent that almost all the species are well known. The world total of butterfly species is about 17,280 (Shields, 1989). Although three species are often listed as extinct (two in South Africa and one in the USA), the records are doubtful. Ehrlich (1995) found that there was no documented extinction of a continental butterfly species anywhere in the world. No island butterfly species has been recorded to be extinct.

There are about 2,300 species of tiger beetles (Pearson, 2001) and, although several are listed as endangered, none has become extinct. For the Odonata, a random sample of 1,500 of the 5,680 described species was assessed (Clausnitzer et al., 2009). Ten percent were found to be threatened but none of them had become extinct. In fact, there are only two documented extinctions, one from Maui in the Hawaiian Islands and the other from St. Helena, an isolated island in the South Atlantic. If the three insect orders can constitute a surrogate group for all insects, and if the lack of extinction among the insects (two out of 25,260) is indicative of the terrestrial invertebrates, the extinction rate has been exceedingly low.

The foregoing indications of very low extinction rates may be compared to data that show continuing gains in species diversity.

### ***Biodiversity gains***

While global losses were evidently minimal during the past 400 to 500 years, there is evidence that concurrent gains have taken place. As noted for the marine environment, invasive species add to local biodiversity and many of them eventually speciate, thus increasing global diversity. Other paths to speciation have also become apparent. Molecular research has revealed numerous cases of rapid adaptive divergence resulting in ecological speciation. Such cases have been demonstrated in plants, invertebrates, and vertebrates (Hendry et al., 2007). Specific examples have been reported in mammals (Rowe et al., 2011), echinoderms (Puritz et al., 2012), and plants (Foxe et al., 2009). Within the past few centuries, species diversity has increased on oceanic islands and in many continental regions; furthermore, no general decreases in diversity have been known to occur at regional scales (Sax & Gaines, 2003).

In fact, human introductions for agricultural and ornamental purposes, along with natural invasions, have produced substantial gains in continental plant biodiversity (Ellis et al., 2012). These positive indications of biodiversity increase indicate that the Earth is still gaining biodiversity, just as it has been for the past 65 million years (MacLeod, 2013).

## **DISCUSSION**

It is now possible to make a realistic assessment of recent global biodiversity trends without having to depend on estimates of habitat destruction, species invasions or other abstract and possibly subjective factors. For the past 500 years, there have been few documented extinctions in the oceans or on the continents, with the exceptions of some restricted freshwater habitats. In using these data, I do not imply an absence of unobserved extinctions among groups of lesser known organisms. Even when estimates of such extinctions are included, it has been found that contemporary extinctions could not have been as high as generally predicted (Costello et al., 2013), and that less than 1% of all

organisms could have become extinct within the past 400 years (Stork, 2010). Global projections of biodiversity loss have generally included estimates of extinction due to invasive species (McGeoch et al., 2010). But, detailed studies have found no evidence that invasive species are implicated in the extinction of continental natives (Gurevitch & Padilla, 2004; Davis, 2009).

The losses of endemic species on islands and in freshwater lakes, while regrettable, took place on very small spots on the Earth's surface and their extinctions had little effect on the ecology of the mainland biotas. Those endemics are generally short-lived and tend to appear and disappear along with their habitats (Whittaker et al., 2008). Of course, there are the exceptions of a few ancient islands and lakes that demonstrate the effects of evolution and extinction over long time periods. Why do small places lose species to invaders while mainland habitats do not? The demise of almost all island/lake endemics has been due to humans and species they introduced (Blackburn et al., 2004). Extinctions resulting from natural (non-human) invaders have seldom been recorded. Despite the early losses of endemic species, oceanic islands have shown biodiversity gains in recent years (Sax & Gaines, 2003).

The world's greatest conservation problem is exemplified by the thousands of species that were once widespread but are now represented only by very small populations. They are the remnants of species that were almost destroyed by human over-exploitation, habitat destruction and pollution. These populations are threatened because they have suffered genetic loss due to their reduced size, inbreeding, and depensation (Allee effect). Genetic loss reduces the ability to respond to environmental change such as continued global warming. Furthermore, small populations are often confined to restricted habitats, from which they would be unable to migrate in response to climatic change. Formerly abundant species that now exist in small numbers are considered to be evidence of an extinction debt, one that will be paid when environmental change proves too difficult for them to adapt (Kuussaari et al., 2009). If governments and conservation societies could be convinced to spend less effort on mythical global biodiversity loss, and more on the needs of species that are at risk, the world would have a consolidated conservation goal that could produce

better results. The conservation plan, initiated by the World Wildlife Fund, and supported by the Zoological Society of London, the Global Footprint Network, and the European Space Agency, is promising. Their Living Planet Index (2012) provided information on the status of 9,014 vertebrate populations belonging to 2,688 species. The Index reported that the population sizes had undergone a 28% global loss since 1970; the greatest decline was in the tropics where the loss was 60%. The Living Planet Index needs to be expanded to cover invertebrates and plants.

## CONCLUSIONS

In regard to the question about the need for conservation measures to be applied to global biodiversity loss or to the precarious condition of species that have been reduced to small populations, there is no longer cause to be concerned about biodiversity loss because it is apparently not true. For the past 40 years, estimates of global loss, based on the extinction of thousands of species per year, have been a primary concern of ecologists and conservationists. These estimates, mainly due to belief in the utility of the SAR, are shown to be erroneous and the SAR is found to be applicable only to small islands, lakes, and other restricted habitats. On the other hand, we now have substantial evidence of gains in global species diversity. This should permit conservation societies, government entities, and interested individuals to concentrate on species that are at risk on the continents and in the oceans, as well as species confined to islands and smaller habitats. Species at risk comprise an extinction debt that will be paid unless they are rescued before global warming or other environmental change takes their toll. A conservation emphasis on critically endangered species does not mean that projects to preserve rain forests, coral reefs, and other natural habitats should be abandoned.

On the contrary, such high diversity areas are sources of biodiversity and are significant in an evolutionary sense. However, each species that is at risk must be considered in view of its own conservation problems that are often unrelated to habitat area. The current (2014) IUCN Red List identifies 4,286 species that are critically endangered and likely to become extinct due to global

warming or the inherent risks of small population size. We need to be aware that many of those species can be rescued prior to the anticipated rise in extinctions.

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## **New records of sea stars (Echinodermata Asteroidea) from Malaysia with notes on their association with seagrass beds**

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### **ABSTRACT**

A survey of sea stars (Echinodermata Asteroidea) was done on a seagrass habitat at the southern coast of Peninsular Malaysia. A total of five species of sea stars from four families (Luidiidae, Archasteridae, Goniasteridae and Oreasteridae) and two orders (Paxillosida and Valvatida) were observed where three of the species were first records for Malaysia. The sea stars do not exhibit specific preference to the species of seagrass as substrate, but they were more frequently found in the area of seagrass that have low canopy heights.

### **KEY WORDS**

Biodiversity; seagrass; sea stars; Straits of Malacca.

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### **INTRODUCTION**

The knowledge of diversity and distribution of asteroids in Malaysia is very limited. There are only three accounts of sea stars (Echinodermata Asteroidea) previously reported in Malaysia where all of the surveys are mainly done in shallow coral reefs (George & George, 1987; Zulfigar et al., 2008; Sim et al., 2009).

Seagrass beds are another important marine environment in Malaysian waters. There are a total of 14 species of seagrasses recorded (Bujang et al., 2006), and apart from the common inshore lagoons, seagrass meadows are also found in the offshore islands with fringing reefs (Bujang & Zakaria, 2003). This study presents the first record of asteroids associated with a seagrass bed in Malaysia.

### **MATERIAL AND METHODS**

A survey of sea stars was done in the seagrass bed of Merambong shoal (N 1°19'58.01"; E 103°36'08.30") southern tip of Peninsular Malaysia (Fig.1). Wandering transect was done by walking at seagrass bed when it was exposed extensively during the best low spring tide of the year from 25th to 27th of May 2013 (07:30-09:30 h). The exposure of the seagrass bed only allowed a window of two hours of sampling per day for three days. Asteroids were collected using labelled sampling bags and brought to the laboratory for further identifications. Asteroid specimens were anaesthetized using seawater mixed with menthol crystals. Colour photographs of live specimens were taken before being fixed using 70% ethanol. All specimens were preserved by drying and deposited in Marine

Science Lab, Universiti Sains Malaysia, Penang, Malaysia (MSL/MS).

## RESULTS AND DISCUSSION

Five species of asteroids from four families and two orders were found in the Merambong shoal seagrass bed: *Luidia maculata* of the family Luidiidae (Fig. 9, voucher specimen MSL/MS/AST001), *Archaster typicus* of Archasteridae (Figs. 2, 3 - voucher specimen MSL/MS/AST002), *Stellaster equestris* from the family Goniasteridae (Figs. 4, 5 - voucher specimen MSL/MS/AST003) and two from family Oreasteridae: *Protoreaster nodosus* (Fig. 8, voucher specimen MSL/MS/AST004), *Goniodiscaster scaber* (Figs. 6, 7 - voucher specimen MSL/MS/AST005).

All species of asteroids occurring in Malaysian waters are listed in Table 1. Previous records were based on George & George (1987), Zulfigar et al. (2008), and Sim et al. (2009). The areas surveyed and covered by these three previous publications were larger and centered at coral reefs which contribute to the higher number of species of asteroids. Zulfigar et al. (2008) and Sim et al. (2009) listed asteroids found in shallow reefs throughout the entire coast of Malaysia and George & George (1987) at the lagoons and coral reefs of east coast

of Sabah. All five species were widely distributed in Indo-West Pacific region (Clark & Rowe, 1971). Besides their wide distribution, the present records of *Stellaster equestris*, *Luidia maculata* and *Goniodiscaster scaber* were new state records in Malaysian waters filling the gap in the species distribution along the transition waters of Straits of Malacca and South China Sea, consequently increasing the total number of asteroids recorded in Malaysian waters to 34 species. The recurring species were *Archaster typicus* and *Protoreaster nodosus*, which had been both recorded in the central of South China Sea and the East Coast of Sabah.

*Protoreaster nodosus* is known to prefer substrates of seagrass and sand (Zulfigar et al., 2008) even though it has been rarely found on corals and rocks (Bos et al., 2008). *Archaster typicus* is found in a wide range of sediment types which include seagrass beds (Huang et al., 2006), and Mukai et al. (1986) noted that the distribution of *A. typicus* was independent of the specific grain size. Other species *S. equestris*, *L. maculata* and *G. scaber* were commonly reported throughout the Indo-Pacific region but were not specifically mentioned to be associated with the seagrass except *L. maculata* on the seagrass of the western Arabian Gulf (Price, 1981).

Seagrass plays many important ecological functions in the marine environment such as food,

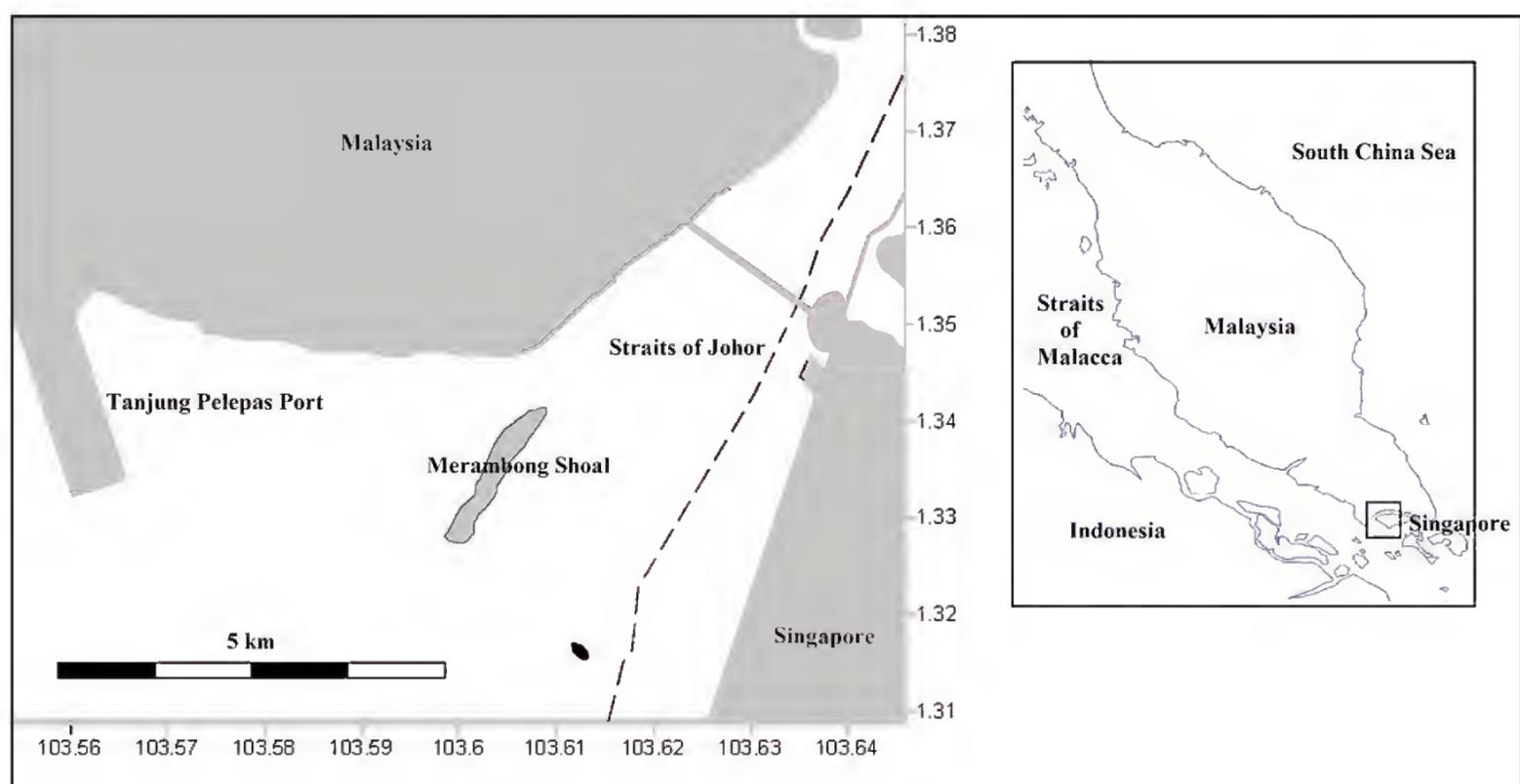
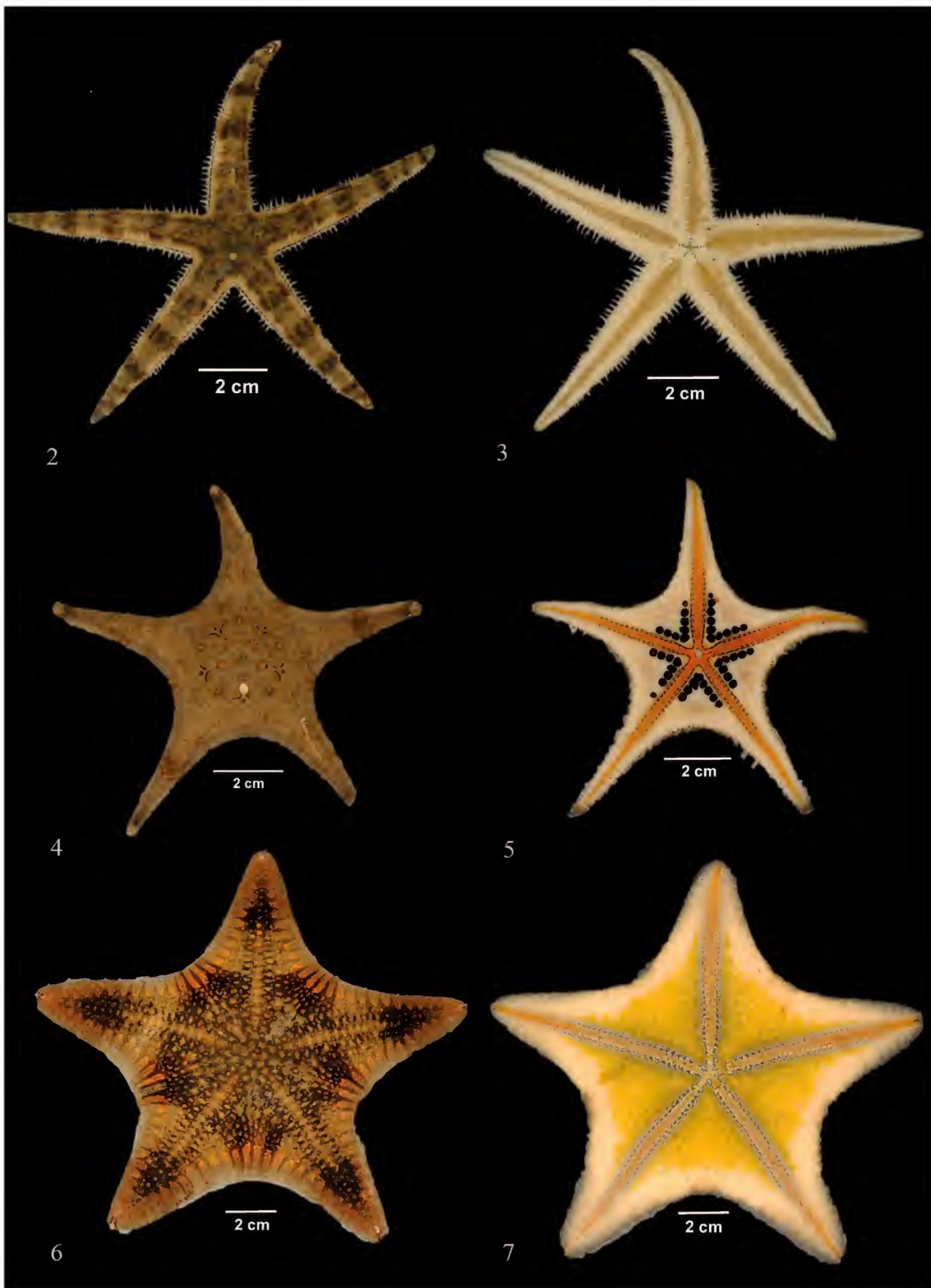


Figure 1. Study area in Merambong shoal, southern tip of Peninsular Malaysia in the Straits of Johor.



Figures 2, 3. *Archaester typicus*: dorsal view (Fig. 2) and ventral view (Fig. 3). Figures 4, 5. *Stellaster equestris*: dorsal view (Fig. 4) and ventral view (Fig. 5). Figures 6, 7. *Goniodiscaster scaber*: dorsal view (fig. 6) and ventral view (Fig. 7).

List of Species	George & George, 1987	Zulfigar et al., 2008	Sim et al., 2009	This study
ACANTHASTERIDAE				
<i>Acanthaster planci</i> (Linnaeus, 1758)	#	#	#	
ARHCASTERIDAE				
<i>Archasterty picus</i> Müller et Troschel, 1840	#			#
ASTEROPSEIDAE				
<i>Asteropsis carinifera</i> (Lamarck, 1816)		#	#	
ECHINASTERIDAE				
<i>Echinaster callosus</i> Marenzeller, 1895	#	#	#	
<i>Echinaster luzonicus</i> (Gray, 1840)	#	#	#	
<i>Echinaster</i> sp.		#		
<i>Metrodira subulata</i> Gray, 1840	#			
GONIASTERIDAE				
<i>Stellaster equestris</i> (Retzius, 1805)				#*
LUIDIIDAE				
<i>Luidia maculata</i> Müller et Troschel, 1840				#*
MITHORODIIDAE				
<i>Mithorodia fisheri</i> Holly, 1932		#	#	
OPHIDIASTERIDAE				
<i>Celerina heffernani</i> (Livingstone, 1936)	#			
<i>Fromia elegans</i> H.L. Clark, 1921	#			
<i>Fromia milleporella</i> (Lamarck, 1816)	#			
<i>Fromia monilis</i> (Perrier, 1869)	#	#	#	
<i>Fromia indica</i> (Perrier, 1869)		#	#	
<i>Fromia</i> sp.		#		
<i>Linckia guildingi</i> Gray, 1840		#	#	
<i>Linckia laevigata</i> (Linnaeus, 1758)	#	#	#	
<i>Linkia</i> cf. <i>multifora</i> (Lamarck, 1816)	#	#	#	
<i>Linckia multifora</i> (Lamarck, 1816)		#	#	
<i>Nardoa</i> cf. <i>gomophia</i> (Perrier, 1875)		#	#	
<i>Nardoa galathea</i> (Lütken, 1865)	#			
<i>Nardoa gomophia</i> (Perrier, 1875)	#			
<i>Nardoa tuberculata</i> (Gray, 1840)	#			
<i>Nardoa novaecaledoniae</i> (Perrier, 1875)	#			
<i>Leiaster speciosus</i> von Martens, 1866		#	#	
<i>Leiaster</i> sp.		#		
<i>Ophidia sterhemprichi</i> Müller et Troschel, 1842		#	#	
OREASTERIDAE				
<i>Choriaster granulatus</i> Lütken, 1869	#	#	#	
<i>Culcita novaeguineae</i> Müller et Troschel, 1842	#	#	#	
<i>Culcita</i> cf. <i>coriacea</i> Müller et Troschel, 1842			#	
<i>Goniodiscaster scaber</i> (Moebius, 1859)				#*
<i>Neoferdina offreti</i> (Koehler, 1910)		#	#	
<i>Protoreaster nodosus</i> (Linnaeus, 1758)	#		#	#
<i>Pentaster obtusatus</i> (Bory de St. Vincent, 1827)	#			
<b>Total number of species</b>	<b>19</b>	<b>20</b>	<b>19</b>	<b>5</b>

Table 1. Records of asteroids in Malaysian (\* new records found in Malaysian waters).

refuge and habitat for numerous other associated organisms, improving water quality and as natural barrier for protection of coasts against wave actions, and sea stars are one important organism associated to the seagrass bed (Gullström et al., 2002). The seagrass of Merambong shoal is composed of ten different species of seagrasses: *Enhalus acroides*, *Halodule uninervis*, *Halodule pinifolia*, *Cymodocea serrulata*, *Cymodocea rotundata*, *Thalassia hemprichii*, *Halophila spinulosa*, *Halophila ovalis*, *Halophila minor* and *Syringodium isoetifolium* (Bujang et al., 2006).

Field observation did not reveal any particular association of these asteroids to any specific species of seagrass nor percentage area coverage of seagrass as they were observed throughout the seagrass area. In terms of canopy heights of seagrass and abundance of asteroids, areas with lower canopy heights (in particular from the genera *Halodule*, *Cymodocea* and *Halophila*) have higher abundance in composition of asteroids compared to areas dominated by high canopy of seagrass (*Enhalus acroides*) no asteroids were observed.

Vonk et al. (2010) proposed that macrobenthic organisms including *P. nodosus* generally prefer area with high seagrass biomass due to increased habitat complexity and shelter from predation. Scheibling (1980) and Scheibling & Metaxes (2008) found that *Oreaster reticulatus* and *Protoreaster nodosus* on seagrass bed feed on microbial and microalgal films, detritus on the surface of seagrass and macroalgae. Scheibling & Metaxes (2008) also noted the presence of detritus mainly made out of decomposing seagrass blades and also epiphytes on the seagrass in the stomach contents of *P. nodosus* in Palau. Some sea stars also utilize the seagrass as a transition habitat in juvenile period as exhibited by *A. typicus* (Bos et al., 2011), where the juveniles migrate from mangrove to sandy and seagrass areas before proceeding to shores. This indicates that seagrass beds are important habitats that are closely linked to asteroids.

The present study suggests the association of asteroids to sea grass habitat. There are many other seagrass beds in the Peninsular Malaysia, yet to be surveyed, that possibly harbor other species of sea stars. Future studies in this region should be done to reveal new records of species and to fill in the gap of species list as well as geographical distribution of sea stars.



Figure 8. Dorsal view of *Protoreaster nodosus*.



Figure 3. Field photograph of *Luidia maculata*.

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## Contribution to the knowledge of the Cicindelidae of Benin with collecting notes (Coleoptera Cicindelidae)

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### ABSTRACT

A checklist of Coleoptera Cicindelidae presently known from Benin is given. Nine taxa are recorded for the first time from this country. Collecting data, habitat and behaviour observations of adults made by the first author during two expeditions are given along with collecting data provided by the second author.

### KEY WORDS

Cicindelidae; new records; collecting notes; West Africa; Benin.

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### INTRODUCTION

Benin is a small country (about 700 km long and from 120 to 200 km wide) bordering Togo in the west, Nigeria in the east and Niger and Burkina Faso in the north. Benin has several rivers, in particular two of them that are restricted to the country: the Ouémé River going throughout a large part of the territory from the north to the south and the Mono. Semi-deciduous forests probably covered the southern part of Benin in the past, however long presence of humans in these areas resulted in extensive deforestation. Nevertheless, still remain few small patches of forests, such as Niaouli and Pobé which are of particular interest. At present the central part of Benin is largely covered by Guinean savannas, as result of deforestation. The north part of Benin is composed of Guineo-sudanian and sudanian savannas.

The country is situated in a very special ecological area known as the Dahomey-gap (Dahomey was the former name of Benin). Dahomey gap is

generally considered as an area where the savannas descend to the Atlantic coast and where forests are completely absent. This area displays a high biodiversity of insects. The high biodiversity and the relatively a few published data treating Cicindelidae from Benin motivated our research and this paper.

### MATERIAL AND METHODS

Taxonomic classification used here follows the last complex work on Cicindelidae of Africa (Werner, 2000a; 2000b) and the only work exclusively studying Cicindelidae of Benin (Cassola, 2007). Most of the data and observations resulted from the first author's two collecting expeditions and the additional valuable informations came from long-term residence of the second author.

All specimens considered in this study are in the first author's collection except for specimens with abbreviation PLC belonging to the collection of the second author.

**RESULTS****List of species presently known from Benin**

Family Cicindelidae Latreille, 1806

Subfamily Cicindelinae Csiki, 1906

Tribus Megacephalini Csiki, 1906

Subtribus Megacephalina W. Horn, 1910

Genus *Megacephala* Latreille, 1802

*M. (M.) quadrisignata quadrisignata* Dejean, 1829

*M. (M.) quadrisignata rivalieri* Basilewsky, 1966

*M. (M.) bocandei bocandei* Guérin, 1848

*M. (M.) denticollis schultzeorum* W. Horn, 1904

*M. (M.) megacephala* (Olivier, 1790) new country record

Tribus Cicindelini Sloane, 1906

Subtribus Prothymina W. Horn, 1910

Genus *Prothyma* Hope, 1838

*P. (P.) concinna concinna* (Dejean, 1831) new country record

*P. (P.) concinna anosignata* Bates, 1878

*P. (P.) leprieuri leprieuri* (Dejean, 1831) new country record

Genus *Euryarthron* Guérin, 1849

*E. dromicarium* (Kolbe, 1894) new country record

*E. walterhorni* Cassola, 1983 new country record

*E. saginatum* (W. Horn, 1912)

*E. gibbosum* (W. Horn, 1894)

*E. planatoflavum* (W. Horn, 1922) new country record

Subtribus Cicindelina W. Horn, 1908

Genus *Elliptica* Fairmaire, 1884

*E. lugubris* (Dejean, 1825)

*E. longestriata longestriata* (W. Horn, 1912)

Genus *Ropaloteres* Guérin, 1849

*R. vittatus* (Fabricius, 1801)

*R. congoensis congoensis* (Fleutiaux, 1893)

*R. feisthamelii* (Guérin, 1849) new country record

*R. nysa nysa* (Guérin, 1849)

*R. cinctus* (Olivier, 1790)

Genus *Hipparidium* Jeannel, 1946

*H. interruptum* (Fabricius, 1775)

Genus *Calochroa* Hope, 1838

*C. flavomaculata sexsignata* (Mandl, 1954) new country record

Genus *Calomera* Motschulsky, 1862

*C. fimbriata fimbriata* (Dejean, 1831)

Genus *Lophyra* Motschulsky, 1859

Subgenus *Lophyra* Motschulsky, 1859

*L. neglecta neglecta* (Dejean, 1825)

*L. senegalensis* (Dejean, 1825)

Subgenus *Stenolophyra* Rivalier, 1958

*L. (S.) luxerii* (Dejean, 1831)

*L. (S.) saraliensis saraliesis* (Guérin, 1849)

Genus *Habrodera* Motschulsky, 1862

*H. nilotica nilotica* (Dejean, 1825)

*H. nitidula nitidula* (Dejean, 1825)

Genus *Chaetodera* Jeannel, 1946

*Ch. regalis regalis* (Dejean, 1831)

Genus *Cylindera* Westwood, 1831

Subgenus *Ifasina* Jeannel, 1946

*C. (I.) lutaria* (Guérin, 1849) new country record

*C. (I.) decellei* Basilewsky, 1968

*C. (I.) octoguttata octoguttata* (Fabricius, 1787)

Genus *Myriochila* Motschulsky, 1862

Subgenus *Myriochila* Motschulsky, 1862

*M. peringueyi peringueyi* (W. Horn, 1895)

*M. plurinotata* (Audoin et Brullé, 1839)

*M. melancholica melancholica* (Fabricius, 1798)

Subgenus *Monelica* Rivalier, 1950

*M. (M.) flavidens flavidens* (Guérin, 1849)

*M. (M.) vicina vicina* (Dejean, 1831)

*M. (M.) dumolinii* (Dejean, 1831)

*M. (M.) legalli* Kudrna, 2008

Genus *Cratohaerea* Chaudoir, 1850

*C. chrysopyga* (W. Horn, 1892)

***Species with listed examined material collected by both authors supplemented with remarks (if available)***

Genus *Megacephala* Latreille, 1802

***Megacephala quadrisignata quadrisignata*** Dejean, 1829

EXAMINED MATERIAL. N. Benin, Kosso, V.1996, several specimens in PLC; Tanguiéta V-VI.1998, several specimens in PLC; Nanébou, VII.2001, several specimens in PLC; C. Benin, Ekpa V.1996, 5 males, 4 females in PLC.

***Megacephala quadrisignata rivalieri*** Basilewsky, 1966

EXAMINED MATERIAL. N. Benin, Kosso, 1 male in PLC; Benin, Nanébou, 1 male in PLC; Benin, Sérrou (Djougou), 1 female in PLC.

***Megacephala bocandei*** Guérin, 1848 (Fig. 1)

EXAMINED MATERIAL. NE Benin, E of Kandi, 4 km W of Bensekou, 24-25.VI.2001, A. Kudrna jr. legit, 1 male; NW Benin, 15 km N of Kouarfa, Bouyagnindi village, 27-28.VI.2001, A. Kudrna jr. legit, 1 female.

REMARKS. The cited pair are the only specimens of *M. bocandei* captured during both first author's trips. The male run quickly in night on black soil path, just where the path left grassy area reach in trees and entered in the field. The female was observed in the late morning of a sunny day in wooded area with high grass and neighbouring field, moving quickly, probably searching for a prey.

***Megacephala denticollis schultzeorum*** W. Horn, 1904 (Fig. 2)

EXAMINED MATERIAL. Benin, village Akongbere, near Save, 19-26.IV.2000, A. Kudrna jr. legit, 2 males, 2 females; Kosso : V-VI.1997-1999, numerous specimens in PLC; Sérrou, V-VI.1997-1999, numerous specimens in PLC; Guinlérrou, 15 km west of Parakou, IV-VII.1996-1998, numerous specimens in PLC.

REMARKS. Specimens were found in night standing on dark paths through dense woodland area with high grass. One female came to light. A torso of a

dead adult was found at the same locality in June 2001.

***Megacephala megacephala*** (Olivier, 1790)

EXAMINED MATERIAL. NE Benin, E of Kandi, around Saa, 21-23.VI.2001, A. Kudrna jr. legit, 1 male, 4 female.

REMARKS. According to Basilewsky (1966), this species is widespread from Senegal and Mauritania to Chad and occurs in sahelian zone or neighbouring areas only. The cited population here reported was discovered in northern area of Benin, where the countryside seems to be more dry and hotter. Specimens were captured during night on sandy roads and occasionally came to light. One specimen was found quickly running through grasses in the end of about two hours lasting hard storm accompanied with intensive rain. New country record.

Genus *Prothyma* Hope, 1838

***Prothyma concinna concinna*** (Dejean, 1831)

EXAMINED MATERIAL. NE Benin, E of Kandi, 7 km E of Bensekou, 23-24.VI.2001, A. Kudrna jr. legit, 2 males.

REMARKS. The first author observed four adults, but managed to catch only two of them due to their very rapid movement from small bare places where discovered, into grass or other hiding-places. These adults didn't fly. New country record.

***Prothyma concinna anosignata*** Bates, 1878

EXAMINED MATERIAL. S Benin, Niaouli, 20.X.1996, 1 female in PLC; S Benin, Niaouli, 10.VII.2002, 1 male in PLC; 1 female; S Benin, Niaouli, 20.XI.2003, 1 female in PLC; Benin, Attogon, V.2001, 1 female in PLC; N Benin, Tanguiéta, 20.VII.1998, 1 female in PLC; Benin, Pénessoulou, VI.1997, 1 male in PLC.

***Prothyma leprieuri leprieuri*** (Dejean, 1831)

EXAMINED MATERIAL. Pénessoulou, 55 km S Djougou, Atakora Benin, Loko/P.Le Gall

REMARKS. A single female specimen without date record, collected by the second author most probably at the light. The discovery of this species

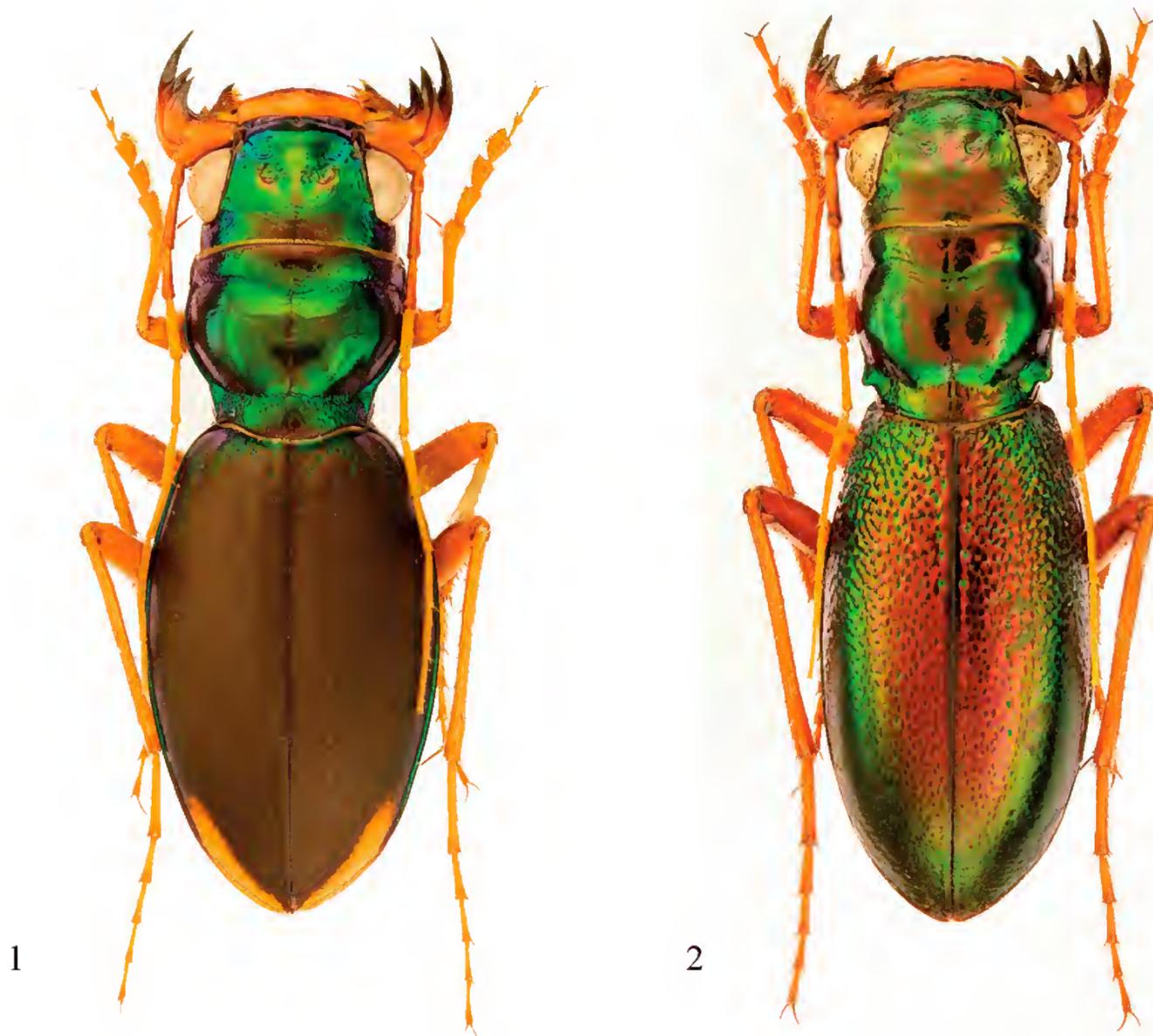


Figure 1. *Megacephala (Megacephala) bocandei*, E of Kandi, 21.3 mm  
 Figure 2. *Megacephala (Megacephala) denticollis schultzeorum*, near Save, 31.5 mm

in Benin is not surprising due to its wide distribution from Senegal to Ethiopia. New country record.

Genus *Euryarthron* Guérin, 1849

*Euryarthron dromicarium* (Kolbe, 1894) (Fig. 3)

EXAMINED MATERIAL. Benin, Bembereke, 2 km W of Gando, 02-03.VII.2001, A. Kudrna jr. legit, 1 female; NW Benin, 5 km N of Tanguieta, direction Tanougou, 28-29.VI.2001, A. Kudrna jr. legit, 3 males.

REMARKS. A very beautiful wingless species of *Euryarthron* which is extremely difficult to find in Benin. It seems, that this species prefers meadows or grassy places at the edges of forested areas. Adults were discovered on bare places, trying to escape into the grass, when disturbed. One male specimen came to light. New country record.

*Euryarthron walterhorni* Cassola, 1983

EXAMINED MATERIAL. Benin, Tanguiéta, 10.V.1997, 1 female; Koso, VI.1998, 2 males, 2 females; Benin, Sérrou VI.2000, 1 male, 1 female; Benin, Sérrou, VII.1998, 1 female. All specimens in PLC.

REMARKS. New country record.

*Euryarthron saginatum* (W. Horn, 1912) (Fig. 4)

EXAMINED MATERIAL. NE Benin, E of Kandi, 4 km W of Bensekou, 24-25.VI.2001, A. Kudrna jr. legit, 2 females; NE Benin, E of Kandi, around Saa, 21-23.VI.2001, A. Kudrna jr. legit, numerous specimens.

REMARKS. This species was found on white-grey soil road through dry woodland with lot of acacia trees. When discovered, it tried to escape flying



Figure 3. *Euryarthron dromicarium*, S of Kerou, 13 mm  
 Figure 4. *Euryarthron saginatum*, E of Kandi, 13.3 mm

away and sit down into the nearby grass. On this road it lived together with *Myriochila plurinotata* and *M. (Monelica) vicina vicina*. In another occasion it was also found in sparse acacia wood.

***Euryarthron gibbosum*** (W. Horn, 1894)

EXAMINED MATERIAL. Benin, village Akongbere, near Save, 19.IV-26.IV.2000, A. Kudrna jr. legit, 6 males, 3 females; NE Benin, E of Kandi, 4 km W of Bensekou, 24-25.VI.2001, A. Kudrna jr. legit, 2 males; NE Benin, E of Kandi, 7 km E of Bensekou, 23-24.VI.2001, A. Kudrna jr. legit, 1 male; NW Benin, 5 km N of Tanguieta, direction Tanougou, 28-29.VI.2001, A. Kudrna jr. legit, 1 female.

REMARKS. In May 2000 this species appeared suddenly in the dense woodland area around Akongbere village, near Save. Whilst first week of intensive collecting there was unproductive, during

four next days about 15 adults, at the same, formerly empty places, were caught. Few more specimens were found in northern parts of country. This species prefers shaded places with sparse grass, paths or roads inside woods.

***Euryarthron planatoflavum*** (W. Horn, 1922)

EXAMINED MATERIAL. Pénessoulou IV.1998, 1 male in PLC.

REMARKS. New country record.

Genus ***Elliptica*** Fairmaire, 1884

***Elliptica lugubris*** (Dejean, 1825)

EXAMINED MATERIAL. NE Benin, E of Kandi, 4 km W of Bensekou, 24-25.VI.2001, A. Kudrna jr. legit, 1 male; N Benin, S of Kerou, 7 km W Yakrigourou, 25-26.VI.2001, A. Kudrna jr. legit, 2

females; NW Benin, 5 km N of Tanguieta, direction Tanougou, 28-29.VI.2001, A. Kudrna jr. legit 3 females, 1 male; NW Benin, 15 km N of Kouarfa, Bouyagnindi village, 27-28.VI.2001, A. Kudrna jr. legit, 4 males, 3 females; NE Benin, E of Kandi, 7 km E of Bensekou, 23-24.VI.2001, A. Kudrna jr. legit, 1 male; Benin, Bembereke, 7 km W of Gando, 03-04.VII.2001, A. Kudrna jr. legit, 2 males; Benin, Bembereke, 2 km W of Gando, 02-03.VII.2001, A. Kudrna jr. legit, 1 male; Pénes-soulou, VI.1998-VI.1999, numerous specimens in PLC; Sérrou.

REMARKS. This very beautiful large species was present at most of the localities, but usually in few specimens only. Horn (1915) described subspecies *E. lugubris anthrax*, based on the black colouration. However, the black specimens represent merely a variation without any taxonomic value. Interesting is the proportion between this black form and the common black-yellow specimens: first author observed only one anthrax variation along tens of individuals on all of the collecting spots except locality 5 km N of Tanguieta, where six from eight caught specimens were black. This locality, near Atacora Mountains with very sparse wood with dominance of acacia trees was very hot and dry place. *Elliptica lugubris* is generally silvicolous dwelling species preferring shaded grassy places.

***Elliptica longestriata longestriata*** (W. Horn, 1912)

EXAMINED MATERIAL. NW Benin, N of Natitingou, 5 km NE of Kouarfa, 26-27.VI.2001, A. Kudrna jr. legit, 1 female, 1 male; NE Benin, E of Kandi, 4 km W of Bensekou, 24-25.VI.2001, A. Kudrna jr. legit, 1 male, 1 female; NW Benin, 30 km SE of Natitingou, 5 km E of Sina Issire, 30.VI-01.VII.2001, A. Kudrna jr. legit, 2 females; NW Benin, 15 km N of Kouarfa, Bouyagnindi village, 27-28.VI.2001, A. Kudrna jr. legit, 1 male.

REMARKS. A very surprising discovery of the species in Benin, as it was in the time of collecting known from north of former Zaire and Central African Republic only. This indicates a much wider distribution than supposed. Adults were found always on dark soil with sparse grass, usually on the edges of fields or directly inside when uncultivated.

Genus *Ropaloteres* Guérin, 1849

***Ropaloteres vittatus*** (Fabricius, 1801)

EXAMINED MATERIAL. NW Benin, 30 km SE Natitingou, 5 km E of Sina Issire, 30.VI-01.VII.2001, A. Kudrna jr. legit, 1 female; Benin, village Akongbere, near Save, 19-26.IV.2000, A. Kudrna jr. legit, 6 males, 3 females.

REMARKS. *R. vittatus* was very rare to find in Benin during both expeditions. Only few specimens on very few localities were discovered. It prefers dark soil paths and clearings in shaded woodland areas.

***Ropaloteres congoensis congoensis*** (Fleutiaux, 1893)

EXAMINED MATERIAL. NW Benin, N of Natitingou, 5 km NE of Kouarfa, 26-27.VI.2001, A. Kudrna jr. legit, 7 females, 4 males; NW Benin, 30 km SE Natitingou, 5 km E of Sina Issire, 30.VI-01.VII.2001, A. Kudrna jr. legit, 2 males, 2 females; N. Benin, Ekpa, VI.1996, 2 males, 1 female in PLC.

REMARKS. This beautiful species was found on the three cited localities only. On one occasion four specimens were collected on the edge of a sandy road and nearby meadow, another time it was discovered on red soil with turfs of high grass. Adults were usually a little bit lazy to fly and preferred rapid run into the shadow of the turfs. Only when disturbed repeatedly, they flew a few meters and sat down again near to turfs. After settling they often disappeared by running through grasses somewhere on the reverse side, and therefore they were hardly found again. This beetle seems to be generally very rare, however, when a spot with its occurrence is found, it is usually possible to collect numerous specimens.

***Ropaloteres feisthamelii*** (Guérin, 1849)

EXAMINED MATERIAL. NW Benin, 30 km SE Natitingou, 5 km E of Sina Issire, 30.VI-01.VII.2001, A. Kudrna jr. legit, 1 female; NW Benin, N of Natitingou, 5 km NE of Kouarfa, 26-27.VI.2001, A. Kudrna jr. legit, 1 female; N Benin, S of Kerou, 7 km W Yakrigourou, 25-26.VI.2001, A. Kudrna jr. legit, 1 female, 2 males; NW Benin, 15 km N of Kouarfa, Bouyagnindi village, 27-

28.VI.2001, A. Kudrna jr. legit, 1 male; NW Benin, 5 km N of Tanguieta, direction Tanougou, 28-29.VI.2001, A. Kudrna jr. legit, 1 male; Benin, Bembereke, 7 km W of Gando, 03-04.VII.2001, A. Kudrna jr. legit, 1 male, 1 female; Sérrou, V. 2000, 1 female in PLC.

REMARKS. Relatively common species occurring in grassy places in woodland areas, regularly attracted to light. New country record.

***Ropaloteres nysa nysa*** (Guérin, 1849)

EXAMINED MATERIAL. Benin, village Akongbere, near Save, 19.IV-26.IV.2000, A. Kudrna jr. legit, numerous specimens; NW Benin, 15 km N of Kouarfa, Bouyagnindi village, 27-28.VI.2001, A. Kudrna jr. legit, 1 male, 2 females; NE Benin, E of Kandi, 7 km E of Bensekou, 23-24.VI.2001, A. Kudrna jr. legit, 1 male; NW Benin, 5 km N of Tanguieta, direction Tanougou, 28-29.VI.2001, A. Kudrna jr. legit, 3 males, 1 female; Benin, Bembereke, 2 km W of Gando, 02-03.VII.2001, A. Kudrna jr. legit, 1 male, 1 female; Pénessoulou, V-VI.1999-2000, numerous specimens in PLC.

REMARKS. Very common species with the same habitat and behaviour as the previous *R. feisthamelii*, often coming to light.

***Ropaloteres cinctus*** (Olivier, 1790)

EXAMINED MATERIAL. Benin, village Akongbere, near Save, 19.IV-26.IV.2000, A. Kudrna jr. legit numerous specimens; NE Benin, E of Kandi, 4 km W of Bensekou, 14-25.VI.2001, A. Kudrna jr. legit, 2 males, 2 females; N Benin, S of Kerou, 7 km W Yakrigourou, 25-26.VI.2001, A. Kudrna jr. legit, numerous specimens; NW Benin, 15 km N of Kouarfa, Bouyagnindi village, 27-28.VI.2001, A. Kudrna jr. legit, 2 males, 1 female; NE Benin, E of Kandi, 7 km E of Bensekou, 23-24.VI.2001, A. Kudrna jr. legit, 2 males, 1 female; Benin, Bembereke, 2 km W of Gando, 02-03.VII.2001, A. Kudrna jr. legit, numerous specimens.

REMARKS. Probably the commonest species of those, which prefer grassy, shadowed places in woodlands. This species, in contrast to *Elliptica lugubris*, occurred only on a few of the visited localities, but there it was abundant.

Genus ***Hipparidium*** Jeannel, 1946

***Hipparidium interruptum*** (Fabricius, 1775)

EXAMINED MATERIAL. Benin, near Cove, E of Abomey, 16.IV.2000, A. Kudrna jr. legit, 1 female; Pobé, Aguigadji, V.1998, 1 female in PLC.

REMARKS. Female from E of Abomey was found on shaded dark soil path inside palm plantation.

Genus ***Calochroa*** Hope, 1838

***Calochroa flavomaculata sexsignata*** (Mandl, 1954)

EXAMINED MATERIAL. Africa/Benin, W-Nat. Park, X.2002, Mekrou river, Triple Point, 1 male; Benin, Pénessoulou, 12.XI.2000, at light, 1 male, 1 female in PLC.

REMARKS. New country record.

Genus ***Calomera*** Motschulsky, 1862

***Calomera fimbriata fimbriata*** (Dejean, 1831)

EXAMINED MATERIAL. Benin, Banks of river Oueme, E of Zangnanado, 14.IV-15.IV.2000, A. Kudrna jr. legit, numerous specimens; Benin, Cové: 20.VI.2000, numerous specimens in PLC; Benin, Cové: 27.VI.2000, numerous specimens in PLC; Benin, Cové: 5.VI.2001, numerous specimens in PLC.

REMARKS. Adults of this species were present in huge masses on yellowish sand around river Oueme, where also *Lophyra neglecta neglecta*, *L. senegalensis*, *Cylindera (Ifasina) octoguttata octoguttata* and *Habrodera nilotica nilotica* occurred. Occasionally, beautiful blueish specimens (in proportion about 1:100) were caught.

Genus ***Lophyra*** Motschulsky, 1859

Subgenus ***Lophyra*** s.str.

***Lophyra (Lophyra) neglecta neglecta*** (Dejean, 1825)

EXAMINED MATERIAL. Benin, Banks of river Oueme, E of Zangnanado, 14.IV-15.IV.2000, A. Kudrna jr. legit, numerous specimens; Benin, Cové, VI.2000, numerous specimens in PLC; Toffo, III.2001, numerous specimens in PLC.

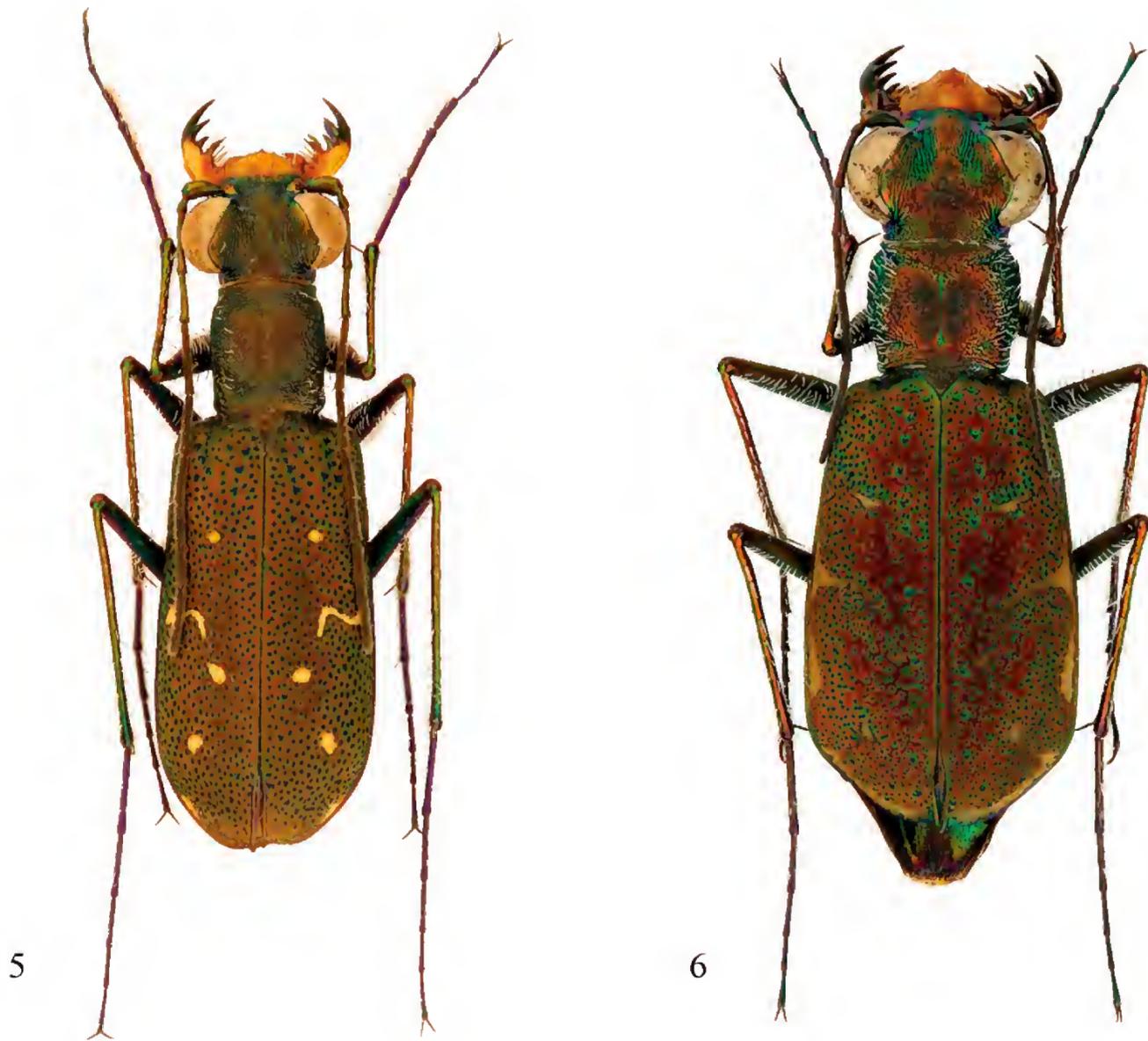


Figure 5. *Cylindera (Ifasina) lutaria*, W of Gando, 7.8 mm  
 Figure 6. *Myriochila (Myriochila) peringueyi*, Ndali, 10.1 mm

REMARKS. Very common species found on sand or sandy road near water.

***Lophyra (Lophyra) senegalensis*** (Dejean, 1825)

EXAMINED MATERIAL. Benin, banks of river Oueme, E of Zangnanado, 14.IV-15.IV.2000, A. Kudrna jr. legit, numerous specimens; Benin, village Akongbere, near Save, 19-26.IV.2000, A. Kudrna jr. legit, numerous specimens; NE Benin, E of Kandi, 7 km E of Bensekou, 23-24.VI.2001, A. Kudrna jr. legit, 1 male, 1 female.

REMARKS. This species does obviously not prefer places near water, but was found on many localities on sandy roads. Even on the river banks it lives further to water. A common species in Benin.

Subgenus *Stenolophyra* Rivalier, 1958

***Lophyra (Stenolophyra) luxerii*** (Dejean, 1831)

EXAMINED MATERIAL. Benin, village Akongbere, near Save, 19.IV-26.IV.2000, A. Kudrna jr. legit, numerous specimens; NW Benin, 15 km N of Kouarfa, Bouyagnindi village, 27-28.VI.2001, A. Kudrna jr. legit, 1 male, 1 female; NE Benin, E of Kandi, 7 km E of Bensekou, 23-24.VI.2001, A. Kudrna jr. legit, numerous specimens; Benin, Niaouli, VI.1997-2002, numerous specimens in PLC; Sérrou, VI.1999, 11 males, 12 females in PLC.

REMARKS. Occurs in woodland areas and prefers dark soil roads and paths. A relatively common species.

Genus ***Habrodera*** Motschulsky, 1862

***Habrodera nilotica nilotica*** (Dejean, 1825)

EXAMINED MATERIAL. Benin, banks of river



Figure 7. *Myriochila (Monelica) vicina*, N of Natitingou, 9.2 mm  
 Figure 8. *Myriochila (Monelica) legalli*, N of Natitingou, 9.75 mm

Oueme, E of Zangnanado, 14.IV-15.IV.2000, A. Kudrna jr. legit, numerous specimens.

REMARKS. This species was found on yellowish sand of river banks.

***Habrodera nitidula nitidula*** (Dejean, 1825)

EXAMINED MATERIAL. Benin south, Grand-Popo, ocean coast, 17.04.2000, A. Kudrna jr. legit, 14 males, 2 females.

REMARKS. A seashore species. The specimens were caught on a huge long sandy beach under windy conditions, always in a large distance from a water line. Uncommon on this beach.

Genus *Cylindera* westwood, 1831  
 Subgenus *Ifasina* Jeannel, 1946

***Cylindera (Ifasina) lutaria*** (Guérin, 1849) (Fig. 5)

EXAMINED MATERIAL. NE Benin, E of Kandi, 4 km W of Bensekou, 24-25.VI.2001, A. Kudrna jr. legit, 1 female; NE Benin, E of Kandi, 7 km E of Bensekou, 23-24.VI.2001, A. Kudrna jr. legit, 7 males, 1 female; Benin, Bembereke, 7 km W of Gando, 03-04.VII.2001, A. Kudrna jr. legit, 1 male, 1 female; Benin, Bembereke, 2 km W of Gando, 02 -03.VII.2001, A. Kudrna jr. legit, 2 males.

REMARKS. *C. (I.) lutaria* was found on various localities, but always near puddles or in muddy or moist places, usually in few specimens only. A rare species in Benin. New record for this country.

***Cylindera (Ifasina) octoguttata octoguttata*** (Fabricius, 1787)

EXAMINED MATERIAL. Benin, banks of river Oueme, E of Zangnanado, 14.IV-15.IV.2000, A.

Kudrna jr. legit, numerous specimens; NE Benin, E of Kandi, 7 km E of Bensekou, 23-24.VI.2001, A. Kudrna jr. legit, 1 male.

REMARKS. This very common species was present in swarms around puddles just next to river. On several occasions it was captured near brooks and small rivers.

Genus *Myriochila* Motschulsky, 1862  
Subgenus *Myriochila* Motschulsky, 1862

*Myriochila (M.) peringueyi peringueyi* (W. Horn, 1895) (Fig. 6)

EXAMINED MATERIAL. Benin, village Akongbere, near Save, 19.IV.-26.IV.2000, A. Kudrna jr. legit, 1 female; Benin, Ndali, 3 km W of Sontou, 04-05.VII.2001, A. Kudrna jr. legit, numerous specimens.

REMARKS. The species was abundant west of Sontou inside a forest area on a flat volcanic rock, partly covered with a thin layer of dark soil. No water was present in the vicinity. This species with unusual red-green body reflexions seems to prefer rocks or stony places, as also the only female collected near village Akongbere was discovered in slightly muddy situation on dark soil road, just where the road cross a big flat rock.

*Myriochila (M.) plurinotata* (Audoin et Brullé, 1839)

EXAMINED MATERIAL. NE Benin, E of Kandi, 7 km E of Bensekou, 23-24.VI.2001, A. Kudrna jr. legit, numerous specimens; NW Benin, 5 km N of Tanguieta, direction Tanougou, 28-29.VI.2001, A. Kudrna jr. legit, numerous specimens; NW Benin, N of Natitingou, 5 km NE of Kouarfa, 26-27.VI.2001, A. Kudrna jr. legit, numerous specimens; NW Benin, 15 km N of Kouarfa, Bouyagnindi village, 27-28.VI.2001, A. Kudrna jr. legit, 2 males, 3 females.

REMARKS. This species was present on several localities, usually sitting on soil roads or other bare places in sunny situation. On the locality situated 5 km NE of Kouarfa it occurred together with another nine species: *Elliptica lugubris*, *E. longestriata*, *Myriochila (Monelica) dumolinii*, *M. (M.) vicina*, *M. (M.) legalli*, *Lophyra (Stenolophyra) luxerii*, *Ropaloteres cintus*, *R. congoensis*

*congoensis*, *R. feisthamelii*. Regularly came to light. Not rare in Benin.

*Myriochila (M.) melancholica melancholica* (Fabricius, 1798)

EXAMINED MATERIAL. Benin, banks of river Oueme, E of Zangnanado, 14.IV-15.IV.2000, A. Kudrna jr. legit, numerous specimens; Benin, village Akongbere, near Save, 19.IV-26.IV.2000, A. Kudrna jr. legit, numerous specimens; Toffo, 12.II.2001, several specimens in PLC; Sérrou, VI.1998, several specimens in PLC.

REMARKS. This very common species was present at most of the collecting places always near water.

Subgenus *Monelica* Rivalier, 1950

*Myriochila (Monelica) flavidens flavidens* (Guérin, 1849)

EXAMINED MATERIAL. NE Benin, E of Kandi, around Saa, 21-23.VI.2001, A. Kudrna jr. legit, numerous specimens; NE Benin, E of Kandi, 7 km E of Bensekou, 23-24.VI.2001, A. Kudrna jr. legit, numerous specimens; Benin, Bembereke, 7 km W of Gando, 03-04.VII.2001, A. Kudrna jr. legit, 2 males, 3 females.

REMARKS. Although considered to be a very rare species (Werner, 2000), it was observed on many localities in northern parts of Benin. Adults were present in masses on laterite soils, always in muddy or moist places or near puddles, and surely represented one of the commonest species during the second collecting trip of the first author.

*Myriochila (Monelica) vicina vicina* (Dejean, 1831) (Fig. 7)

EXAMINED MATERIAL. NW Benin, 5 km N of Tanguieta, direction Tanougou, 28-29.VI.2001, A. Kudrna jr. legit, numerous specimens; N Benin, S of Kerou, 7 km W Yakrigourou, 25-26.VI.2001, A. Kudrna jr. legit, numerous specimens; NE Benin, E of Kandi, 7 km E of Bensekou, 23-24.VI.2001, A. Kudrna jr. legit, numerous specimens; NW Benin, 15 km N of Kouarfa, Bouyagnindi village, 27-28.VI.2001, A. Kudrna jr. legit, 1 male, 2 females; Pénessoulou, V.1998 numerous specimens in PLC; Pénessoulou, V.1999 numerous specimens in PLC.

REMARKS. During second collecting trip of the first author, this species was abundantly found in the northern parts of the country. Specimens were collected on bare places, paths or roads through grass or fields.

*Myriochila (Monelica) dumolinii* (Dejean, 1831)

EXAMINED MATERIAL. Benin, Bembereke, 7 km W of Gando, 03-04.VII.2001, A. Kudrna jr. legit, 2 males; N Benin, S of Kerou, 7 km W Yakrigourou, A. Kudrna jr. legit, 2 females; NW Benin, N of Natitingou, 5 km NE of Kouarfa, 26-27.VI.2001, A. Kudrna jr. legit, 1 male; NW Benin, 30 km SE Natitingou, 5 km E of Sina Issire, 30.VI-01.VII.2001, A. Kudrna jr. legit, 1 female; Sérrou, VI.1997, several specimens in PLC; Sérrou, VII.1998, several specimens in PLC.

REMARKS. Adults came regularly to light. Two specimens were found on laterite soil road in a sunny day. Uncommon.

*Myriochila (Monelica) legalli* Kudrna, 2008 (Fig. 8)

EXAMINED MATERIAL. NW Benin, N of Natitingou, 5 km NE of Kouarfa, 26-27.VI.2001, A. Kudrna jr. legit, 5 males, 2 females; NE Benin, E of Kandi, 7 km E Bensekou, 23-24.VI.2001, A. Kudrna jr. legit, 1 male, 1 female; NW Benin, 15 km N of Kouarfa, Bouyagnindi village, 27-28.VI.2001, A. Kudrna jr. legit, 1 female; S Benin, vill. Akongbere, near Save, 16-20.VI.2001, A. Kudrna jr. legit, 1 female.

REMARKS. Specimens of this recently described species (Kudrna, 2008) were found during sunny day on dark soil road through dense wood in forested area and also on laterite soil of a wide field road in the agricultural area.

Genus *Cratohaerea* Chaudoir, 1850

*Cratohaerea chrysopyga* (W. Horn, 1892)

EXAMINED MATERIAL. Benin, village Akongbere, near Save, 19.IV-26.IV.2000, A. Kudrna jr. legit, 15 males, 5 females; NE Benin, E of Kandi, around Saa, 21-23.VI.2001, A. Kudrna jr. legit, 3 males, 3 females; Benin, Bembereke, 7 km W of Gando, 03-04.VII.2001, A. Kudrna jr. legit, 2 males, 1 female; Ouidah, 20.V.1996, 1 female in PLC; Benin, Pobé,

X.2001, 1 male in PLC; Niaouli IV-VI.1996 several specimens in PLC; Niaouli VI.1998 several specimens in PLC; Niaouli V-VI.1999 several specimens in PLC; Benin, Parakou, V.1996, several specimens in PLC; Benin, Kosso, V-VII.1998-2000, several specimens in PLC.

REMARKS. All specimens of *C. chrysopyga* were found on termitaries. They prefer bigger ones, situated entirely or at least partly in shaded places and with more or less preserved structure. When disturbed, they tried to hide themselves by running constantly on the reverse side of the termitaries and with care it was even possible to catch them by hand. When adult successfully escaped from behind the net, then settled on the opposite side of the termitaries, in the nearby grass or flew away and disappeared somewhere in the forest. But after some time, the beetle was back. It was usually necessary to visit several termitaries to find one inhabited. Generally one or two specimens together were found on one termitarium, but in one occasion even four were present. Relatively rare in Benin.

DISCUSSION

Werner (2000a, b), in his monographic review of African tiger beetle fauna listed 17 species and subspecies from Benin. Recently Cassola (2007), in the only so far existing publication devoted solely to Cicindelidae of Benin reported 31 taxa (30 species and one subspecies) from this country. In this contribution we add another nine species as new for Benin thus the total number is 41. Most of the species added in this contribution were expectable to occur in Benin. We suppose that new records will follow and the number of tiger beetles taxa known from this beautiful country can exceed 50 or even 55.

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(Rudofov), driver Wirgile Adingni and Mr. and Mrs. Ahanhanzo.

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## The first record of *Trigonostigma somphongsi* (Meinken, 1958), a critically endangered species, in its natural habitat of Thailand (Cypriniformes Cyprinidae)

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### ABSTRACT

A population of a critically endangered *Trigonostigma somphongsi* (Meinken, 1958) has been discovered in a deepwater rice field, floodplain of Bangpakong Basin, Nakhornayok Province, central Thailand. The population was the first record of this species in its natural habitat since its description by Meinken in 1958. The species appeared to be a seasonal horizontal migration species, since it migrates to breed in the floodplain during the rainy season between July and November and migrates back into the main channel during the dry season.

### KEY WORDS

*Trigonostigma somphongsi*; Cyprinidae; Bangpakong; Thailand.

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### INTRODUCTION

*Trigonostigma somphongsi* (Meinken, 1958) was placed in the genus *Rasbora* (Bleeker, 1859) (Meinken, 1958) and, subsequently, in the genus *Trigonostigma* Kottelat et Witte, 1999 described by Kottelat & Witte (1999).

The genus *Trigonostigma* is a well defined group comprising 4 species: *T. heteromorpha* (Duncker, 1904), as type species, with its distribution in Malay Peninsula, *T. espei* (Meinken, 1967) found in south eastern and southern part of Thailand, and *T. hengeli* (Meinken, 1956) reported from Sumatra; the fourth species, *T. somphongsi*, differs from the rest of the genus in its dark pattern which occurs as a strait horizontal line that extends from

the base of the caudal fin and ends just after it passed the posterior part of the dorsal fin instead of showing the wedge-like marking of other species in the genus.

Apart from external characters of the body shape and marking, this genus also differs from other Rasborins in its breeding strategy since parents deposit eggs under broad leaves of aquatic plants instead of scattering eggs like most others. In this regard, it is interesting to note the sex ratio skewed towards males in this species observed in this survey.

The type series of *T. somphongsi* was said to come from aquarium trade, sent to Meinken by Somphongs Aquarium, an ornamental fish exporter run by Mr. Somphongs Lekaree with its base in

Thailand. The fish was thus, named after Somphong in honor of his contribution of the type series.

No detail of its habitat was given in the paper; Meinken only mentioned that it was from Southern Thailand (Meinken, 1958). The fish appeared in various hobby publishing during the 70s in both Europe and Asia before completely disappearing for some 20 years. It wasn't until 2006 when three *T. somphongsi* were found among a batch of *Boraras urophthalmoides* (Kottelat, 1991) by Uta Hanel (Germany). They happened to be one male and two females thus forming the core for a captive breeding population which is still going on in Europe, mainly Germany and England, as well as in Thailand.

However, to date, no fish has ever been observed in its natural habitat, which prompted IUCN to list it as Critically Endangered (Vidthayanon, 2013) and listed it as world's 100 most threaten species (Baillie & Butcher, 2012). Upon our survey of a flood plain in deepwater rice field, flood plains of Bangpakong Basin, Nakhornayok Province, central Thailand, a population of *T. somphongsi* was discovered. Its habitat and population demography will be described here.

## MATERIAL AND METHODS

Surveys were conducted by dragging fine mesh sein, along marginal area of floodplain as well as along the road and rice field. We also snorkeled to observe its habitat and behavior under water. All other species were released on site as quickly as possible after identification.

All *T. somphongsi* (Fig. 1) were kept alive for further study in captivity. Surveys were conducted from September 2012 to November 2013. Locals were interviewed for further information and water quality parameters were measured with methods by APHA et al. (2009).

### Study area

*Trigonostigma somphongsi* was found in a deepwater rice field, in the flood plains of Nakhornayok River, Bangpakong Basin, Nakhornayok Province, central Thailand (Fig. 2), one of the main tributaries of Bangpagong River, which empties into the Gulf of Thailand. The head water, to the north, originated in KhaoYai National Park, which

is a part of Dong Phrayayen-KhaoYai Forest Complex - UNESCO World Heritage site. The area is characterized by flat land, with numerous water ways. Majority of the land has been turned into agricultural land. The main crop is rice (*Oryza* sp.). Our survey plot was in Pak Phli District, Nakhornayok Province.

The fish was found in the rice field and in a densely vegetated ditch, which was flooded by a nearby river. The water quality parameters are shown in Table 1. It is interesting to note the drop of the water's pH from 7.98, when it first enters the floodplain, to 3.81 after a few months of inundation. The field was planted with a variety of rice called "Banna 423", developed by the Rice Department of Thailand. This variety is said to be able to grow as fast as 10 centimeters in 24 hours and can grow as long as 5 meters, thus being immune to the flood and forming a dense under-water jungle.

In the same area, the other fish species were surveyed and reported by Petsut et al. (2013a) and Petsut et al. (2013b). A total of 23 species, 8 families and 4 orders of freshwater fishes were recorded.

The natural aquatic plants in this area was reported by Petsut et al. (2012) with Poaceae as

WATER QUALITY PARAMETERS	RESULT
Water temperature (°C) at 1.00 p.m.	31.0 – 33.5
Transparency (cm)	80 - bottom soil (transparent)
Water depth (cm) in flood season	300 - 30
Water pH	3.81 – 7.98
Soil pH	3.85-4.70
Alkalinity (ml/L as CaCO <sub>3</sub> )	6.37 – 47.00
Ammonia (ml/L Nitrogen)	0.042 - 0.450
Nitrite (ml/L Nitrogen)	0.076 – 0.160
Nitrate (ml/L Nitrogen)	0.461 – 0.680
Hardness (ml/L as CaCO <sub>3</sub> )	35 – 202
Orthophosphate (ml/L Phosphorus)	0.020 – 0.022

Table 1. Water quality parameters in a deepwater rice field, flood plain of Bangpakong Basin, central Thailand.

dominant family. The change of benthic fauna composition and ecological structure of plankton communities in these area was reported by Petsut et al. (2013c) and Petsut et al. (2013d).

## RESULTS

During the dry season, i.e. when water has completely receded into the river, in the area where we would have found, later, *T. somphongsi* during the flooding, only *Boraras urophthalmoides* and *Trichopsis vittatus* (Cuvier, 1831) were observed. July represented the first month of inundation. Many species of fishes were found in the floodplain in abundance. In this period we only caught one *T. somphongsi* gravid female.

From September to November, the peak of flooding period, we caught many semi-adult (probably young of the year), but failed to find any full grown adults. We believe that the adults only migrate to breed and then leave the flood plain, back to the main channel. *T. somphongsi* is weakly sexual dimorphic. Females can be distinguished from males by larger size, plumper belly and less intense orange coloration on the body. Twelve semi-adults grew up to be 7 males and 5 females, such a skewed sex ratio towards males was also reported in a captive-bred population, although our sample size is definitely too small to be conclusive.

*Trigonostigma somphongsi* were found in a mixed school with many other small cyprinids, especially *Rasbora borapetensis* Smith, 1934, *Amblypharyngodon chulabhornae* Vidthayanon et Kottelat, 1990 and *Boraras urophthalmoides* which often form large schools (Fig. 3), sometimes of more than a hundred specimens. These fishes were found swimming in margin of the deepwater rice field and in an area with not so dense aquatic plants. *T. somphongsi* were found to be minority in the school with only a few individuals observed. The school was often led by *R. borapetensis* (the strongest swimmer), then followed by *A. chulabhornae* with *B. urophthalmoides* (smallest species) and *T. somphongsi* at the tail of the school.

Sometimes the school could be observed eating suspended food particles stirred up by researchers from the bottom of the floodplain. At one point, a small crab accidentally stepped on



Figure 1. The female of *T. somphongsi* is larger (left), the male (right) shows more intense colors (in breeding tank).



Figure 2. Habitat of *T. somphongsi* in a deepwater rice field, flood plains of Bangpakong Basin, central Thailand.



Figure 3. *Trigonostigma somphongsi* in its natural habitat can be found in mixed school with many other small cyprinids.

which attracted many of the fish in the area including *T. somphongsi* to come and eat the fresh prey. Surveys by sein mostly yielded only one *T. somphongsi*, if any, among many other individuals of other species; only once during our survey three individuals turned up.

## DISCUSSION

Given that the other 3 species in the genus live in peat swamps or lowland streams, it is interesting to find *T. somphongsi* living in a large river and migrating to breed in floodplain during the rainy season. It is highly possible that the range of this species once occupied most of the central plain of Chao Phraya River as well as the floodplain of Mae Klong River, in the west. However, flood control and lost of habitat have reduced its distribution to current area. The species appeared to be naturally low in density in the study area, however the floodplain appears to be large enough to support a healthy population.

Our study showed that the floodplain formed an integral part to the live cycle of this rare species, it is thus recommended that the flooding in this area should be managed so that both human and fishes can both benefit from it.

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## First record of the Caucasus field mouse *Apodemus ponticus* Sviridenko, 1936 (Rodentia Muridae) from Iran

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### ABSTRACT

This study is the first record of six specimens of *Apodemus ponticus* Sviridenko, 1936 (Rodentia Muridae) from the Zagros Mountains, north western Iran. Four external features besides 13 linear measurements of the skull and 14 dental characters were measured. This species was identified by its extensive and well-marked boundary throat spot. In addition, *A. ponticus* shows morphometric characters including head and body length (mean = 90.86 ± 2.54), length of bullae (mean = 6.34 ± 0.11), breadth of bullae (mean = 4.77 ± 0.12) and dental characters consisting of maxillary tooth row (mean = 3.85 ± 0.06) and mandibular tooth row (mean = 3.90 ± 0.05) which are different from the sympatric species *A. witherbyi* Thomas, 1902. Based on our results, the distributional range of *A. ponticus* extends to oak forests of the Zagros Mountains, west Iran which is considered to be the easternmost boundary of its range.

### KEY WORDS

*Apodemus ponticus*; sympatric; Zagros Mountains; Iran.

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### INTRODUCTION

Caucasus field mouse *Apodemus ponticus* Sviridenko, 1936 (Rodentia Muridae) is one of the most ambiguous members of the genus *Apodemus* Kaup, 1829. It was first described from Olginka Village, northwest Caucasus and supposed to be endemic to southern Caucasus region (Azerbaijan and Georgia; Ellerman & Morrison-Scott, 1951; Musser & Carleton, 2005). Its limit expansion reaches up to south Russia.

Initially, it had been considered intermediate hybrid between *A. sylvaticus* (Linnaeus, 1758) and *A. flavicollis* (Melchior, 1834) or included in a superspecies namely *A. flavicollis* (Heptner, 1940; Neithammer, 1978). Vereshchagin (1959) misclas-

sified *A. ponticus* as a form of *A. fulvipectus* (Ognev, 1924). However, subsequent studies indicated that Caucasus field mouse is a separate species.

Differences between Allozyme-electroforetic patterns of *A. ponticus* from *A. uralensis* (Pallas, 1811) (as *A. ciscaucasicus* Ognev, 1924), *A. witherbyi* (Thomas, 1902) (as *A. fulvipectus*) and *A. flavicollis* were described by some authors (Mezhzherin, 1990; Mezhzherin et al., 1992; Lavrenchenko & Likhnova, 1995). In addition, some diagnostic karyological features of *A. ponticus* were identified (Kozlovsky et al., 1990; Orlov et al., 1996a, b). The Caucasus field mouse can be diagnosed from *A. witherbyi* by multivariate analysis (Lavrenchenko & Likhnova, 1995).

Although, based on mt DNA cytb gene sequences, Balakirev et al. (2007) proposed unity between *A. ponticus* and *A. flavicollis*. Suzuki et al. (2008) clustered it as a sister clade of *A. flavicollis* based on trees constructed applying four nuclear and one mitochondrial genes but with weak support for the formers.

Until recently five species of wood mice of the genus *Apodemus* including the following species: *A. witherbyi*, *A. uralensis*, *A. hyrcanicus* Vorontsov, Boyeskorov et Mezhzherin, 1992, *A. flavicollis* and *A. mystacinus* were recorded (Javidkar et al., 2005; Krystufek & Hutterer, 2006; Darvish et al., 2010; Darvish et al., 2014) and *A. avicennicus* has been described by Darvish et al. (2006) from Iran.

In this study, the first record of *A. ponticus* as a member of murine rodents would be added to the checklist of rodent fauna of Iran.

## MATERIAL AND METHODS

The study was done in Kordestan Province, west Iran from June 2013 to July 2013, using live-traps and snack baits (Fig. 1).

Specimens were captured and determined based on cranial and external morphological features, using keys including: Mezhzherin et al. (1992) and Vorontsov et al. (1992). Standard vouchers of specimens (skins, skulls, tissues) were deposited in the Zoology Museum of Ferdowsi University of Mashhad (ZMFUM).

Specimens were weighted, sexed and four external characters were measured; besides, 13 linear measurements of the skull were taken using a vernier calliper accurate to the nearest 0.05 mm (Table 1). 14 dental measurements were performed with a measuring microscope to 0.001 mm (Table 1).

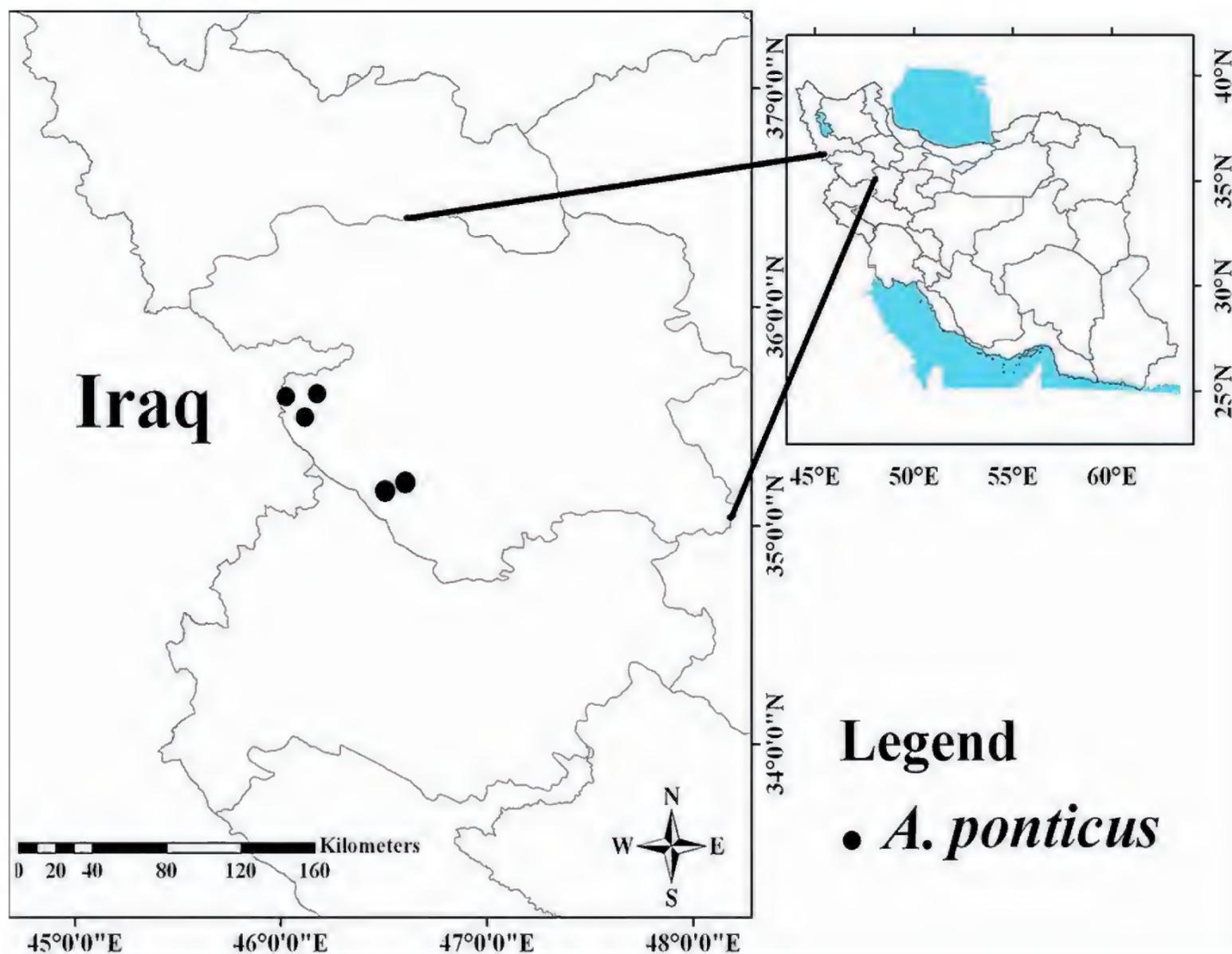


Figure 1. Location of the study areas: Zagros Mountains, northwestern Iran.

Variables	<i>A. ponticus</i> n=6			<i>A. witherbyi</i> n=38		
	Mean ± SE	Min	Max	Mean ± SE	Min	Max
HBL	89.86±2.54	83	103	90.40±1.18	77	103
TL	101.33±1.09	97	104	99.56±1.17	78	117
HFL	22.71±0.47	21	24	21.37±0.24	15	24
EL	17.43±0.33	14	21	15.79±0.28	11	26
CBL	24.14±0.34	23.28	25.24	23.31±0.10	21.24	24.72
FL	12.51±0.14	11.94	13.20	12.28±0.05	11.32	12.90
PAL	4.88±0.08	4.58	5.34	4.79±0.05	4.12	5.46
ZYGB	13.18±0.18	12.64	14.02	12.72±0.08	11.40	13.88
RW	4.28±0.082	4.00	4.52	4.43±0.04	3.66	4.84
IOC	4.30±0.07	3.92	4.52	4.33±0.02	4.10	4.66
BCW	11.97±0.11	11.56	12.38	11.70±0.04	11.23	12.32
IBW	11.40±0.13	10.94	11.98	10.98±0.50	10.44	12
RH	6.21±0.09	5.72	6.54	5.94±0.04	5.40	6.38
BCBH	9.42±0.15	8.54	9.88	8.93±0.04	8.34	9.46
TBL	6.34±0.11	5.76	6.78	5.91±0.05	5.32	6.82
TBW	4.77±0.12	4.28	5.22	4.40±0.02	4.08	4.76
ML	11.98±0.33	10.82	13.44	11.57±0.07	10.34	12.52
M1.L	1.86±0.05	1.55	2.08	1.85±0.01	1.69	1.96
M1.W	1.17±0.04	0.92	1.27	1.16±0.01	1.02	1.26
M2.L	1.15±0.02	1.06	1.21	1.13±0.01	1.03	1.20
M2.W	1.10±0.03	0.94	1.17	1.11±0.01	1.01	1.22
M3.L	0.87±0.02	0.82	1.04	0.84±0.01	0.76	0.98
M3.W	0.82±0.03	0.63	0.95	0.81±0.01	0.67	0.93
M.1L	1.77±0.02	1.63	1.89	1.66±0.01	1.17	1.78
M.1W	1.04±0.03	0.84	1.13	1.03±0.01	0.88	1.12
M.2L	1.18±0.01	1.11	1.25	1.14±0.01	1.04	1.25
M.2W	1.06±0.03	0.89	1.18	1.04±0.01	0.90	1.19
M.3L	0.96±0.03	0.79	1.05	0.97±0.01	0.88	1.06
M.3W	0.89±0.07	0.74	0.96	0.89±0.04	0.80	1
MxTR	3.83±0.06	3.54	4.14	3.78±0.01	3.54	3.95
MnTR	3.90±0.05	3.68	4.14	3.76±0.01	3.37	3.94

Table 1. External, cranial and dental measurements (in mm) of *A. mystacinus* and *A.witherbyi* from northwest of Iran.

**ABBREVIATIONS.** Abbreviations of characters are as follows (for descriptions of characters see Frynta et al., 2001; Javidkar et al., 2005, 2007 and Kryštufek & Vohralik, 2009): HBL: head and body length; TL: tail length; HFL: hind foot length; EL: ear length; CBL: condylobasal length; FL: facial length; PAL: palatal length; ZYGB: zygomatic breadth; RW: rostrum width; IOC: interorbital constriction; BCW: braincase width; IBW: interbulla width; RH: height of rostrum; BCBH: height of braincase with tympanic bulla; TBL: tympanic bulla length; TBW: tympanic bulla width; ML: mandible length; M1.L: length of first upper molar; M1.W: width of first upper molar; M2.L: length of second upper molar; M2.W: width of second upper molar; M3.L: length of third upper molar; M3.W: width of third upper molar; M1.L: length of first lower molar; M1.W: width of first lower molar; M2.L: length of second lower molar; M2.W: width of second lower molar; M3.L: length of third lower molar; M3.W: width of third lower molar; MxTR: length of maxillary tooth row; MnTR: length of mandibular tooth row.

## RESULTS

*Apodemus ponticus* is sympatric and syntopic with *A. witherbyi* at 1545 m (a.s. l.) in the western slopes of the Zagros Mountains. This species was identified by its extensive and well-marked boundary throat spot.

The length of sole is more than 21 mm. *A. ponticus* shows morphometric characters including head and body length (mean = 90.86 ± 2.54), length of bullae (mean = 6.34 ± 0.11), breadth of bullae (mean = 4.77 ± 0.12) and dental characters consisting of maxillary tooth row (mean = 3.85 ± 0.06) and mandibular tooth row (mean = 3.90 ± 0.05) which are different from the sympatric species *A. witherbyi* (Table 1).

## DISCUSSION

The Zagros Mountains is a part of the Irano-Anatolian hotspot, one of the richest biodiversity and endemism hotspot regions in the world (Mittermeier et al., 2012). Irano-Anatolian hotspot also encompasses the Ponto-Caspian realm including

the regions between Black and Caspian Sea and southern coast of Caspian Sea proposed the refugial area for evolution of some endemic lineages of rodents such as *Glis glis* (Linnaeus, 1766) (Naderi et al., 2013) and some insectivores (Dubey et al., 2007a; Dubey et al., 2007b).

In addition, terrestrial exchange is partially conceivable via some corridors (i.e. Aras River valley; Missone, 1959) between the region and the Caucasus hotspot where the Caucasus field mice were supposed to be endemic.

The Caucasus field mice are sympatric with congener species *A. witherbyi* and *A. mystacinus* in Kordestan province. *A. ponticus* is syntopic with *A. witherbyi* in bushy foothills of the Zagros Mountains in 1545 m (a.s.l.) however; it has not been collected with *A. mystacinus* at the same altitude. So, the Caucasus field mice could pass the Aras valley and establish the populations in the Zagros Mountains.

Moreover, the Zagros Mountains are the southernmost boundary of the distributional range of the species. Finally, the Caucasus field mice from Iran show lower average in size (i.e. CBL = 24.14; MxTR = 3.83) comparing to that of specimens reported from Caucasus (CBL = 25.53; MxTR = 3.98) and the minimum of the foot length (21 vs 22.5); based on measurements published by Vorontsov et al. (1992).

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## Little effect of ecological factors and symbiotic specificity on the distribution of *Medicago* subsect. *Intertextae* (Urban) Heyn (Fabales Fabaceae) in the Mediterranean Basin

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### ABSTRACT

In the Mediterranean region, *Medicago granadensis* Willd. and *M. muricoleptis* Tineo (Fabales Fabaceae) of the *Intertextae* subsection are rare and present, each one in well defined areas, whereas the others taxa, in the same subsection, *M. ciliaris* (L.) All. and *M. intertexta* (L.) Mill., are more frequent with large distribution. This kind of geographical distribution is not a coincidence; certainly different factors are the origin of this distribution. In 125 sites of different Mediterranean countries, the ecology of the four taxa was studied, 34 trapped strains in one site of *Intertextae* rhizobiums were characterized by rep-PCR and some symbiotic tests were carried out. The results confirm that *M. muricoleptis* and *M. granadensis* are endemic in the north and east of the Mediterranean, respectively; whereas, *M. ciliaris* and *M. intertexta* are widespread. Although their geographic specificity, the four taxa showed no important differences in ecological conditions. *M. muricoleptis*, given its presence in the north of the Mediterranean only, is distinguished by its precipitation requirement. By inference, the absence of *M. muricoleptis* and *M. granadensis* in some regions is not due to the absence of the symbiont. We confirm the symbiotic specificity of *Sinorhizobium medicae* (Rome, 1996) for the *Intertextae* subsection and the existence of coevolution between taxa (widespread and endemic) and rhizobia. We suppose that endemic taxa are in the process of allopatric speciation, which explains their narrow distribution in the Mediterranean Basin.

### KEY WORDS

Distribution; diversity; ecology; *Intertextae*; *Medicago*; Mediterranean; symbiosis.

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### INTRODUCTION

Legumes hold an important economic and social place and have a definite environmental benefit in the Mediterranean Basin, which is the area of distribution of several genera of this family, including the *Medicago* L. genus. This genus includes 86 species (Small & Jomphe, 1989) and comprises several sections and subsections, including the *Intertextae* (Urban) Heyn subsection (Small, 2011; Coulot & Rabaute, 2013). Some taxa of the *Inter-*

*textae* show a morphological ambiguity, which reflected in different classifications. Indeed, some authors ascribe to the subsection 4 species, namely, *Medicago ciliaris* (L.) Krock., *M. intertexta* (L.) Mill., *M. muricoleptis* Tineo and *M. granadensis* Willd. (Quézel & Santa, 1962; Lesins & Lesins, 1979; Small & Jomphe, 1989; Coulot & Rabaute, 2013) and others mention only 3 species, *M. intertexta*, *M. muricoleptis* and *M. granadensis* (Heyn, 1963; Ponert, 1973; Jauzein, 1995; Dobignard & Chatelain, 2012; Tison et al., 2014). According to

the latter authors *M. ciliaris* is either a subspecies, *M. intertextae* subsp. *ciliaris* (L.), Ponert, or a botanical variety [*M. intertextae* var. *ciliaris* (L.) Camb, Heyn] of *M. intertextae*.

The early observations on the distribution of annual *Medicago* in relation with soil factors were made by Trumble & Donald (1938) and Aitken & Davidson (1954). Besides, the first work on autoecology was carried out in Australia by Andrew & Hely (1960). Thereafter, several studies were performed, particularly in the regions of origins of *Medicago*, which allowed the definition of the ecological requirements of various species (Abdelguerfi et al., 1988; Ehrman & Cocks, 1988; Prospero et al., 1989; Ehrman & Cocks, 1990; Abdelkefi et al., 1992; Bounejmate, 1992; Bounejmate et al., 1992a; 1992b).

For the most common taxa of the *Intertextae* subsection, *M. ciliaris* and *M. intertextae*, autoecology research was carried out, but most of that research did not allow comparisons between the two taxa since they were included in a single species as indicated by Heyn (1963). The most specific study on these two taxa was carried out in Algeria (Abdelguerfi-Laouar et al., 2003) on 179 sites. Besides, *M. muricoleptis* and *M. granadensis* are poorly distributed and are reported in the literature as rare taxa. Although they belong to the same subsection as *M. ciliaris* and *M. intertextae*, they are not found in Algeria, Morocco, and Tunisia. The ecological requirements of the two taxa are not yet determined; they have only been reported in various regions (Table 1).

Other factors, besides ecological ones, symbiosis for example, may affect the distribution of legumes species. The species of rhizobia that nodulate the *Medicago* ssp. belong to the *Ensifer* (formerly *Sinorhizobium*) genus and are *S. meliloti* (Dangeart, 1926) and *S. medicae* (Rome, 1996). One of the major characteristics of the rhizobium-legume association is their host specificity. In general, a given rhizobium species can only establish an efficient symbiotic relationship with a limited number of plant partners. Similarly, legumes species can only be specific to a certain number of rhizobium species. This coevolution is often ignored in studies on the distribution and evolution of legumes taxa. The *Intertextae* subsection taxa were described as specific to *S. medicae* (Béna et al., 1998; 2005). Béna et al. (1998) suggest, for this

subsection, a recurrent loss of the capacity to form an efficient symbiosis with strains of the *S. meliloti* species; they hypothesize a punctual mutation inducing a modification of the mechanisms of recognition such as the flavonoid structure.

The rather particular geographical distribution of the four *Intertextae* subsection taxa, namely those with a wide distribution and those with a narrow distribution, needs clarification as to whether this is due to an ecological adaptation and/or to a specific taxon-rhizobium interactions; this is the objectives of this work.

## MATERIAL AND METHODS

Given the taxonomic ambiguity that exists within the subsection of the *Intertextae*, we will use the term taxon instead of species for *M. ciliaris*; synonym: *M. intertextae* subsp. *ciliaris* and *M. intertextae* var. *ciliaris*, *M. intertextae*, *M. muricoleptis* and *M. granadensis* throughout the document.

### *Ecological data and origin of sites*

The study is focused on taxa *M. ciliaris*, *M. intertextae*, *M. muricoleptis* and *M. granadensis*. The collected ecological data come from the Australian *Medicago* Genetic Resource Centre (South Australian Research and Development Institute: SARDI), a total number of 125 sites were surveyed in 17 Mediterranean countries and islands (Table 2). 13 sites of 125 are sympatric (sci and sig), one of which is sympatric to *M. intertextae* and *M. granadensis* (sig; Israel) and the other (12) are for *M. ciliaris* and *M. intertextae* (sci). All the other sites are allopatric (sc, si, sm and sg) and correspond only to a species per site among the four (Table 3).

### *Ecological data analysis*

Nine (9) ecological characters were studied; they correspond to orographic (altitude and slope), climatic (annual rainfall) and edaphic characters (pH, soil texture, soil depth, soil reaction, type of drainage and land use). Analyses of variance (ANOVA) with a single factor (sites) were carried out on 76 sites whose data on rainfall, altitude, and pH were available; the 'site' factor was considered as random effect. The software used is STAT-ITCF

Species	Regions	References
<i>M. ciliaris</i> (L.) All.	- <b>Macaronesia</b> Madeira Island (Portugal), Canary Island (Spain)	Coulot & Rabaute, 2013 Davis, 1965-1988
	- <b>North Africa</b> Algeria, Egypt, Morocco, Tunisia	Dobignard & Chatelain, 2012
	- <b>Western Asia</b> Cyprus, Iraq, Israel, Lebanon, Western Syria, Western Turkey	Heyn, 1963 Jahandiez & Maire, 1931-1941
	- <b>South-Eastern Europe</b> Greece (including Crete), Italy (including Sardinia and Sicily)	Lesins & Lesins, 1979 Meikle, 1977-1985
	- <b>South-Western Europe</b> France (including Corsica), Portugal and Spain (including the Balearic Islands)	Mouterde, 1966 Pignatti, 1982
	- <b>Macaronesia</b> Canary Island (Spain)	Pottier-Alapetite, 1979-1981
	- <b>North Africa</b> Northern Algeria, Morocco, Tunisia	Quézel & Santa, 1962
<i>M. intertexta</i> (L.) Mill.	- <b>South-Eastern Europe</b> Greece, Italy (including Sardinia and Sicily)	Small & Jomphe, 1989 Small, 1981
	- <b>South-Western Europe</b> France (including Corsica), Portugal and the South of Spain	Small et al., 1981 Smythies, 1984-1986
	- <b>North Africa</b> Northern Egypt	Täckholm, 1974
<i>M. granadensis</i> Willd.	- <b>Western Asia</b> Israel, Lebanon, Jordan, Western Syria, Turkey	Townsend & Guest, 1966 Tutin et al., 1964-1980
	- <b>South-Eastern Europe</b> Southern Italy (including Sicily)	Zohary & Feinbrun-Dothan, 1966
<i>M. muricoleptis</i> Tineo	- <b>South-Western Europe</b> Southeast of the France near Toulon	GRIN, 2014

Table 1. Geographical distribution of the *Intertextae* subsection taxa.

(Gouet & Philippeau, 2002). For each quantitative variable, two analyses of variance were carried out; the first analysis comprised 4 levels corresponding to the presence of the taxon: (i) site of *M. ciliaris* (sc+sci), (ii) site of *M. intertexta* (si+sci), (iii) site of *M. muricoleptis* (sm) and (iv) site of *M. granadensis* (sg+sig); the second analysis (5 levels) differed from the first by the distinction of allopatric sites (12) from sympatric sites

for *M. ciliaris* and *M. intertexta*. For only those where the null hypothesis is rejected a Fisher's LSD test was calculated. The hypothesis is null when the F test (MSA/MSE) of ANOVA is greater than 1 ( $p < 0.05$ ).

For the qualitative variables, environmental profiles were established for each taxon having more than five sites; the classes of each variable are represented in Table 4.

*M. ciliaris*: Algeria: 5.776 - 10.464 - 10.465 - 10.642 - 10.643 - 10.644 - 10.645 - 10.648 - 10.792 - 10.932 - 10.933 - 10.934 - 10.935 - 10.936 - 11.571 - 11.574 - 11.575 - 11.576 - 12.547 - 12.551. Crete: 2.081. Cyprus: 23.627 - 23.629 - 23.635 - 23.636. Greece: 2.239. Israel: 2.004 - 7.687 - 7.688. Italy: 2.075 - 5.782 - 22.419 - 22.420. Morocco: 25.506 - 25.506 - 29.024. Portugal: 7.826 - 24.554. Sardinia: 26.016. Sicily: 2.067 - 2.186 - 24.831 - 24.844 - 24.847 - 24.849 - 24.852 - 24.853. Spain: 7.721 - 28.255 - 28.256. Syria: 22.206 - 24.022 - 24.023. Tunisia: 5.785 - 5.786 - 7.714 - 7.723 - 10.637 - 18.460 - 18.463 - 18.464 - 20.104 - 21.802 - 21.803 - 21.804. Turkey: 23.932.

*M. intertexta*: Algeria: 4.010 - 10.647 - 10.649 - 10.650 - 10.651 - 10.652 - 10.659 - 10.788 - 10.791 - 11.579 - 11.580 - 11.909 - 11.910 - 11.911 - 11.912 - 15.748. Cyprus: 2.367 - 2.370 - 5.777. Egypt: 13.797 - 13.799. France: 2.044 - 2.045. Israel: 1.589 - 2.363 - 2.364 - 2.366 - 5.779. Italy: 2.071 - 2.375. Jordan: 18.084 - 19.002. Morocco: 10.662. Portugal: 2.372 - 2.377 - 5.783 - 8.323. Sardinia: 12.302 - 26.021. Sicily: 24.816 - 24.819 - 24.821 - 24.823 - 24.824. Spain: 1.590 - 2.361 - 2.362 - 28.257. Syria: 13.795 - 13.796. Tunisia: 4.008 - 4.011 - 5.489 - 7.724 - 18.465 - 18.466.

*M. granadensis*: Israel: 2.359 - 5.778 - 5.822. Syria: 13.818 - 13.819 - 22.207. Turkey: 23.928 - 23.931 - 26.380.

*M. muricoleptis*: Greece: 22.423. Italy: 15.343 - 22.422. Sicily: 24.825 - 25.026 - 25.027 - 25.002.

Table 2. Collection of SARDI.

Country	Allopatric sites				Sympatric sites			Total
	<i>M. ciliaris</i> (sc)	<i>M. intertexta</i> (si)	<i>M. muricoleptis</i> (sm)	<i>M. granadensis</i> (sg)	<i>M. ciliaris</i> - <i>M. intertexta</i> (sci)	<i>M. intertexta</i> - <i>M. granadensis</i> (sig)		
Algeria	15	11	-	-	5	-	31	
Crete	1	-	-	-	-	-	1	
Cyprus	4	3	-	-	-	-	7	
Egypt	-	2	-	-	-	-	2	
Spain	2	3	-	-	1	-	6	
France	-	2	-	-	-	-	2	
Greece	1	-	1	-	-	-	2	
Israel	3	4	-	2	-	1	10	
Italy	4	2	2	-	-	-	8	
Jordan	-	2	-	-	-	-	2	
Morocco	3	1	-	-	-	-	4	
Portugal	1	3	-	-	1	-	5	
Sardinia	1	2	-	-	-	-	3	
Sicily	5	2	4	-	3	-	14	
Syria	3	2	-	3	-	-	8	
Tunisia	10	4	-	-	2	-	16	
Turkey	1	-	-	3	-	-	4	
Total	54	43	7	8	12	1	125	

Table 3. Number of allopatric and sympatric sites by country.

### Collection of rhizobium strains

In a homogeneous site in Algiers (sub-humid, soil with loamy texture and slightly alkaline pH), 8 populations, two by taxon, were planted. The populations of *M. granadensis* and *M. muricoleptis* originate from the Mediterranean collection (SARDI) and those of *M. ciliaris* and *M. intertexta* originate from an Algerian collection (ENSA d'Alger). Populations of *M. ciliaris* (C58) and *M. intertexta* (I58) from a sympatric site were taken into account. On the generated seedlings, nodules were collected from which a collection of 34 strains of rhizobia was obtained (Table 5). Bacterial isolates were obtained using the crushed-nodule method (Vincent, 1970) from nodules removed from 60 days old plants. The various strains were stored in glycerol at -80 °C, after having been identified by a symbiotic test on *M. polymorpha*, in addition to the analysis of 16S rRNA sequences (Rome et al., 1996).

### Extraction of DNA, Amplification by REP-PCR and method of analysis

The DNA extraction was conducted following the protocol of Abdelguerfi-Laouar (2005). The rep-PCR and BOX-PCR was completed according to the protocol of Rademaker et al. (1998). A primer for BOX-PCR (BOX A1R: 5'-CTACGGCA-AGGCGACGCTGACG-3') and two primers for REP-PCR (REP 1R: 5'-IIICGICGICATCIGGC-3' and REP 2I: 5'-ICGICTTATCIGGCCTAC-3') were used (Versalovic et al., 1994). The visualization of bands was made by UV on long agarose gels at 1.5 % (0.5X TBE) at 90 V voltage.

The binary data were established on the basis of the presence (1) absence (0) of bands of REP and BOX markers. From these data, a tree of genetic distance was obtained by groupings of plant from a comprehensive comparison of characters, then by calculating the mean distances of grouped plants (NJ method: Neighbour Joining). Support for clustering was determined by bootstrap procedure applied on binary REP-BOX data (1000 replications). The software used is Dissimilarity Analysis and Representation for Windows (DARwin) (Perrier et al., 2003; Perrier & Jacquemoud-Collet, 2006).

### Symbiotic Test

The two species *S. meliloti* and *S. medicae* represented by a 2011 strain and two ABS7 strains (Bekki et al., 1987) and USDA1827, respectively, were inoculated on the populations of the four taxa of the *Intertextae* subsection. For symbiotic tests we kept the same host populations that served to obtain the collection of rhizobium. The seeds were disinfected with sulphuric acid for 30 minutes and then germinated after flushing. After germination, each seed was transferred, in sterile conditions, in tubes containing the FAHRAEUS agar medium (1.5 %) and placed in a culture chamber (20 °C, 60 % relative humidity and a photoperiod of 16 h light and 8 h darkness). The inoculation was carried out after 48 h of development of the roots (0.3 ml/seedling). The notations begin after a week and end after 90 days. The experimental protocol used for the symbiotic tests is total randomization with three plants per population.

## RESULTS

### Frequencies and geographical distribution of taxa

The most frequent taxon of the *Intertextae* subsection in the Mediterranean region is *M. ciliaris* with a frequency of 47.8 % followed by *M. intertexta* (40.6 %) and, finally, *M. granadensis* (6.5 %) and *M. muricoleptis* (5.1 %). Of 17 Mediterranean countries and islands, Algeria has the highest frequency for *M. ciliaris* and *M. intertexta*. From figure 1, which represents the distribution of 121 sites (longitude and latitude data available), *M. muricoleptis* and *M. granadensis* are confined in two restricted and different regions: the North and the East of the Mediterranean, respectively. These two taxa are included in the area of distribution of *M. ciliaris* and *M. intertexta*.

By comparing the presence of taxa by country between the bibliographic data (Table 1) and the collection studied (Table 2, Fig. 1) similarities and differences can be noted. In the Collection SARDI, *M. ciliaris* was not collected in Egypt, Iraq, France, and Lebanon; the same is true for *M. intertexta* in Crete, Greece and Turkey. *M. muricoleptis* was not collected in France and *M. granadensis* was not col-

lected in Egypt, Jordan, and Lebanon. Contrarily to the literature, *M. ciliaris* and *M. intertexta* were collected in Israel; *M. intertexta* was collected in Egypt, Cyprus, and Jordan; these two taxa therefore exist in these countries.

**Inter-taxa ecological variability**

**Rainfall, altitude and pH**

The comparison among *M. ciliaris*, *M. intertexta*, *M. muricoleptis* and *M. granadensis* shows that, with regard to altitude and pH, few differences exist (Table 6). Only rainfall allows differentiating between the sites of *M. ciliaris*, *M. intertexta*, sympatric sites (*M. ciliaris* and *M. intertexta*) (Table 7), *M. granadensis* and the sites of *M. muricoleptis*. This latter taxon prefers the highest rainfalls that exceed 800 mm. *M. granadensis* has the lowest rainfall average of all the subsection.

To have an idea about the limits of adaptation of each taxon, minimum and maximum values of each character and each taxon were taken into considerations. *M. intertexta* shows very broad adaptation for its precipitation needs; it shows the biggest amplitude with 850 mm (Fig 2). It manages

to grow in dry conditions (150 mm, a single site in Jordan) as well as in very wet conditions (1000 mm), but given the average for this character, it is more frequent in the rainy areas. *M. granadensis* and *M. ciliaris* are the least demanding in terms of precipitation. *M. muricoleptis* is water demanding as it is only found in sites with more than 700 mm of rainfall (Fig 2). In altitude, minimum and maximum values are very close in the four taxa; they vary from 5 to 10 m for low altitudes and from 900 to 1000 m for higher values. Sympatric sites of *M. ciliaris* and *M. intertexta* show an average rainfall closer to the average for *M. intertexta* than to the average for *M. ciliaris*.

**Edaphic characters (Texture, drainage, depth of soil and soil reaction)**

The soil textures in the sites of the four taxa are fine; they are clayey or clay-loam. The loamy texture is specific only to *M. ciliaris*, *M. intertexta* and *M. granadensis* (Fig. 3). The *Intertextae* taxa are found both in soils with good water drainage and soils where water stagnates on the surface. Only *M. intertexta* shows 100%, in relative frequency, for the class of submerged soil (waterlogged) (Fig. 4) it is the only taxon that was not mentioned in the

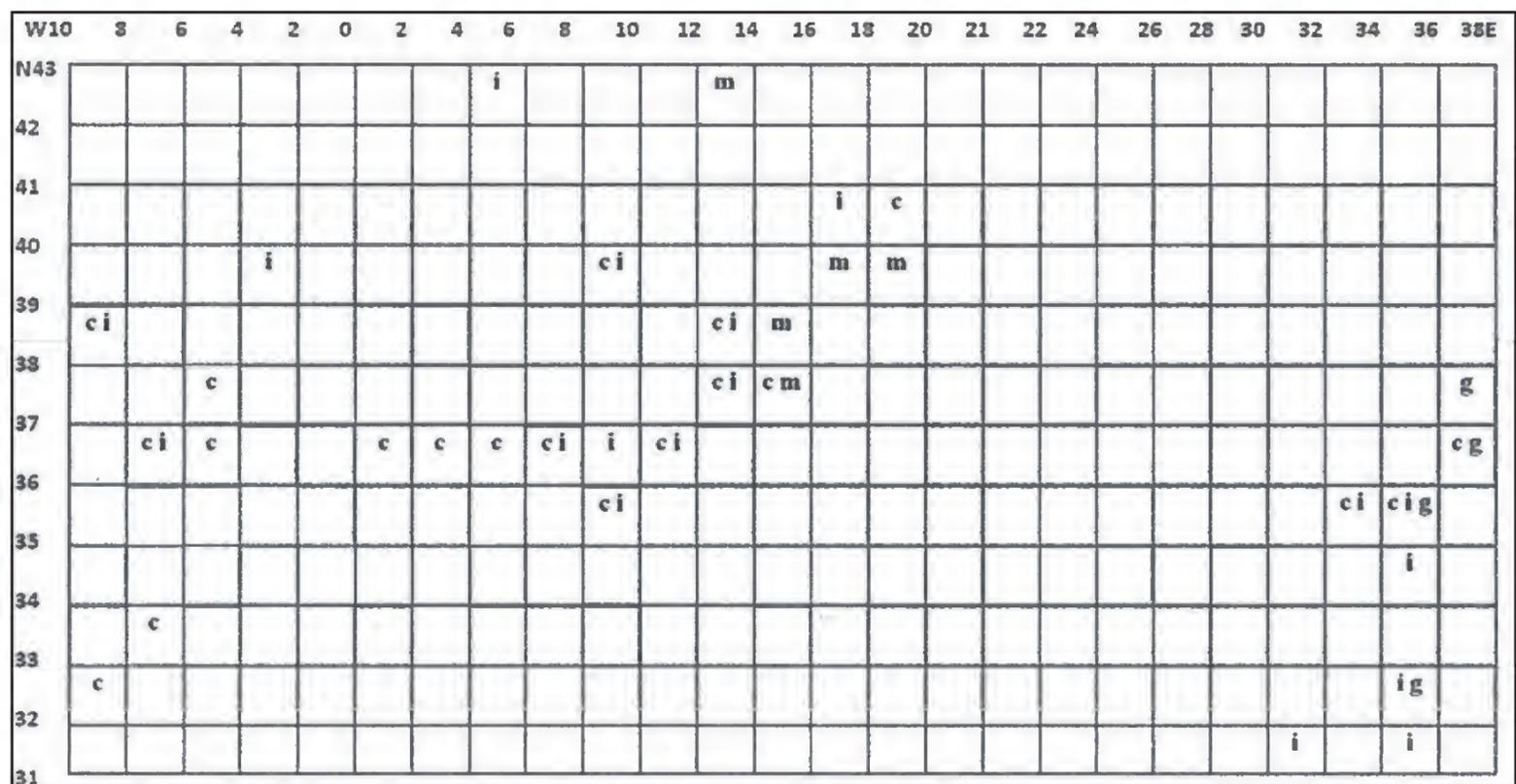


Figure 1. Geographical distribution of *Intertextae* subsection taxa (121 sites) by longitude and latitude. The rectangle is 1 x 2 degrees [1 line: North Latitude (N: 31 to 42); 2 column: East Longitude (E: 0 to 38) and West (W: 0 to 10)]. Abbreviations : c, *M. ciliaris*; i, *M. intertexta*; g, *M. granadensis*; m, *M. muricoleptis*.

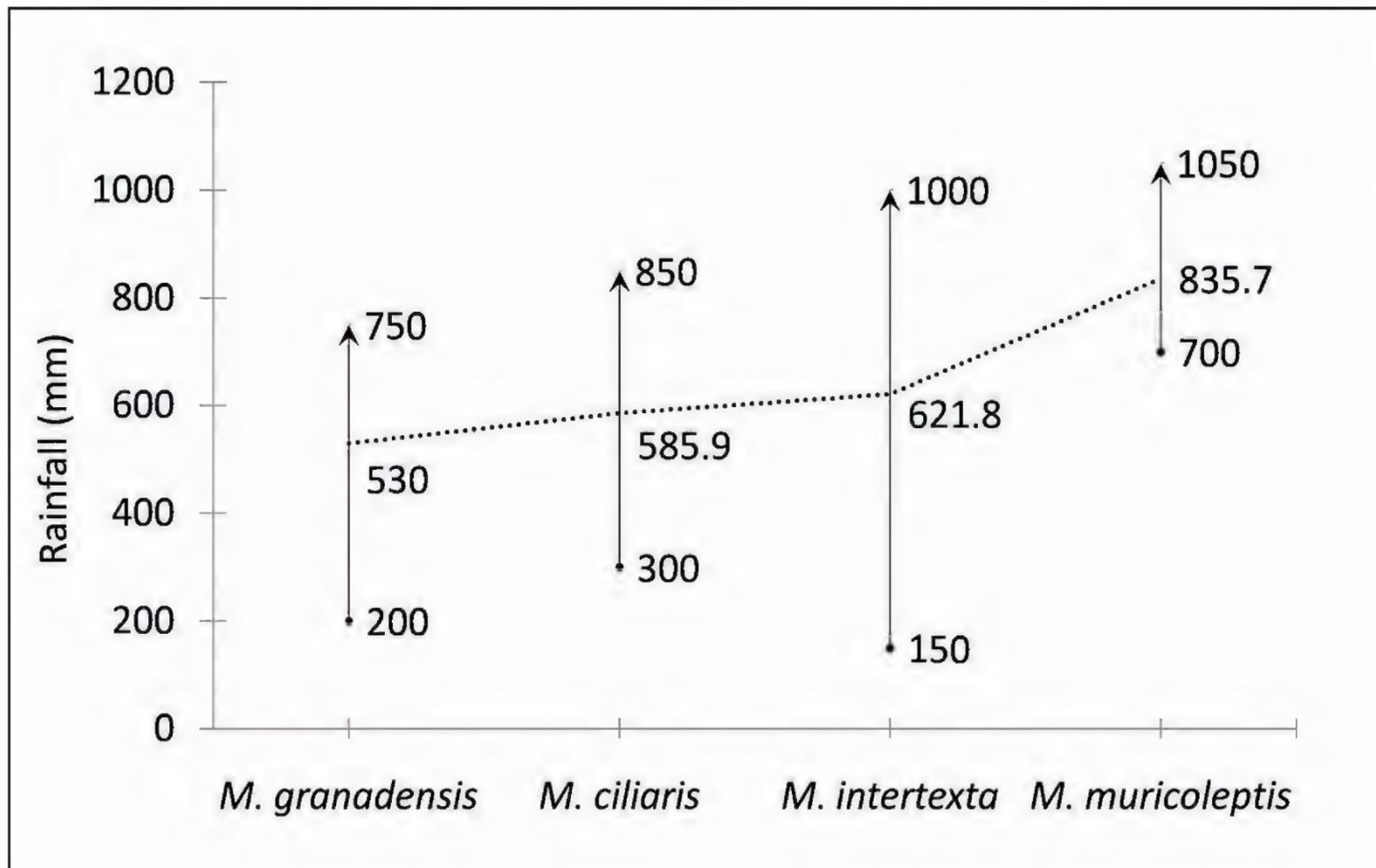


Figure 2. Minimum, average, and maximum values of annual average rainfalls by taxon.

class with more than 40 cm of depth (Fig. 5). *M. ciliaris* and *M. intertexta* can develop in soils that are not very deep (10 cm). *M. muricoleptis* and *M. granadensis* prefer deep soils.

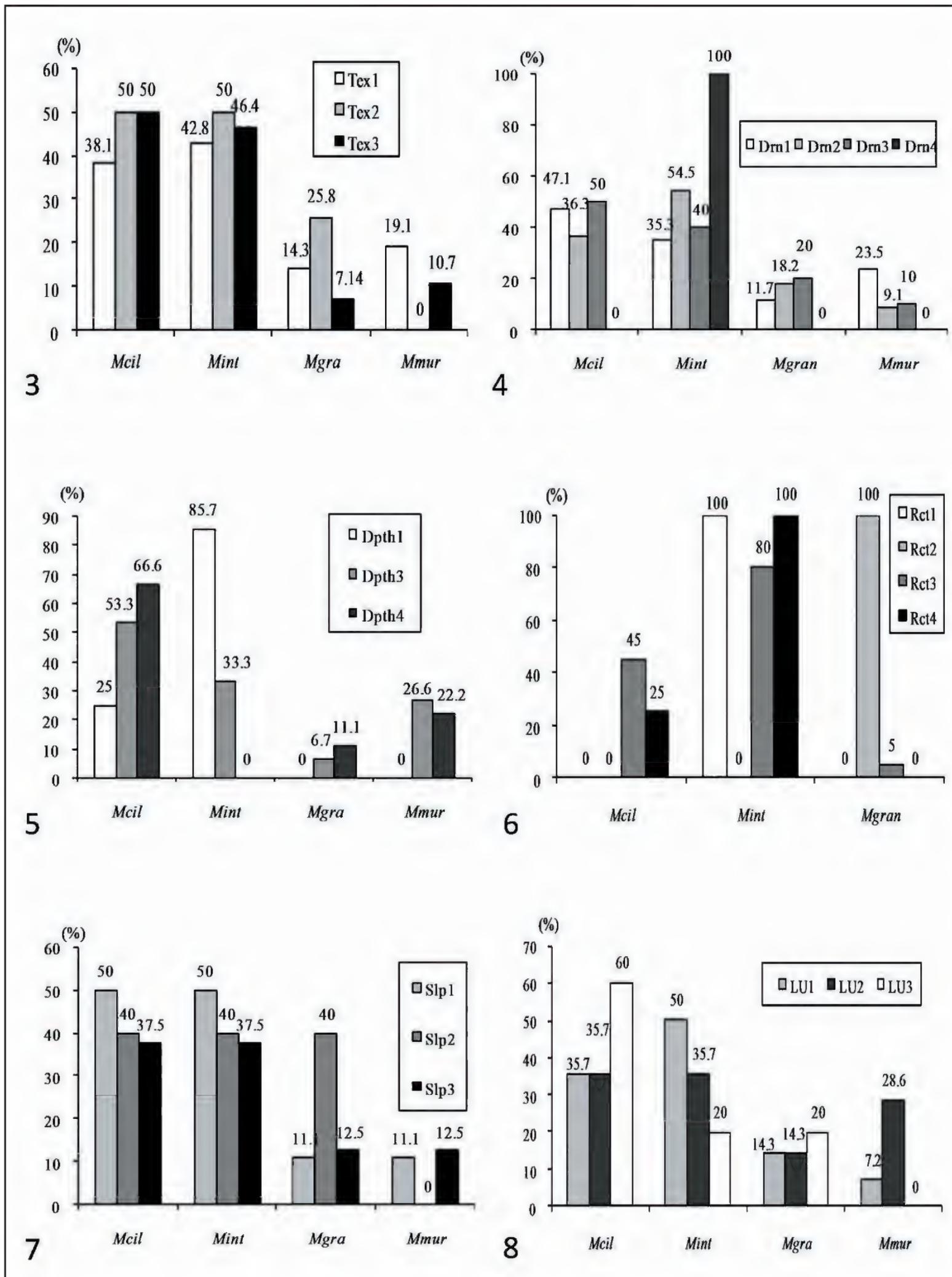
*M. granadensis* does not seem to withstand soil salinity considering its total absence in this type of soil (Fig. 6). Owing to the absence of data on soil reaction, *M. muricoleptis* was not studied. Although this data is qualitative, ecological profiles confirm the resistance of *M. ciliaris* and *M. intertexta* to salts as they are present in various sites qualified as salty. Although the variance analysis did not highlight significant differences for the pH, from ecological profiles of the soil reaction character (Fig. 6) there are preferences depending on the taxon. All of the three taxa *M. ciliaris*, *M. intertexta* and *M. granadensis* grow on alkaline soils. *M. granadensis* is the only one present in sites with neutral soils and *M. intertexta* confirms its presence on acid soils. Acid soils, with a pH of 5, characterize only a few sites of *M. ciliaris* and *M. intertexta*. By contrast, neutral and alkaline soils are suitable for the four taxa of the subsection.

### **Slope and Land Use**

*M. ciliaris* and *M. intertexta* prefer flat grounds in contrast to *M. granadensis*, which prefers sloping grounds (16-30%). *M. muricoleptis* is intermediary with a preference for flat to undulating ground (Fig. 7). The four taxa of the *Intertextae* subsection are found in cultivated and grazed soils and only *M. ciliaris*, *M. intertexta* and *M. granadensis* are found on roadsides (Fig. 8). *M. ciliaris* and *M. granadensis* are more frequent on roadsides and *M. intertexta* is more frequent in cultivated lands. Unlike other taxa, *M. muricoleptis* is found more often in pastures.

### **Symbiotic responses**

The endemic taxa, *M. muricoleptis* and *M. granadensis*, just as the taxa of *M. intertexta* and *M. ciliaris*, are exclusively nodulated, in Algeria. The inoculation of 34 trapped strains of rhizobia on *M. polymorpha* showed an efficient nodulation Nod+/Fix+ on all tested plants. This result confirms that all collection of rhizobium is *S. medicae*.



Figures 3–8. Ecological profiles indicate the relative frequency of the taxon in the different classes (for class limits see Table 4). Figure 3: soil texture. Figure 4: soil drainage. Figure 5: depth. Figure 6: soil reaction. Figure 7: slope. Figure 8: land use.

The inoculation of the reference strain 2011 *S. meliloti* shows that on *M. truncatula* (A17) all the plants nodulate and are efficient. No taxon of the *Intertextae* nodulated efficiently with this strain. *M. ciliaris* and *M. intertexta* do not show any nodule. *M. ciliaris* offers the highest percentage of bumps

and *M. granadensis* shows the highest percentage of Nod-. In *M. granadensis* and *M. muricoleptis* non efficient nodules were formed on a small number of plants (Fig. 9). The strain ABS7, obtained from *M. ciliaris*, nodulates efficiently, without exception, all the plants of the *Intertextae* subsection.

Variables	Abbreviation	Class codes	Classes
Texture	Tex	Tex1-Tex3	Clay, loamy, loamy-clay
Drainage	Drn	Drn1-Drn4	Good soil drainage, free flow, Stagnation in surface, Submersion
Depth (cm)	Dpth	Dpth1 -Dpth3	0-10, 20-40 and +40 cm
Soil Reaction	Rct	Rct1 -Rct4	Acidic, Neutral, Alkaline, Saline
Slope (%)	Slp	Slp 1-Slp3	0-3 % Flat, 3-8 % hilly, 16-30 % sloping
Land Use	LU	LU1-LU3	Crops, grazing, roadside

Table 4. Upper Limits of qualitative variable classes used for ecological profiles.

Taxon	Population	Code	Altitude (m)	Rainfall (mm)	Origin	Rhizobia Strains
<i>M. ciliaris</i>	DZ.C242	242	980	450	Algeria	<b>3 Strains:</b> DZ.c242.G3.1 ; DZ.c242.G3.2 ; DZ.c242.G3.3
<i>M. ciliaris</i>	DZ.C58	58	860	649	Algeria	<b>3 Strains:</b> DZ.c58.G1.2, DZ.c58.G1.4, DZ.c58.G1.5
<i>M. intertexta</i>	DZ.I331	331	880	1053	Algeria	<b>5 Strains:</b> DZ.i331.G2.1; DZ.i331.G2.2; DZ.i331.G2.3 ; DZ.i331.G2.4 ; DZ.i331.G2.5
<i>M. intertexta</i>	DZ.I58	58	860	649	Algeria	<b>5 Strains:</b> DZ.i58.G2.1, DZ.i58.G2.2, DZ.i58.G2.3, DZ.i58.G2.4 DZ.i58.G2.5
<i>M. granadensis</i>	DZ.GAUS98	5.822	200	550	Israel	<b>5 Strains:</b> DZ.GAUS98.1.1, DZ.GAUS98.1.2, DZ.GAUS98.1.3, DZ.GAUS98.1.4, DZ.GAUS98.1.5,
<i>M. granadensis</i>	DZ.GAUS105	23.928	950	600	Turkey	<b>5 Strains:</b> DZ.GAUS105.1.1, DZ.GAUS105.1.2, DZ.GAUS105.1.3, DZ.GAUS105.1.4, DZ.GAUS105.1.5
<i>M. muricoleptis</i>	DZ.MAUS.110	24.825	630	800	Sicily	<b>5 Strains:</b> DZ.MAUS.110.1.1, DZ.MAUS.110.1.2, DZ.MAUS.110.1.3, DZ.MAUS.110.1.4, DZ.MAUS.110.1.5
<i>M. muricoleptis</i>	DZ.MAUS.107	25.028	5	700	Italy	<b>3 Strains:</b> DZ.MAUS.107.1.1 DZ.MAUS.107.1.3, DZ.MAUS.107.1.4

Table 5. Collection of 34 rhizobia of *Intertextae* obtained by trapping.

Factors	Rainfall		Altitude		pH	
	Number of sites	Average (mm)	Number of sites	Average (m)	Number of sites	Average
<i>M. ciliaris</i> (sc+sci)	34	585.88 b	34	278.24	16	7.98
<i>M. intertexta</i> (si+sci)	30	621.83 b	30	249.50	8	7.73
<i>M. granadensis</i> (sg)	5	530.00 b	5	398.00	4	7.90
<i>M. muricoleptis</i> (sm)	7	835.71 a	7	333.57	3	7.17
Meaning	-	**	-	ns	-	ns

LSD = 1.996

Table 6. Comparison between environmental factors of the sites of *Medicago ciliaris*, *M. intertexta*, *M. granadensis* and *M. muricoleptis*. The letters a and b: indicate average groups. P(t), t-test on the groups of average [\*\*\*: P < 0.001; \*\*: P < 0.01; \*: P < 0.05; n.s.: P > 0.05].

Factors	Rainfall		Altitude		pH	
	Number of sites	Average (mm)	Number of sites	Average (m)	Number. of sites	Average
<i>M. ciliaris</i> (sc)	22	571.82 b	22	288.41	13	7.84
<i>M. intertexta</i> (si)	18	628.61 b	18	242.78	5	7.20
<i>M. granadensis</i> (sg)	5	530.00 b	5	398.00	4	7.90
<i>M. muricoleptis</i> (sm)	7	835.71 a	7	333.57	3	7.17
Mixed <i>M. ci-M. int</i> (sm)	12	611.67 b	12	259.58	3	8.60
Meaning	-	**	-	ns	-	ns

LSD = 1.98

Table 7. Comparison between environmental factors (3) of sites with *Medicago ciliaris* alone, *M. intertexta* alone, *M. granadensis*, *M. muricoleptis* and mixed sites with *M. ciliaris* and *M. intertexta*. The letters a and b: indicate average groups. P(t), t-test on the groups of average [\*\*\*: P < 0.001; \*\*: P < 0.01; \*: P < 0.05; n.s.: P > 0.05].

By contrast, USDA1827 (obtained from *M. truncatula*) nodulates neither *M. muricoleptis* nor *M. granadensis*. It nodulates one population of each taxon of *M. intertexta* and *M. ciliaris*. Indeed, the USDA1827 is specific within the species *M. truncatula*, for it nodulates some populations and not others.

#### Genetic diversity of the trapped rhizobia

The electrophoresis of rep-PCR and BOX-PCR revealed 114 bands (we only took intense bands) of which 45 are monomorphic and the remainder is made up of polymorphic bands. Polymorphism is more frequent in *M. granadensis* strains with 55.5%

of polymorphic bands, followed by *M. intertexta* strains (50%); it is less than 25% in the other taxa. We did not find specific bands that differentiate the strains of the 4 taxa. Genetic distances (Fig. 10) show a structuring of the strains of *S. medicae* by forming 2 different groups. The first group (G1) corresponds to the strains that nodulate *M. ciliaris* and *M. intertexta* and the second group (G2) is the one trapped in *M. granadensis* and *M. muricoleptis*. There are 2 strains of *M. granadensis* of the population DZ.GAUS98, which come together with those of *M. intertexta*. Symbiotic specificity is clearly established among widespread taxa and endemic ones.

## DISCUSSION

### Geographic distribution

In the Mediterranean Basin, the four taxa, which have a close relationship (Rose et al. 1988), show different types of distributions: (i) endemic and rare represented by *M. granadensis* and *M. muricoleptis*, (ii) widespread and common represented by *M. ciliaris* and *M. intertexta*. These results confirm those obtained by several authors (Table 1). The new data is that *M. ciliaris* and *M. intertexta* are present in other countries that were never mentioned before in the literature. *M. ciliaris* is present in Israel and *M. intertexta* in Israel, Egypt, Cyprus, and Jordan. *M. ciliaris* is the most frequent in the Mediterranean basin and particularly in Algeria. In this country, this taxon is ranked fifth (163 sites/564) (Abdelguerfi, 2002).

Contrary to *M. ciliaris*, in the south west of the Mediterranean *M. intertexta* is rare; it is absent in the Northwest of Algeria and in the arid areas (Abdelguerfi-Laouar et al., 2003). *M. muricoleptis* is present in very restricted areas, Toulon in France and Sicily in Italy. Nevertheless (according to Coulot & Rabaute, 2013), the presence of *M. muricoleptis* in Toulon (France) is accidental, endemic in the north Mediterranean, from the south of Italy to Greece and *M. granadensis* is more confined to western Asia, endemic in the East of the Mediterranean and only adventitious in Europe and Chile. Contrary to what mentioned by Small et al. (1999), *M. granadensis* coexists with *M. intertexta* as the two taxa were found together on a site.

### Ecological requirements

*M. muricoleptis* is the most demanding water of the *Intertextae*. Its geographic distribution corresponds perfectly with this need. In Morocco, *M. intertexta* and *M. ciliaris* were found only in the areas with high rainfall and are confined to the areas with mild winter and summer (Bounejmate et al., 1992a, 1992b; Bounejmate, 1996). This does not reflect their requirement in the Mediterranean basin.

The *Intertextae* is known for its preference for heavy and humid soils (Small et al., 1999). In Algeria, *M. ciliaris*, *M. intertexta*, *M. rigidula* and *M. scutellata* prefer heavy soils and *M. ciliaris* grows particularly on marly soils (Abdelguerfi, 2002). Considering the specificity of the texture of the *Intertextae*, the taxa should withstand soils with poor water drainage. Indeed, the results show that the taxa are found both in soils with good water drainage and soils where water stagnates on the surface. *M. intertexta* is the most adapted to hydromorphic soils, is considered one of the most tolerant to waterlogging of the Annual *Medicago* genus (Francis & Poole, 1973). The waterlogging and salinity are associated characters in the Mediterranean basin (Kepner et al., 2005). The tolerance of plants to this condition is due to a combination of anatomical, physiological and morphological adaptations (Predeepa-Javahar, 2012). Only *M. ciliaris* and *M. intertexta* are present in salt soil. Therefore we may conclude that these two taxa are adapted to salinity. Indeed, genotypes originating from salty soils are often considered as tolerant, that is the conclusion of Ben Salah et al. (2010) when they compared under saline conditions (100 mmol of NaCl) two pure lines originating from two different sites, one rich in salt, and the other poor.

In Morocco, Bounejmate et al. (1992a; 1992b; 1994) and Bounejmate (1996) found the two taxa in soils low in phosphorous, hydromorphic and salty. According to Abdelkrim (1995), *M. ciliaris* is found in fallows and idle lands with soils that are colluvial, heavy, mostly marly and clayey, poorly drained and more or less salty. *M. ciliaris* is classified as glycophyte and found in association with halophyte species (Abdelly et al., 2006; Merabet et al., 2006; Barret-Lennard & Setter, 2010). Other research confirmed the adaptation of these taxa to salinity (Greenway & Andrew, 1962; Lachaal et al., 1995; Chérifi et al., 2011).

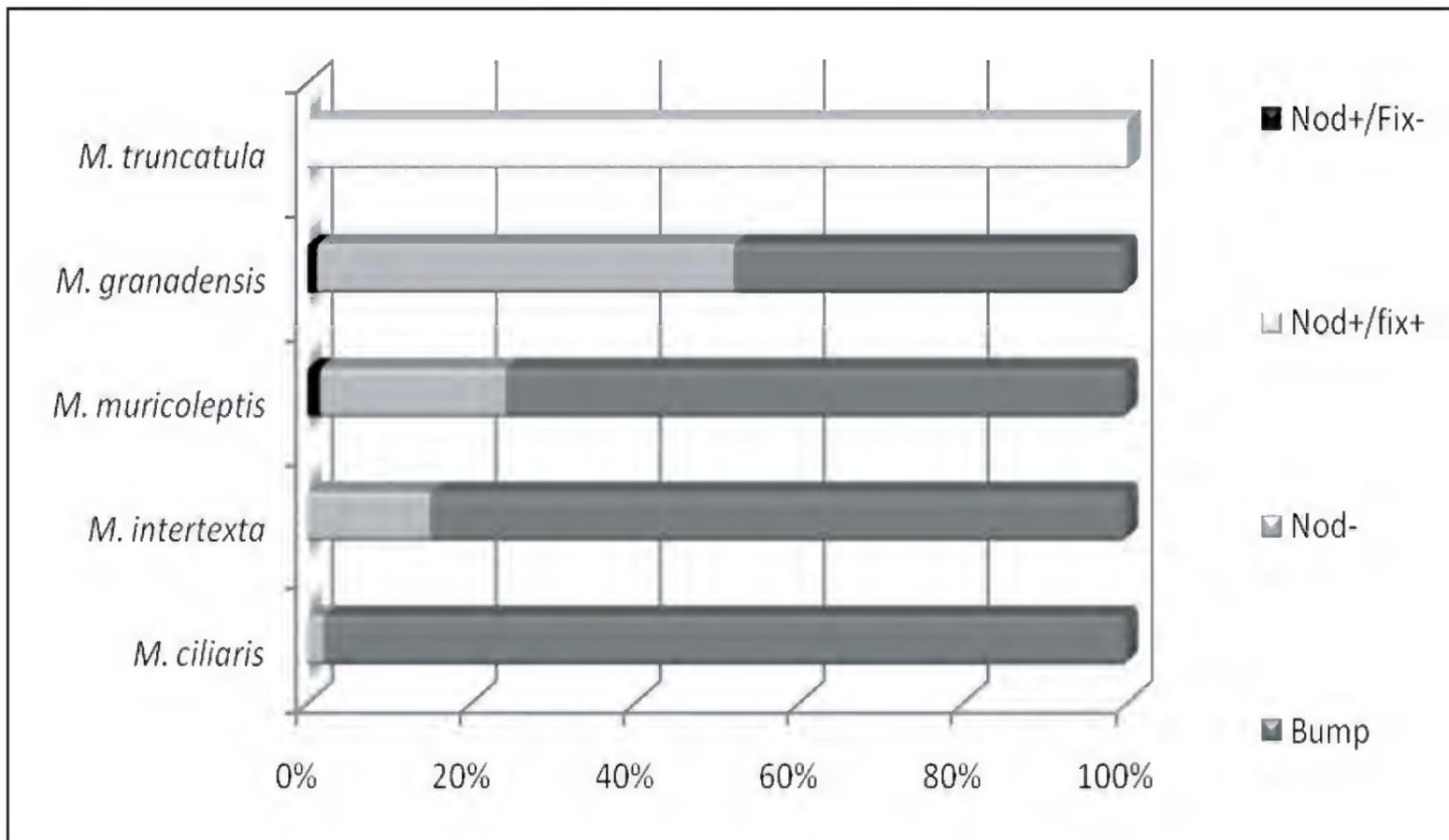


Figure 9. Symbiotic responses to the inoculation of the reference strain 2011 *S. meliloti* in the taxa of the Intertextae subsection. Abbreviations : Nod +, nodulating phenotype; Nod + /fix+, nodulating phenotype-fixer; Nod-, non nodulating phenotype; Bump, non nodulating root bulge.

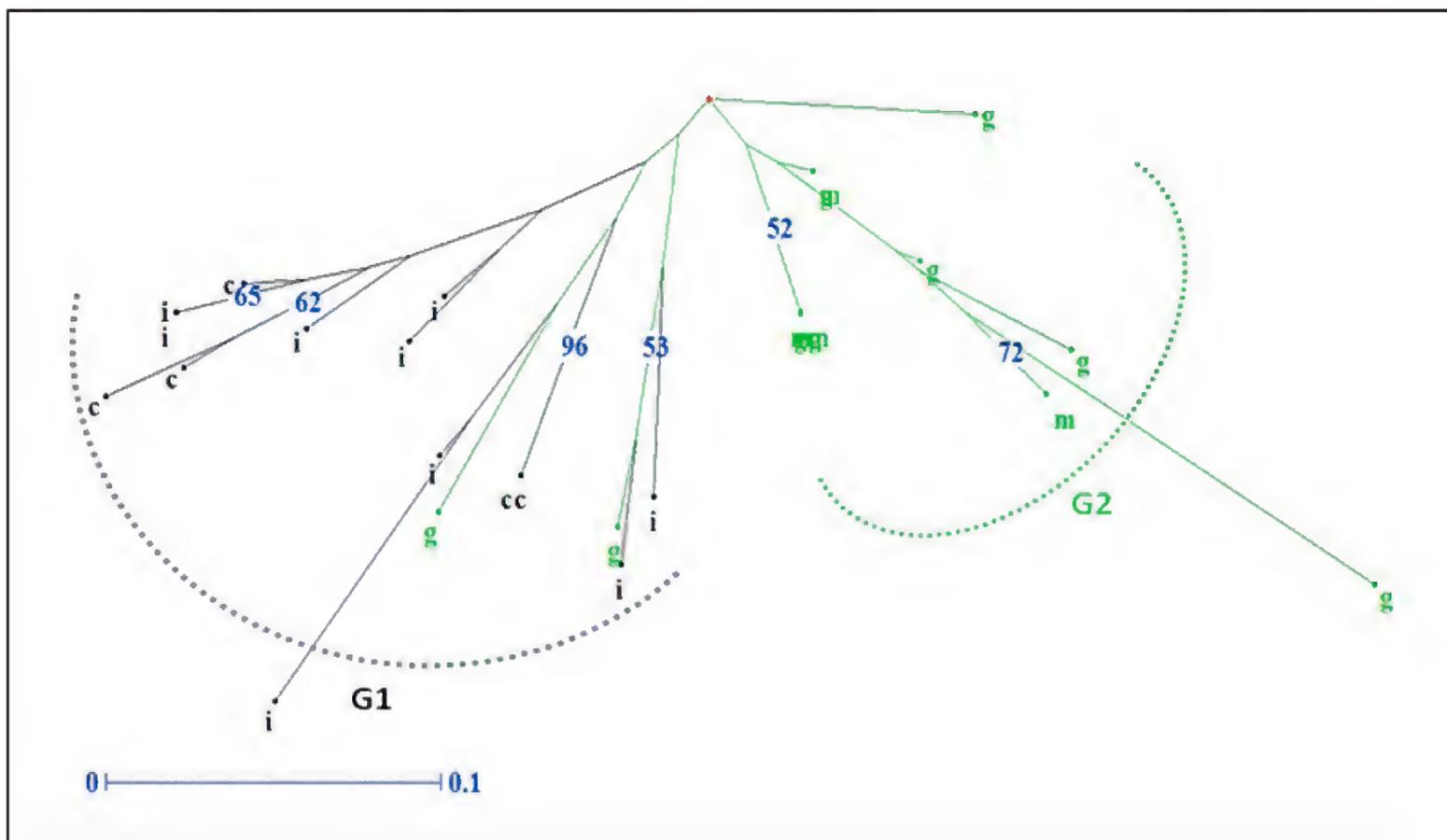


Figure 10. Un-weighted neighbour-joining tree based on the simple matching dissimilarity matrix of REP and BOX markers across the 34 strains of rhizobia trapped in a common site to all taxa in the subsection *Intertextae*. The numbers on the tips indicate bootstrap values (expressed in percentages) and are shown for all clusters with >50 % bootstrap support. Abbreviations: c, *M. ciliaris*; i, *M. intertexta*; m, *M. muricoleptis*; g, *M. granadensis*.

Furthermore, some studies have shown that the frequency of *M. intertexta* diminishes when the pressure of pasture increases (Piano, 1987). Piano et al. (1991) noted that *M. ciliaris* and *M. intertexta* are more frequent in cultivated lands.

### **Symbiotic response of *M. granadensis* and *M. muricoleptis* in an exotic site**

The various populations of *M. granadensis* and *M. muricoleptis* nodulated efficiently in the Algerian common site. The fact that *M. granadensis* and *M. muricoleptis* nodulated efficiently with rhizobia natives of Algeria, shows that their absence is not related to a restrictive coevolution plant-rhizobium in this region. On some species, particularly cultivated ones, a clear evolution was noted between the species and its symbiote and one of the more interesting examples is the pea, which may form an efficient symbiosis with strains of rhizobium from its site of origin in Turkey, but not with strains from other parts of this country (Lie et al., 1987).

### **Taxonomic determination of the trapped collection of *Rhizobia***

*M. muricoleptis*, *M. granadensis*, *M. intertexta* and *M. ciliaris* are exclusively nodulated by the strains of *S. medicae*, which confirms the results of Béna et al. (1998) on the *Intertextae* subsection and the results of Zribi et al. (2007) on *M. ciliaris*. Indeed, in the trapping site, there were different species of *Medicago* that were only nodulated by *S. meliloti* including species of the *Melilotus* Mill. genus. This confirms the specificity between the subsection of the *Intertextae* and *S. medicae*. A recent study (Epstein et al., 2012), comparing the two genomes of *S. medicae* and *S. meliloti*, showed that horizontal exchanges were almost exclusively of plasmid genes and that the divergence between the two species resulted from episodes of recent selection pressures.

Maybe it is not very correct to believe that this specificity, whether for *M. polymorpha* or the subsection of the *Intertextae*, is related only to the host. Indeed, other mechanisms affect the chemical structure of the synthesized Nod factors and therefore prevent the nodulation (Van Rhijin & Vanderleyden, 1995; Dénarié et al., 1996; Long, 1996). Alfalfa, for

example, is only nodulated in the presence of sulphated Nod factors. This specificity mechanism is based on the presence or absence, depending on bacterial strains, of some genes that control the synthesis of specific substitutes or their transfer on the common skeleton. Other than genetic factors, exogenous factors can influence the symbiosis either for the choice of rhizobia that nodulate the plant or for their efficiency.

According to Garan et al. (2005), *S. medicae* nodulate more the species of *Medicago* that are adapted to acid soils; by contrast, *M. meliloti* forms a more frequent symbiosis with those that grow on alkaline to neutral soils. This result does not apply to the 4 taxa of the *Intertextae* subsection, since they rather prefer alkaline to neutral soils.

### **Symbiotic specificity**

The symbiotic response is not limited to the presence or absence of nodules. Others structures can exist and appear visually on the roots in the form of more or less developed protuberances. Generally, these forms do not grow bigger in length, in fact, their development stops quickly. The study of the effect of the Nod factors of *Rhizobium meliloti* (equivalent to *S. meliloti*) on cultivated alfalfa revealed several structures, such as nodules and other protuberances (Grosjean & Huguet, 1997).

Therefore, the symbiotic response other than the presence absence of efficient nodules cannot be dissociated from genetic variations of the host plant. In this sense, the Nod- of *M. muricoleptis* and *M. granadensis* induced by *S. meliloti* shows the difference of these taxa relative to *M. ciliaris* and *M. intertexta*.

Furthermore, the strain USDA1827 shows a specificity of inter- and intra-species host and it is not the only one. The population ES103 of *M. polymorpha* achieves an efficient symbiosis with ABS7m, while the population F34003 does not form any nodule with this same strain (Béna et al., 1998).

### **Genetic relation between rhizobium and taxa**

According to Martínez -Romero (2009), plant-rhizobium coevolution is more oriented by the plant

than by the rhizobium; it is the plant that must constantly select the strains with which it gets in symbiosis. This result shows that the taxa acquired genetic differentiation. In Tunisia, the results of molecular and enzymatic analysis did not show strains-species specificity in indigenous strains of *M. sativa* cv. Gabbès, *M. scutellata* cv. Kelson, *M. truncatula* and *M. ciliaris* (Jebara, 2001). Although *M. muricoleptis* and *M. granadensis* do not share the same areas of distribution, they select genetically close strains of rhizobium that are different from the ones of indigenous taxa, *M. ciliaris* and *M. intertexta*.

These results indicate cospeciation between the rhizobia and the endemic and widespread taxa. Cospeciation between the rhizobia and leguminous plants is not clearly established. Some authors indicate that there is little concordance between the phylogeny of bacteria and the phylogeny of legumes plants (Doyle, 1998; Béna et al., 2005); others, on the contrary, find links between both partners (Ueda et al., 1995; Wernegreen & Riley, 1999; Laguerre et al., 2001).

#### **What is the effect of the two factors on the geographical distribution of taxa?**

When analyzing ecological data, it appears that there are no conditions specific to either taxon. Some variations were observed among taxa but are not discriminating. Consequently, *M. muricoleptis* and *M. granadensis* are not specific to some habitats and the limit of their dispersion is not ecological. According to Griggs (1940), climatic and edaphic factors are not the primary causes of the rarity of a species, but the primary cause is competitiveness. Other biotic factors may come into play; we have seen that symbiosis does not seem to be a factor that limits the dispersion of endemic species since they have grown and nodulated in Algeria where they are naturally absent. Indeed, from a study on the effect of symbiosis on the expansion of the *Medicago* genus (Béna et al., 2005), it was concluded that symbiotic specificity can influence the distribution of the species of the *Medicago* genus, but not to the point of influencing their level of endemism.

In this case, *M. muricoleptis* and *M. granadensis* show local endemism that generally results from geographic and genetic isolation. The geographical distribution of the 4 taxa may result from allopatric

speciation where the populations are first separated geographically, which provokes a net decrease or a stop of the genetic exchanges, and the progressive accumulation of differences among the populations.

According to the phylogenetic results, that indicate that *M. ciliaris* and *M. intertexta* evolved from a common lineage and that *M. intertexta* evolved independently and gave rise to *M. muricoleptis* and *M. granadensis* (Rose et al., 1988), we may assume that *M. muricoleptis* and *M. granadensis* are young species (neoendemism) (Willis, 1922; Stebbins, 1980) compared with *M. intertexta* and *M. ciliaris* and that over time they could extend to other areas. As mentioned by Lamotte (1994), in allopatric speciation, populations may be confronted to different environments allowing or provoking differential adaptations.

#### **CONCLUSION**

Ecological factors did not explain why phylogenetically close taxa belonging to the same subsection have different geographical distributions, one narrow and one wide. The ecological requirements of taxa are more or less similar demonstrating that this is not the factor limiting the distribution of *M. muricoleptis* and *M. granadensis* in the region of the Mediterranean. Either the symbiosis is not a factor limiting the presence of these taxa which perform an efficient symbiosis in an area where are naturally absent. As against, endemic and widespread taxa show selectivity in symbiont (rhizobia strains) which confirms their differences. Other factors, such as genetic pool of taxa, should be investigated to clarify the distribution of the *Intertextae*.

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# On the presence of *Notodiaphana atlantica* Ortea, Moro et Espinosa, 2013 in the Mediterranean Sea, with notes on *Retusa multiquadrata* Oberling, 1970 and *Cylichna mongii* (Audouin, 1826) (Cephalaspidea Cylichnidae)

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## ABSTRACT

*Notodiaphana atlantica* Ortea, Moro et Espinosa, 2013 (Cephalaspidea Cylichnidae) is reported from various localities of Western and Central Mediterranean. Records of *Retusa multiquadrata* Oberling, 1970 are listed and discussed, most of them are considered to be based on *N. atlantica*. Possible synonymy between *N. atlantica* and *R. multiquadrata* is discussed, but former name is preferred. Based on the study of material from Suez channel, *Bulla mongii* Audouin, 1826 seems to be based on a very young specimen of the common species *Liloa curta* (A. Adams in Sowerby, 1850), but as Audouin's name is older, then *Bulla curta* shall be considered synonym of *Bulla mongii*. *Liloa mongii* (Audouin, 1826) new combination is than proposed.

## KEY WORDS

*Bulla mongii*; *Notodiaphana atlantica*; *Retusa multiquadrata*; Mediterranean; Lessepsian.

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## INTRODUCTION

The recently described species *Notodiaphana atlantica* Ortea, Moro et Espinosa, 2013 (Cephalaspidea Cylichnidae) is here reported for the first time in the Mediterranean Sea. In the Mediterranean Sea have also been reported *Cylichna mongii* (Audouin, 1826) and *Retusa multiquadrata* Oberling, 1970, two poorly known species, which need to be clarified to avoid misuse of the name. Mediterranean records of these three species, obviously only those accompanied by a photo, are discussed.

*Notodiaphana atlantica* Ortea, Moro et Espinosa, 2013

2013. *Notodiaphana atlantica* - Ortea et al.: 17, fig. 4, pl. 1.

1972. *Cylichnina multiquadrata* - Nordsieck: 35, pl. O XVI, fig. 18

1995. *Retusa multiquadrata* - Mikkelsen: 205, fig. 2E

2001. *Cylichnina multiquadrata* - Cachia et al.: 125, pl. XX, fig. 7

2008. *Cylichnina multiquadrata* - Cecalupo et al.: 128, pl. 75 figs. 5-7 (not fig. 4)

EXAMINED MATERIAL. Jerba (Tunisia), -2/3 m, 6 sh. (Figs. 5, 12–16); Pace, 5 km north of Messina, Sicily, -6 m, 1 sh., 2014, legit A. Villari (Fig. 6); Augusta, north of Syracuse, Sicily, beached in the harbour area, 1 sh., 1990, legit A. Villari; Linosa

island, Sicily Channel, -10 m, 1 sh., 2013, legit P. Micali; Cabo Negro, Tetouan, Morocco, -30m, 1sh.

REMARKS. *N. atlantica* is described based on specimens from a wide area ranging from Bahamas islands to Cuba and Canary islands, type locality is not designated.

Authors widely discuss the Mediterranean records, bearing also a photo, of *C. mongii* and *R. multiquadrata*, to ascertain whether this species is present in the Mediterranean. In particular Authors refer to the photos of three specimens in a work published on web ([http://www.naturamediterraneo.com/forum/topic.asp?TOPIC\\_ID=100306](http://www.naturamediterraneo.com/forum/topic.asp?TOPIC_ID=100306)) by the Gruppo Malacologico Livornese and later on published in the "Notiziario S.I.M." (Gruppo Malacologico Livornese, 2004), ignoring that the three photos have been taken from Cecalupo & Quadri (1996). Authors note that one of the three specimens (they do not indicate which one, but possibly that at photo 1b) resembles *N. atlantica* for the profile and the presence of spiral and axial threads. Authors are misled by the indication that the figured specimen is 2.2 mm high and 1.5 mm wide and conclude that it is not *N. atlantica* for the size and the H/W of 1.46 against 2 in *N. atlantica*. Really Cecalupo & Quadri (1996) determine the three specimens as *C. cfr. mongii* and indicate that the specimen at fig. 1 is 2.2 mm high, while the other two, whose height is not indicated, but may be calculated from the enlargement (x 25) indicated in the legend of the table, should be 1.7 mm (fig. 1b) and 1.24 mm (fig. 1c) high. Ortea et al. (2013) conclude that *N. atlantica* is not present in the Mediterranean.

Nordsieck (1972) describes and draws a specimen from Le Franqui, type locality of the species. The Author states "nach Foto von Oberling", therefore description and drawing are taken from a photo of *C. multiquadrata* that Oberling sent to Nordsieck, and this is proved by the dimension of the drawn specimen, that is very close to that indicated by Oberling.

Ortea et al. (2013) do not mention the work of Cecalupo et al. (2008) on the malacofauna of Gabés gulf, where are figured two specimens from various localities of Kerkennah island, as *C. multiquadrata*, having height ranging from 3.2 to 3.4 mm, therefore well mature. Photo of a living specimen clearly shows that soft parts are white, with a large darker zone hardly visible inside the shell. This colour cor-

responds with *N. atlantica*, for which a large dark spot, corresponding to digestive gland is indicated.

The specimen in Cecalupo et al. (2008) is clearly different by *N. atlantica*, and it is currently under study.

Cachia et al. (2001) describe and figure *C. multiquadrata*, stating that few empty shells have been found at Salina Bay, Malta. From the description and drawing of a specimen 3.9 mm high, there is no doubt that it is *N. atlantica*.

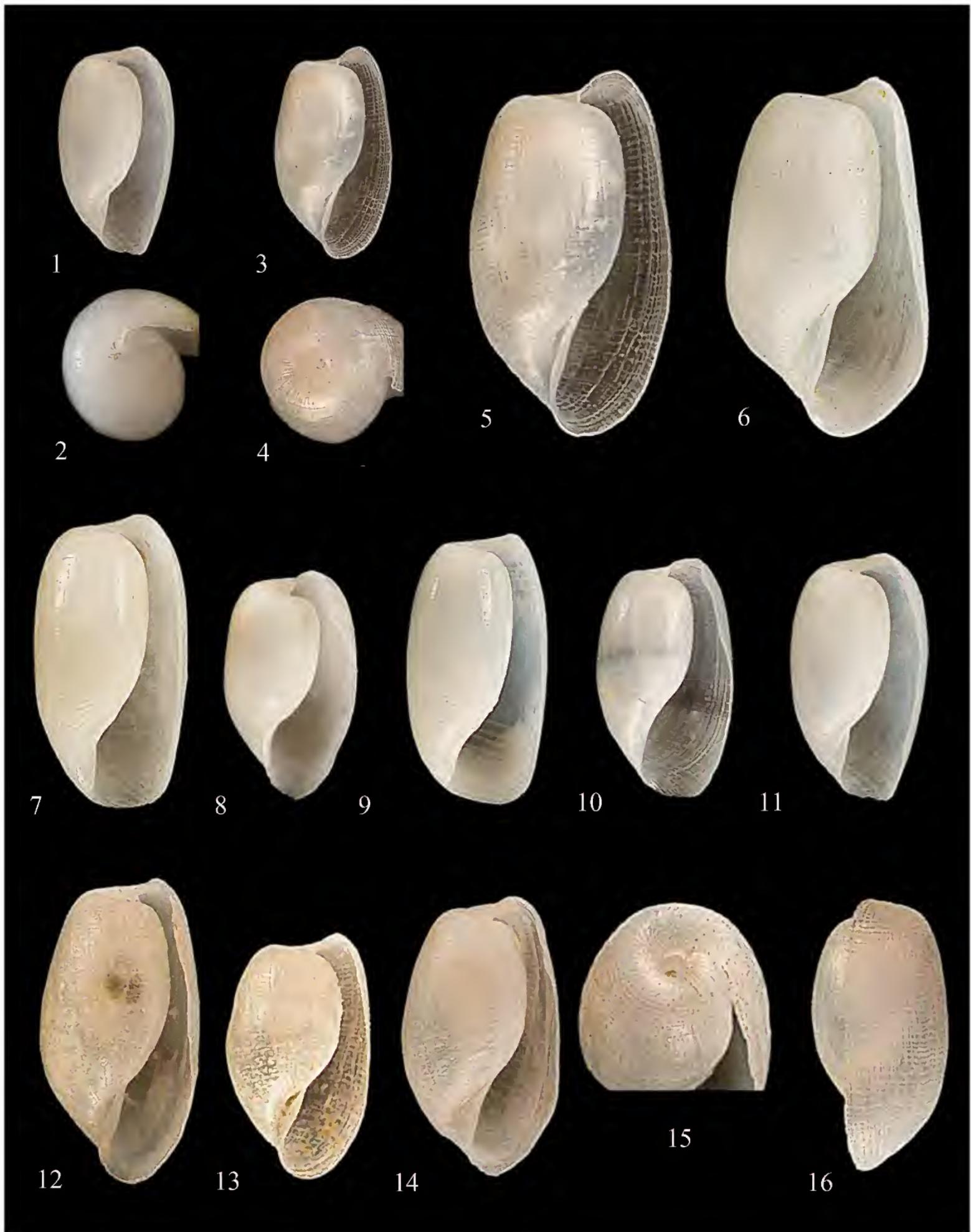
Vazzana (2010) lists *C. cfr. mongii* at Scilla (Strait of Messina), without figuring it. Based on reported findings of *N. atlantica* in this area and the photos on web, where this species is also on sale, there is no doubts that the records in the Strait of Messina shall be referred to *N. atlantica*.

Therefore based on studied material and confirmed records, *N. atlantica* is widespread in the western and central Mediterranean sea, up to south France, Sicilian coasts, Malta and south Tunisia.

*N. atlantica* may be easily separated from *Liloea mongii* for the much finer cancellate sculpture with more than double number of spiral grooves. The sculpture of *L. mongii* is not cancellate, consisting of spiral grooves and growth folders. In specimens about 2.2 mm high *N. atlantica* has a nearly straight, instead of regularly convex lateral shell profile. Seen from the aperture the profile shows a wider and more squared last whorl and columellar lip extended over the umbilical rim. Columellar profile is inclined but almost straight in the joint to the whorl, while in *L. curta* the columella is short and there is an angle, not covered by columellar lip. The abapical margin is more acute and by transparency it is visible the external cancellate sculpture, while in *L. curta* the margin is squared, quite straight and only some spiral grooves may be seen from inside (compare Figs. 1, 2 and Figs. 3, 4)

*R. multiquadrata* was described a first time (Oberling, 1970) with the following description: "De rares spécimens sur la plage de la Franqui [north of Perpignan, south France]. Forme en cylindre trapu, un peu comme *R. mammillata*. Phil., mais avec sommet perforé. Sculpture réticulée de sillon spiraux et transverses, comme pour *R. crebisculpta* Mtr., mais réseau plus dense que dans cette espèce. La columelle est fortement développée".

In one later work (Oberling, 1971) the species is again described with more details "Un petit (1 3/4 x 1 mm.) *Retusa*, presque cylindrique quoique avec



Figures 1, 2. *Liloa mongii*, Great Bitter Lake (Suez channel), height 2 mm. Fig. 1: front view. Fig. 2: apical view. Figures 3–5. *Notodiaphana atlantica*, Jerba (Tunisia), height = 2.3 mm. Fig. 3: front view for comparison with Fig. 1. Fig. 4: apical view. Fig. 5: front view. Figure 6. *N. atlantica*, Pace (Messina), height = 2.3 mm. Figures 7–11. *Liloa mongii*, Great Bitter Lake (Suez channel). Fig. 7: height 4.6 mm. Fig. 8: height 1.4 mm. Fig. 9: height 3.7 mm. Fig. 10: height 2 mm. Fig. 11: height 2.3 mm (same specimen of Fig. 1). Figures 12–16. *N. atlantica*, Jerba (Tunisia). Fig. 12: height = 4.5 mm. Fig. 13: height = 1.7 mm. Figs. 14–16: height = 3.3 mm. Fig. 14: front view. Fig. 15: apical view. Fig. 16: lateral view.

tours quelque peu convexes; spire enfoncée, protoconque visible au fond du trou ainsi créé, tours autour de celui-ci-embrassants. Columelle très allongée (longueur près de  $\frac{3}{4}$  de celle de la région pariétale); surface de la coquille treillissée de stries spirales et verticales bien marquées. – Cette espèce ressemble vaguement au *R. crebisculpta* Mtrs.: celui-ci est relativement deux fois plus long, sa columelle beaucoup plus courte, sa protoconque est cryptique, etc...”. The description fits with *N. atlantica*, but without the study of type material, even after Nordsieck’s illustration of the species, the name should be considered nomen dubium.

The name *Cylichnina multiquadrata* is used by Mikkelsen (1995) for specimens from Azores, by Buzzurro & Greppi (1997) in a list of shells from Tasuçu (south Turkey), without any comment or figure and, later on, by Cecalupo et al. (2008) who figure three specimens as *C. multiquadrata*, basing the determination upon Oberling’s description. As proved below, the specimens at figures 5-7 shall actually be referred to *N. atlantica*, while specimen at fig. 4, which is a little different, could be another species.

It is astonishing that a species poorly described and not figured, has met such a success. The type material (not the holotype, which was not fixed) seems to be lost (Oliverio in litteram, 08 Sept. 2014).

From what above seems that *C. multiquadrata* and *N. atlantica* are synonyms, anyway as the specimen figured by Nordsieck is not indicated as belonging to type series, then *C. multiquadrata* is here considered nomen dubium and *N. atlantica* is the name to be used until Oberling’s type material will be traced and studied.

#### ***Liloa mongii*** (Audouin, 1826) new combination

1826. *Bulla mongii* - Audouin: 39 (ref. to Savigny’s figure, 1817: pl. 5, fig. 7).

1869. *Cylichna mongii* - Issel: 170 n° 424; 347 (ref. to Savigny’s figure at pl. 5, fig. 7).

1926. *Cylichna mongii* - Pallary P.: 76, pl. 5, fig. 7.

1939. *Cylichna mongei* (sic) - Moazzo: 135.

1982. *Bulla mongii* - Bouchet & Danrigal: 14, fig. 58.

1996. *Cylichnina* cfr. *mongii* - Cecalupo & Quadri: 110, tav. III, fig. 1, 1a, 1b.

2008. *Liloa curta* - Rusmore-Villaume: 150, fig.

2014. *Liloa curta* - Too et al.: 383, fig. 1J (living), 3D, 17A-I

For further figures of *L. curta* see Too et al. (2014).

EXAMINED MATERIAL. Great Bitter lake, Suez Channel, Egypt, legit G.P. Franzoni, 10 sh.

REMARKS. *Cylichna mongii* (Audouin, 1826) is a species of controversial determination, with many records in literature (see below). At present not all Authors agree on the origin or determination of this species. Gofas & Zenetos (2003) list among the species excluded from CIESM the *C. cf. mongii*, with a “(m)” to indicate that “citation is considered to proceed from a misidentification of a native species”.

The difficulty in the determination of this species is because Audouin (1826) assigned the name of *Bulla mongii* to the species figured by Savigny (1817) at pl. 5, fig. 7, therefore the species was never described and Savigny’s drawing is very small.

Issel (1869) indicates that the species is known to him only from fossil specimens collected on beaches above sea level (“spiagge emerse del Golfo Arabico”), but as the species was figured by Savigny, it is then included among the recent species. Issel (1869) gives the first description, obviously based on his interpretation of the species: “*Conchiglia assai piccola, sottile, ovato-cilindrica, più ristretta alla parte inferiore che alla superiore, bianca, liscia, non striata né solcata, poco nitida; apice incavato, non perforato. Apertura stretta, più allargata in basso che in alto; margine destro regolarmente arcuato, semplice, superante l’apice alla parte superiore; parte visibile della columella assai breve e non troncata. Dimensioni: Altezza millim. 2; diametro 1 [shell very small, thin, ovate-cylindrical, more restricted in the lower than in the upper part, white, smooth, not striated or sulcate, not glossy; spire sunken, not perforated. Aperture narrow, larger in the lower than in the upper part; right margin regularly arched, acute, protruding the apex; visible portion of the columella very short, not truncate. Dimensions: height 2 mm, width 1 mm]*”.

Pallary (1926) does not add any comment. Lamy (1938) reports this species for Ismailia (Suez

Channel), without comments. Moazzo (1939) reports it for the bay of Suez and lake Timsah. Bouchet & Danrigal (1982) illustrate the single specimen, only 1.6 mm high, present in Savigny collection, to be then considered the holotype. From the photo it is possible to see the spiral lines present all over the shell and the straight and folded outwardly columellar lip.

From the comparison of type specimen and Issel's description, it is clear that Issel's interpretation of this species is wrong, because he describes the surface as smooth, not striated or sulcate.

Ortea et al. (2013) show the type specimen, after metal coating, in little different position from photo in Bouchet & Danrigal (1982), with a more realistic view of the columellar profile and aperture.

Cecalupo & Quadri (1996) figure as *C. cf. mongii* three specimens from Kyrenia (North Cyprus), stating that this is the first Mediterranean record.

The CIESM (<http://www.ciesm.otg/atlas/appendix3bis.html>, last update: December 2003) includes *C. cf. mongii* (Audouin, 1826) in the "List of excluded species", with the following comment: "*The taxon reported under this name, from Cyprus by Cecalupo and Quadri (1996), may be an undescribed Mediterranean species. According to Van Aartsen (pers. comm.) this species is also known from the Island of Djerba, Tunisia, and Akkum, Turkey, and without doubt lives in the Mediterranean*".

Cossignani & Ardovini (2011) figure the *C. cf. mongii* using the photos from Cecalupo et al. (2008), from Kerkennah (Tunisia), instead of those from Cecalupo & Quadri (1996), showing the specimens from Cyprus, to which is referred the comment in CIESM (see above). In addition it is erroneously indicated Malaga as origin of the material.

The reduced size of the holotype (H= 1.6 mm) let one suppose that it could be the immature stage of a species living in the area. Studying the specimens of *Liloea curta* (A. Adams in Sowerby, 1850) collected in the Great Bitter Lake, it became clear that *Bulla mongii* is based on an immature specimen of the species known as *L. curta*. Figures 7–11 show a growth series from a specimen corresponding to type of *Bulla mongii*, to a specimen corresponding to *Liloea curta*. The shell profile varies with the growth, as the sculpture, which is more evident in small specimens. As the Audouin's name is much older than Adams's name, then the

new combination *Liloea mongii* (Audouin, 1826) is here proposed. This species shall be considered a true Lessepsian migrant, as it is present in the Suez Channel since long time and has entered the Mediterranean.

*L. curta*, as such, has not been reported in the Mediterranean sea, but record of *C. mongii* from Cyprus by Cecalupo & Quadri (1996) shall be considered the first in Mediterranean. Comparison between *L. mongii* from Suez Channel and specimens from Cyprus has been carried out with positive result.

*L. mongii* is a well known species with very wide distribution covering Red Sea, Malaysia the Philippines, China, Japan, Papua New Guinea, Guam, New Caledonia and Hawaii (fide Too et al., 2014). The description from Too et al. (2014) is the following: "*Maximum height 18 mm; whitish; thin and fragile, translucent, cylindrically oval, sides slightly convex only, anterior end slightly rounded, posterior end truncated; spire sunken, aperture broad, outer lip thin, base semi-circular; spiral grooves covering entire shell, distance between spiral grooves almost equal, faint irregular axial lines present*".

Moazzo (1939) reports this species as *C. semisulcata* Dunker, 1882 indicating it frequent in Lake Timsah, less frequent in the Great Bitter Lake and rare in Suez bay. Rusmore-Villaume (2008) in her work on the Egyptian Red Sea, indicates *L. curta* as "*infrequent in all areas. Locally common in shell grit*", reaching a height of 12.5 mm. Studied specimens from Great Bitter Lake reach about 5 mm. *Atys porcellana* Gould, 1859, *C. semisulcata* and *B. curta* A. Adams in Sowerby, 1850 are then synonyms of *B. mongii* Audouin, 1826.

*L. mongii* may be easily separated from *Atys cylindricus* (Hebling, 1779) for the depressed spire, with a smaller protrusion between the spire and lip, for the more cylindrical profile and the spiral grooves covering the whole height of the spire.

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## The first earthworm records from Malta (*Oligochaeta Lumbricidae*)

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### ABSTRACT

The first earthworm report from Malta lists seven species; six species from the Holarctic family Lumbricidae and one species from the Mediterranean family Hormogastridae. Apart from the Circum-Mediterranean *Octodrilus complanatus* (Dugès, 1828) and the Trans-Aegean *Octodrilus transpadanus* (Rosa, 1884) the other four lumbricid species recorded are widely distributed peregrine. The unidentified hormogastrid specimen might represent an autochthonous species in Malta.

### KEY WORDS

Earthworms; fauna; new record; Maltese Islands.

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### INTRODUCTION

Earthworms (*Oligochaeta Lumbricidae*) represent one of the most important groups of the soil fauna. Due to the earthworms' activity not only the structure of the soil is altered, but also the chemical composition is substantially changed (Lee, 1985).

As members of the saprophagous guild, earthworm species play a paramount role in the decomposition of dead plant material (litter, dead grass, etc.) in temperate forests (Zicsi, 1983). Their activity is also important in the tropical regions as well, where, together with termites, earthworms are responsible for the decomposition of 40% of dead plant material (Lee, 1985).

This is the reason why earthworms are considered "soil ecosystem engineers" (Jones et al., 1994; Decaëns et al., 2001), which play a fundamental role in maintaining soil fertility and consequently are indispensable for sustainable agricul-

ture (Jiménez et al., 2001). Contrary to their vital importance in biogeochemical cycles we have detailed ecological data only about two dozen species (Zicsi et al., 2011) from the some 800 valid lumbricid species distributed over the Holarctic (Csuzdi, 2012).

In addition, there are regions even in Europe from where earthworm records are scarce or completely missing.

One of such region is Malta from where, up to our present knowledge, there are no earthworm records published. In the last year the second author, a herpetologist interested in different lizard groups investigated the available prey-population including earthworms in Malta.

During this short-term study five earthworm species have been recorded which, together with some other specimens from the collection of the Hungarian Natural History Museum, are herewith presented.

## MATERIAL AND METHODS

A larger study collecting all fauna present in sampling sites was being carried out in two previous separate studies.

One of the authors (AS) resident on Malta, was able to monitor, dig and hand sort the mentioned retrieved specimens along with his colleague Patrick Vella. Along with the latter specimens from the Hungarian Natural History Museum, all specimens were studied by CC and included in the current list.

All voucher specimens that have been collected are now housed in the collection of one of the authors (CC).

## RESULTS

Family LUMBRICIDAE Rafinesque-Schmaltz, 1815

### *Allolobophora chlorotica* (Savigny, 1826)

*Enterion chloroticum* Savigny, 1826: 182.  
*Allolobophora chlorotica*: Csuzdi & Zicsi, 2003: 50 (for complete synonymy).

EXAMINED MATERIAL. Santa Marija bay, Comino Island (Maltese Archipelago), 3 adult ex., 1 adult and 1 juvenile ex., 3 adult ex., leg. A. Sciberras.

### *Aporrectodea trapezoides* (Dugès, 1828)

*Lumbricus trapezoides* Dugès, 1828: 289.  
*Aporrectodea trapezoides*: Blakemore, 2008: 531 (for complete synonymy).

EXAMINED MATERIAL. 23 adult ex., 1 adult ex., Chadwick Lakes, 1 adult ex., leg. V. Mahnert, 06.V.1974.

### *Aporrectodea rosea* (Savigny, 1826)

*Enterion roseum* Savigny, 1826: 182.  
*Aporrectodea rosea*: Csuzdi & Zicsi, 2003: 92 (for complete synonymy).

EXAMINED MATERIAL. 1 adult ex., 1 adult and 1 juvenile ex., Around St. Georges Bay under stones, in Garrique, 1 adult ex., leg. V. Mahnert, 04.V.1974.

### *Eiseniella tetraedra* (Savigny, 1826)

*Enterion tetraedrum* Savigny, 1826: 184.  
*Eiseniella tetraedra*: Csuzdi & Zicsi, 2003: 153 (for complete synonymy).

EXAMINED MATERIAL. Chadwick Lakes, 1 adult ex., leg. V. Mahnert, 06.V.1974.

### *Octodrilus complanatus* (Dugès, 1828)

*Lumbricus complanatus* Dugès, 1828: 289.  
*Octodrilus complanatus*: Blakemore, 2008: 625 (for complete synonymy).

EXAMINED MATERIAL. 6 adult and 51 juvenile ex.

### *Octodrilus transpadanus* (Rosa, 1884)

*Allolobophora transpadana* Rosa, 1884: 45.  
*Octodrilus transpadanus*: Csuzdi & Zicsi, 2003: 215 (for complete synonymy).

EXAMINED MATERIAL. Around St. Georges Bay under stones, in Garrique, 1 adult ex., leg. V. Mahnert, 04.V.1974.

Family HORMOGASTRIDAE Michaelsen, 1900

### *Hormogaster* sp.

EXAMINED MATERIAL. 1 juvenile ex.

REMARKS. We have only one juvenile specimen representing this Mediterranean family Hormogastridae, therefore, the exact species identification is not possible.

## DISCUSSION

This small sample from Malta consisted of seven earthworm species of which four lumbricids

(*A. chlorotica*, *A. rosea*, *A. trapezoides* and *E. tetraedra*) are widely distributed, peregrines which most probably were introduced by human activities. The other two lumbricid species (*O. complanatus* and *O. transpadanus*) possess more restricted area (Circum-Mediterranean and Trans-Aegean respectively) however, they are also capable for human introduction (see e.g. Mischis et al., 2005; Blakemore, 2008).

The only species which can be endemic in the island is the unidentified *Hormogaster* species. *Hormogaster* are distributed over the Western Mediterranean basin (Omodeo & Rota, 2008) and seemingly have no tendency for human introduction. Consequently, the presence of this species in Malta can be connected with the island's geological history.

The Maltese islands are situated on a shallow shelf called Malta-Ragusa Rise extending from the Ragusa Peninsula of Sicily toward the African coast (Magri et al., 2008). The presence of many Siculo-Maltese endemic species proves the close biogeographic relationships between Malta and Sicily which is a consequence of land connections with Sicily either in the Quaternary or in the Messinian stage of the Miocene Epoch (Hunt & Schembri, 1999).

Therefore, the abundant presence of *Hormogaster redii* Rosa, 1887 in Sicily (Omodeo & Rota, 2008) provides an apparent explanation of the origin of *Hormogaster* in Malta, however to draw more specific conclusions exact species identification is needed.

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## ***Alvania dalmatica* Buzzurro et Prkic, 2007 (Gastropoda Rissoidae): range extension, shell variability, habitat and relationships with *A. hallgassi* Amati et Oliverio, 1985**

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### **ABSTRACT**

Shell samples of *Alvania dalmatica* Buzzurro et Prkic, 2007 (Gastropoda Rissoidae) were obtained from Corfu. This is the first record of the species from the Ionian Sea and Greece. The shells show a wide morphological variation not previously reported for the species. Numerous shells of *A. hallgassi* Amati et Oliverio, 1985 were also found in the same localities. Some unreported features of this species are pointed out and the relationships with *A. dalmatica* are considered.

### **KEY WORDS**

Rissoidae; *Alvania*; variability; Mediterranean Sea; new findings.

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### **INTRODUCTION**

*Alvania* Risso, 1826 (Gastropoda Rissoidae) is a rissoid genus represented in the Mediterranean Sea by more than 70 species (Gofas, 2014). Its intrageneric relationships are still largely unresolved, lacking large-scale investigations on anatomical and molecular grounds. Some widely distributed and polymorphic taxa are probably complex of cryptic species while others often form quite uniform groups of species with not clear interspecific boundaries. Most of the latter have been recently described with very limited ranges.

*Alvania dalmatica* Buzzurro et Prkic, 2007 was described from some Dalmatian islands (Croatia), from bottoms rich of *Corallium rubrum* (Linnaeus, 1758) (Buzzurro & Prkic, 2007), no further records are known.

It is closely related, on conchological grounds, to *A. hallgassi* Amati et Oliverio, 1985 and *A. di-*

*aniensis* Oliverio, 1988. All these species occur in central Mediterranean and share a paucispiral protoconch sculptured with spiral threads and an ovate-conical teleoconch with a reticulated pattern, formed by the intersection of spiral and axial sculptures which are comparable in size.

*Alvania hallgassi* is known from Ionian coasts of Southern Italy and Sicily (Amati & Oliverio, 1985; Oliverio et al., 1986; Giannuzzi-Savelli et al., 1997; Trono, 2006; Cossignani & Ardochini, 2011; Scuderi & Terlizzi, 2012) and reported from central Tyrrhenian Sea (Scaperrotta et al., 2012). *Alvania daniensis* is distributed along Tyrrhenian coasts from southern France to Sicily and recently found in northern Adriatic Sea (Oliverio, 1988; Buzzurro et al., 1999; Cossignani & Ardochini, 2011; Micali & Siragusa, 2013; pers obs.).

Relying on published data, the three species can be characterized by shell morphology, habitat and distribution, as reported in Table 1.

	<i>Alvania dalmatica</i>	<i>Alvania hallgassi</i>	<i>Alvania daniensis</i>
<b>Total height</b>	2.6-3.5 mm	2-2.3 mm	2-2.4 mm
<b>Teleoconch whorls</b>	3.6	3	3.2
<b>Number of axial ribs on the last whorl</b>	16-17	15-30	14-23
<b>Spiral cords on the last whorl</b>	7-9	8-11	6-7
<b>Spiral cords above the aperture</b>	4-5	4-7	3
<b>Denticles in the outer lip</b>	Yes	No	No
<b>Protoconch whorls</b>	1.4	1.5	1.5
<b>Protoconch spiral threads</b>	6-7, running throughout its extension	5-6, the nucleus with only the first and last threads	5-6, running throughout its extension
<b>Protoconch interspaces</b>	smooth	smooth	papillose
<b>Colour</b>	Background light yellow with two small darker bands (one sutural and one basal)	Background yellow with two darker bands (one sutural and one basal)	Whitish-yellowish, uniform
<b>Habitat</b>	<i>Corallium rubrum</i>	photophilic algae	photophilic algae
<b>Depth</b>	60-90	down to 20	18-48
<b>Distribution</b>	Dalmatian coasts	Ionian Sea	Tyrrhenian and Ligurian seas

Table 1. Characters of *Alvania dalmatica*, *A. hallgassi*, *A. daniensis* from literature.

## MATERIAL AND METHODS

All shells were found in bottom samples collected by SCUBA diving. The protoconch whorls are counted according to the method as described by Verduin (1977).

**EXAMINED MATERIAL.** *A. dalmatica*. 4 shs from Lastovo Island (Croatia), 60-90 m, in CBC and SBC; 80 shs from Skeloudi Island (Paleokastritza, Corfu, Greece), 40-50 m, Kolowri island (Paleokastritza, Corfu, Greece), 53 m, Liapades reef off Cape Agios Iliodoros (Liapades, Corfu, Greece), 45 m, in SBC and ARC.

*Alvania* cf. *hallgassi-dalmatica*. About 40 shs from the aforementioned Corfu localities, dates and collectors, in SBC and ARC; about 15 shs from Lastovo Island (Croatia), 40 m, in SBC.

*Alvania hallgassi*: holotype (MCZR); more

than 180 shs from the aforementioned Corfu localities, dates and collectors, in SBC and ARC; about 200 shs from Punta Campanella and Scoglio Vervece (Naples, Italy), 50 m, in SBC and ARC; about 150 shs from Lastovo Island (Croatia), 40 m, in SBC; 6 shs from Gallipoli (Lecce, Italy), 80 m, in CBC; 2 shs from Torre Suda (Lecce, Italy), 82 m, in APC; 4 shs from Cannizzaro (Catania, Italy), 35 m, in LRC; 2 shs from Scilla (Reggio Calabria, Italy), 50 m, in LRC.

*Alvania daniensis*. some hundred shs from Palinuro (Salerno, Italy) 30 m, in SBC and CBC; 8 shs from Giglio Island (Grosseto, Italy), in SBC and CBC; 15 shs from Cres (Croatia), 36 m, in FSC.

*Alvania oliverioi*. 10 shs from Protaras (Cyprus), 25 m, in SBC and CBC; 2 shs from N Cyprus, 2-6 m, in CBC.

ABBREVIATIONS AND ACRONYMS. APC: Attilio Pagli collection (Lari, Italy); ARC: Alessandro Raveggi collection (Florence, Italy); CBC: Cesare Bogi collection (Livorno, Italy); FSC: Franco Siragusa collection (Livorno, Italy); LRC: Luigi Romani collection (Lucca, Italy); SBC: Stefano Bartolini collection (Florence, Italy); MCZR: Zoological Museum Rome, Italy; shs: shells.

## DISCUSSION

*Alvania dalmatica* original description was based on the holotype, with no mention of the other shells' features (except size), so the morphological variability of the species cannot be properly assessed. It's however supposed to be very limited. Despite the low number of the examined topotypical shells, they match very well with the original description and show a great uniformity (Table 2, Figs. 1–8).

The greek shells share all diagnostic characters with topotypical *A. dalmatica*: paucispiral protoconch sculptured by spiral threads and smooth interspaces (Fig. 13); teleoconch with quite regular cancellate sculpture, axial microsculpture on the surface among spiral and axial ribs, outer lip inter-

nally lirate and thickened. While the protoconchs are very uniform in the two samples, the teleoconchs show a far greater variability previously unreported, both in size, sculpture and colour (Table 2, Figs. 1–8). Measured shells are fully developed adult (labial lirae and varix present) but their average size is lower than topotypical ones, although it varies considerably.

Shells outline is more or less slender (Figs. 5, 8), while the number of labial lirae is regularly lower, probably due to the smaller size. The genesis of the spiral chords follows the same pattern in both samples: two chords starting immediately after metamorphosis, later a third chord rising between them; finally in a few specimens a fourth and/or a fifth chord appearing. The teleoconch sculpture is highly variable due to the interaction between axial and spiral elements: from coarse and sparse (Figs. 2, 5, 7) to quite delicate and close-set (Fig. 6).

The number of spiral cords is on average lower compared to the Croatian shells but the appearance of the 3rd one is far more variable as well as well as the number of axial ribs. Consequently the spiral cords above the aperture numbering from 2 (Fig. 2) to 4 (Fig. 4) or 5 (Fig. 6), most commonly 3 with an incipient subsutural chord (Fig. 3). The intersec-

	<i>Alvania dalmatica</i> Croatia (4 shs)	<i>Alvania dalmatica</i> Greece (70 shs)
<b>Total height</b>	3.2–3.5 mm	2.3–3.1 mm (average 2.7 mm)
<b>Teleoconch whorls</b>	3.7–4	3.1–4 (average 3.5)
<b>Number of axial ribs on the last whorl</b>	16–17	13–22 (average 17.5)
<b>3rd spiral cord appearance (whorl)</b>	1.5–1.7	1.3–2.7 (average 1.9)
<b>Spiral cords on the last whorl</b>	8–9	5–9 (average 6.7)
<b>Spiral cords above the aperture</b>	4	2–5 (average 3)
<b>Number of lirae in the outer lip</b>	9–11	7–8
<b>Protoconch diameter</b>	400–410 µm	380–410 µm (average 400 µm)
<b>Nucleus diameter</b>	130–140 µm	130–140 µm
<b>Protoconch whorls</b>	1.4–1.5	1.3–1.5 (average 1.5)
<b>Protoconch spiral threads</b>	6–7	6–7

Table 2. Shell morphological features of *Alvania dalmatica*.

tions are generally nodulous, but varying from weak and barely raised (Fig. 6) to strong and somewhat spinous (Figs. 2, 7). The cancellation from squarish (Figs. 2, 3) to clearly rectangular (Figs. 7, 8). The size and sculpture features appear substantially continuous. The colour also is not constant: generally it is uniform whitish to caramel (Figs. 3, 4), some specimens are brownish (Fig. 8), others have two faint subsutural and columellar hazelnut bands (Fig. 7), or spiral cords more marked than background colour (Fig. 5).

Up to now *A. dalmatica* range was restricted to south-central Adriatic Sea, with the present note it is extended 400 km southward into Ionian Sea. This suggests a wider distribution probably overlooked due to the confusion with other *Alvania* species. Concerning the habitat, *A. dalmatica* was reported in exclusive association with *Corallium rubrum* and with a restricted bathymetrical range (60–90 m), here it is extended to 40 m depth and coralligenous bottoms. Surprisingly no *A. dalmatica* shells were found in Lastovo Is., the type locality of the species. The depth 40 m is shallower than that reported for the type material but coincide with that of *A. dalmatica* from Corfu.

A large population of *A. hallgassi* was found sympatrically with *A. dalmatica* in Corfu. The shells fit with the original diagnosis in some respects: paucispiral protoconch (Fig. 14); general outline; quite delicate, reticulate sculpture with axial ribs ranging from 20 to 40 (most commonly around 30) and 8–10 spiral cords on the body whorl; outer lip relatively thin with a faint external varix. Yet some features disagree: the total height is on average greater, spanning from 2.4 mm to 3 mm; the protoconch size and sculpture are substantially identical to *A. dalmatica* with spiral threads all beginning from the nucleus, not only the first and last ones as stated in the original description; the outer lip (in fully developed shells, about 15% of the samples) has inner denticles (lirae) yet weaker than *A. dalmatica*. The teleoconch sculpture is also quite variable and in some shells is rather coarse (Figs. 9, 10). The genesis of the spiral chords is very similar to *A. dalmatica* but fourth and/or a fifth chords are present in most shells (Figs. 9, 11).

The colour in most cases shows typical pattern: two brown bands (a sutural and a basal) on a yellowish background, but several shells are uni-

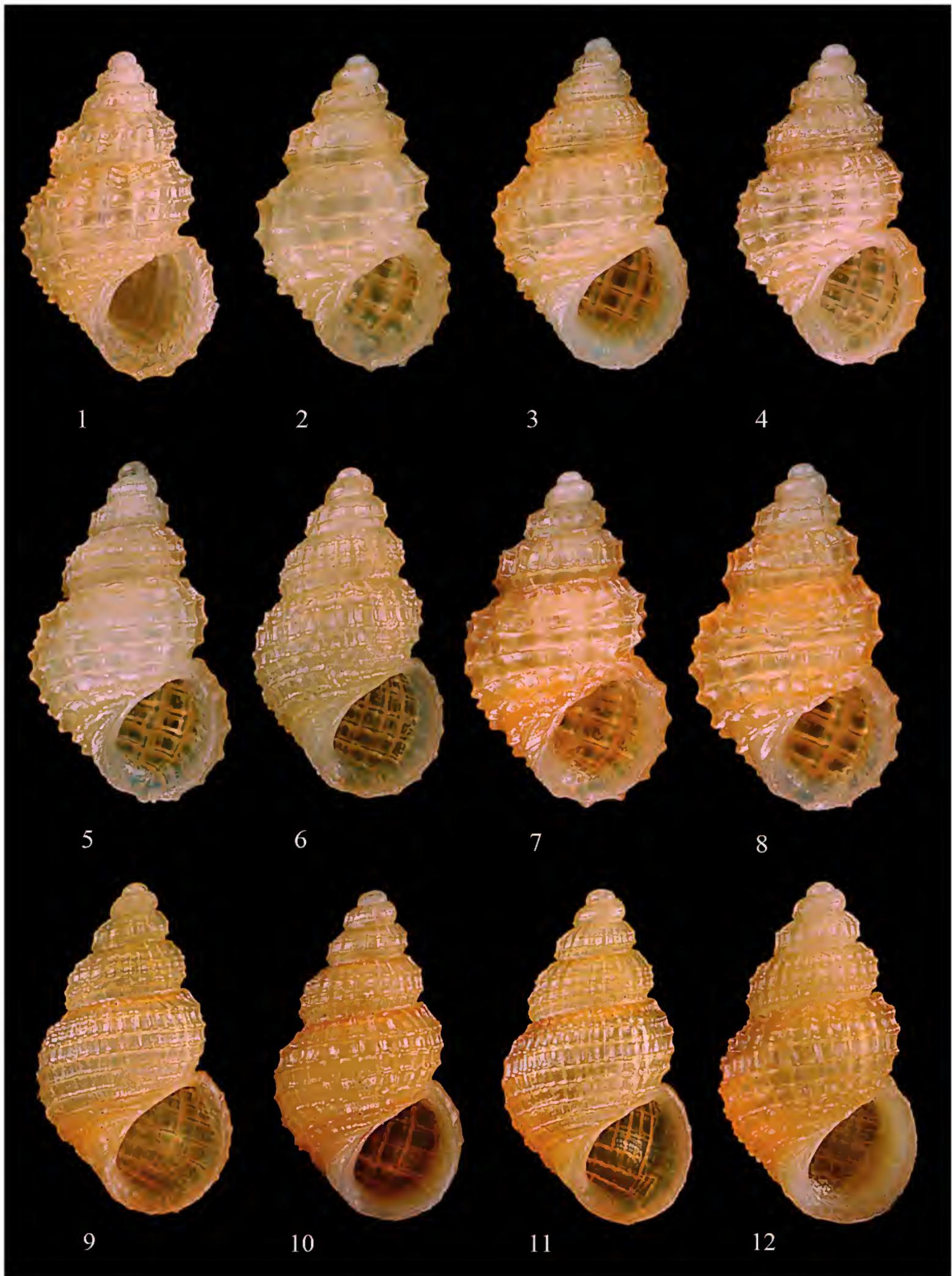
formly whitish-yellowish sometimes with spiral cords darker.

To better place these characters in a more general context, *A. hallgassi* shells from various southern Italy localities were examined: The holotype is a slightly worn shell with a pebble occluding the aperture, so it is not very useful in order to examine these features. But in two large samples very near the type locality about 20% of fully developed shells are lirate (50 shs from Punta Facì, 36 m, and 40 shs from Torre del Serpe, 25 m, both south of Otranto, Lecce, Italy, Macrì pers. com.). *Alvania hallgassi* from Naples have typical size (maximum 2.2 mm) colour pattern, shell sculpture, but the protoconch is identical to *A. dalmatica* and a small percentage of shells exhibit weak denticles in the aperture. Also *A. hallgassi* from Sicily share the same protoconch and denticulation features (the size of the sample is small, yet two specimens are weakly lirate). It seems, therefore, that a protoconch wholly marked by spiral threads beginning from the nucleus and the presence of labial lirae in a small percentage of adult shells are typical of the species.

## CONCLUSION

Concluding, *A. hallgassi* and *A. dalmatica* share some key diagnostic features (protoconch size/sculpture and inner lip denticulation). On the other hand, examining large samples, several specimens of *A. hallgassi* and *A. dalmatica* come close in terms of sculpture and colour in an apparent continuous spectrum, so being difficult to attribute them with certainty to each species (Figs. 6, 12); these latter features indeed are so variable in each individual that it's difficult to use them for diagnostic purposes. Also some *A. hallgassi* shells from Lastovo Is., with particularly coarse sculpture, overlap with delicate-sculptured *A. dalmatica*.

*A. daniensis* has a papillose protoconch surface, no labial denticles and seems to have more uniform shell sculpture, but Micali & Siragusa (2013) attributed to *A. daniensis* a population from N Adriatic Sea with a very coarse teleoconch sculpture, largely different from the typical pattern of the species. So, in this context, extensive investigations involving also molecular tools, are desirable to better understanding the boundaries within *A. hallgassi-daniensis-dalmatica* complex of species.



Figures 1–12. *Alvania* spp. Fig. 1. *A. dalmatica*, Lastovo is., Croatia, 3.3 mm; Figs. 2–8. *A. dalmatica*, Corfu, Greece, 2.6 mm (2), 3.2 mm (3), 3 mm (4), 3 mm (5), 2.8 mm (6), 2.7 mm (7), 2.9 mm (8). Figs. 9–10. *A. hallgassi*, Corfu, Greece, 2.8 mm (9), 3 mm (10). Fig. 11. *A. hallgassi*, Lastovo is., Croatia, 2.9 mm. Fig. 12. *A. hallgassi-dalmatica*, Corfu, Greece, 2.8 mm.

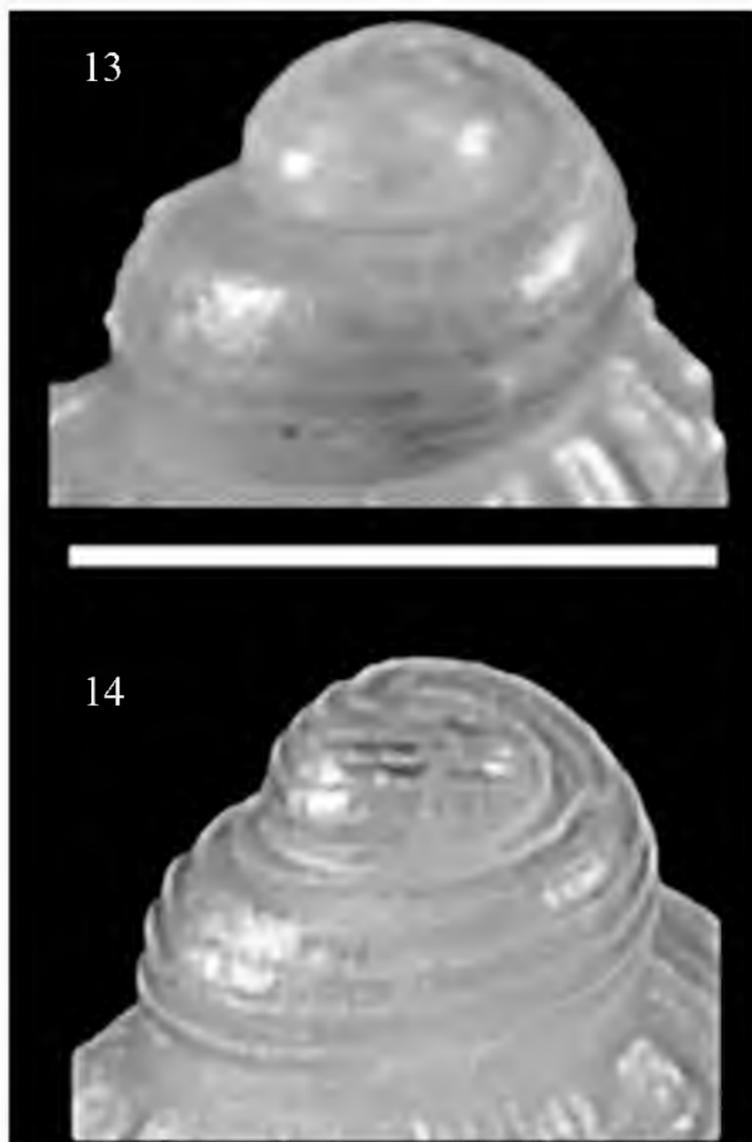


Figure 13. Protoconch of *A. dalmatica*.  
Figure 14. Protoconch of *A. hallgassi*.

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## Mediterranean Umbraculida Odhner, 1939 (Gastropoda Opisthobranchia): diagnostic tools and new records

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### ABSTRACT

Some diagnostic tools are given to distinguish juvenile shells of the Mediterranean Umbraculida Odhner, 1939 species (Gastropoda Opisthobranchia) and some new records of rare species are added.

### KEY WORDS

juveniles; Mediterranean Sea; new findings; protoconch; Umbraculida.

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### INTRODUCTION

The Umbraculida is a small order of opisthobranchiate molluscs represented in the Mediterranean Sea by 4 species and 2 families: Umbraculidae Dall, 1889 comprising *Spiricella unguiculus* Rang, 1828 and *Umbraculum umbraculum* (Lightfoot, 1786) and Tylo-dinidae Gray, 1847 with *Tylodina perversa* (Gmelin, 1791) and *Anidolyta duebenii* (Lovén, 1846).

*Tylodinella trinchessii* Mazzarelli, 1897 is an obscure entity put in synonymy with *T. perversa* but still poorly understood (Waren & Di Paco, 1996; Gofas, 2013).

All species share an uncoiled patelliform or shield-like shells. Aside from anatomical differences adult specimens can be easily identified by shell features (Vayssière, 1885; Pruvot-Fol, 1954; Warén & Di Paco, 1996; Valdés & Lozouet, 2000; Cachia et al., 2001; Da Silva & Landau, 2007) (Table 1, 2 and Figs. 1-9). Juvenile shells (except *S. unguiculus*) instead are not easily distinguishable from each other. Here are provide some information on the protoconch and early teleoconch morphology to set some characters useful for specific determination.

### MATERIAL AND METHODS

EXAMINED MATERIAL. *Umbraculum umbraculum*: 7 shs, 0.7 mm to 4 mm, Larnaca (Cyprus), 45 m, in ARC; 3 shs, 2.2 mm to 4.7 mm Corfu (Greece), 40 m, in SBC; 2 shs, 35-65 mm, Isola delle Femmine (Palermo, Italy), 30 m, SBC; 1 sh, 51 mm, Gorgona is. (Livorno, Italy), 70/80 m, in ECC; 1 sh, 11.7 mm, Palinuro (Salerno, Italy) 30 m, in CSC; 1 sh, 11.5 mm, Acitrezza (Catania, Italy) 40 m, in CBC.

*Spiricella unguiculus*. 1 sh, 3.6 mm, Salina (Messina, Italy), 35 m, in PPC; 1 sh, 2.7 mm, Palinuro (Salerno, Italy), 35 m, in SBC; Castelsardo (Sassari, Italy), 50 m, 2.6 mm, in CBC; 1 sh, 2.2 mm, Tarifa (Spain), 27 m, in CSC.

*Tylodina perversa*. 16 shs, Palinuro (Salerno, Italy), 35 m, in SBC and CSC; 2 shs, Protaras (Cyprus), 35 m, in SBC; 2 shs, Campomarino (Taranto, Italy), in SBC; 1 sh, Krk is. (Croatia), in SBC; 22 shs, Elba is. (Livorno, Italy), in SBC; 1 sh, Capraia is. (Livorno, Italy), 260 m, in SBC; Gorgona is. (Livorno, Italy), 150 m, in CSC; 1 sh, Capraia is. (Livorno, Italy), 150 m, in CSC; 1sh, Almeria (Spain), 110 m, in APC; 2 shs, Capraia is.

(Livorno, Italy), 180 m, in APC. Shs ranging from 1.5 mm to 25 mm.

*Anidolyta duebenii*. 3 shs, 5 mm, 3.2 mm and 3.1 mm, Almeria (Spain), 110 m, in APC and SBC; 1 sh, 3.3 mm, Scoglio Vervecce (Naples, Italy), 51 m, in APC; 1 sh, 8.3 mm, Capraia is. (Livorno, Italy), 300 m, in CSC; 2 shs, 1.3 mm and 3.2 mm, Pianosa is. (Livorno, Italy), 400 m, in RRC.

ABBREVIATIONS AND ACRONYMS. APC: Attilio Pagli collection (Lari, Italy). ARC: Alessandro Raveggi collection (Florence, Italy). CBC: Cesare Bogi collection (Livorno, Italy). CSC: Carlo Sbrana collection (Livorno, Italy). ECC: Enzo Campani collection (Livorno, Italy). PPC: Paolo Paolini collection (Livorno, Italy). RRC: Romualdo Rocchini collection (Pistoia, Italy). SBC: Stefano Bartolini collection (Florence, Italy). sh(s): shell(s)

## DISCUSSION

*Umbraculum umbraculum* juveniles (Figs. 10–13) can be easily recognized by the protoconch size, by far the largest of the considered species. It is quite variable in size ranging from 630  $\mu\text{m}$  to 710  $\mu\text{m}$  (average 670  $\mu\text{m}$ ) in maximum diameter, composed by 1.3–1.5 whorls, globose (nucleus not prominent), quickly expanding, glossy, thin and semitransparent, colour light brown. A shallow depression is present beyond the protoconch-teleoconch border. Shell up

to 3–4 mm, more elevated, somehow capuliform, quite thin, of the same color of the protoconch, then increasingly flat, greyish and thicker.

*Spiricella unguiculus* juveniles are unmistakable, having basically the same silhouette of adult shells with the protoconch arranged in the horizontal plane, adherent to the surface of the teleoconch.

*Tyrodina perversa* juveniles (Figs. 14, 16, 19) are similar in outline to *U. umbraculum* but the protoconch is smaller, ranging from 360  $\mu\text{m}$  to 400  $\mu\text{m}$  (average 370  $\mu\text{m}$ ) in maximum diameter. It is composed by 0.9–1.1 whorls, globose (nucleus not prominent), not quickly expanding. It is quite protruding, glossy, thick, not transparent, white or yellowish uniform in colour. Teleoconch is thickened in apical region becoming thinner toward the margin, its profile is very variable, from extremely flat to rather conical. Colour varies from white to brownish. The muscle scar marks are obvious and often make internal surface quite uneven.

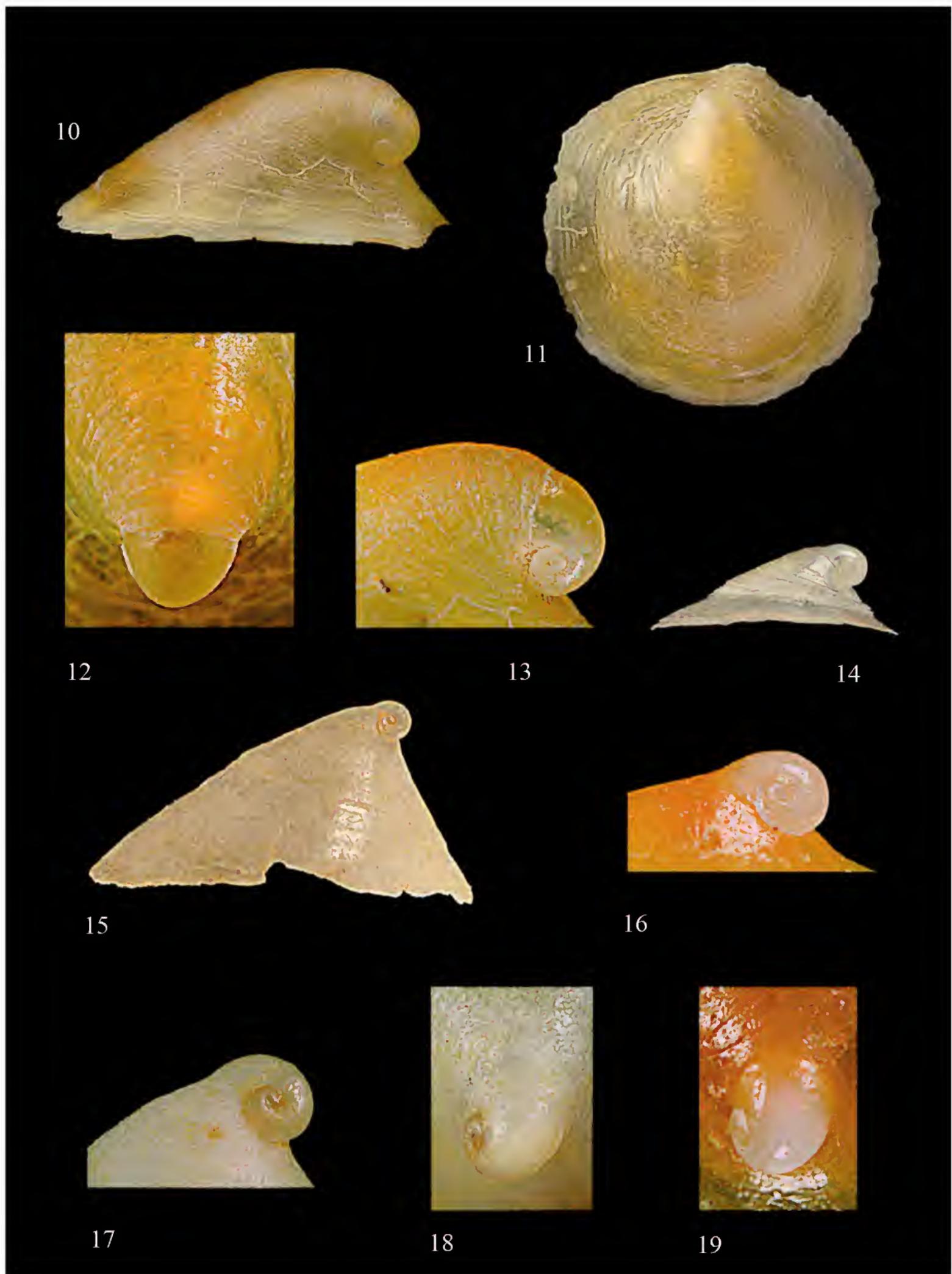
*Anidolyta duebenii* juveniles (Figs. 15, 17, 18) have a protoconch ranging from 350  $\mu\text{m}$  to 400  $\mu\text{m}$  (average 370  $\mu\text{m}$ ) in maximum diameter composed by 0.9–1.1 whorls, substantially comparable to *T. perversa* in size and form, but some slight differences can be detected: the nucleus is tinged while the remaining of the protoconch and teleoconch are white, the protoconch whorl increases less than *T. perversa* so the apex has apparently a more prominent aspect, with a clear “neck” on the protoconch-

Shell features	<i>Umbraculum umbraculum</i>	<i>Spiricella unguiculus</i>	<i>Tyrodina perversa</i>	<i>Anidolyta duebenii</i>
Size (average)	50-70 mm	4-7 mm	15-20 mm	8-10 mm
Outline	oval	subrectangular	oval	oval
profile	depressed	depressed, arched	Conical to depressed	regularly conical
apex	pointed, slightly excentric	flat, strongly excentric	pointed, slightly excentric	pointed, slightly excentric
surface	dull, with only concentric growth lines	Quite glossy, with only concentric growth lines	glossy, with only concentric growth lines	glossy, with only concentric growth lines
colour	grey-yellowish	grey-yellowish	whitish-yellowish	white
Periostracum	Thick, felt-like, dark brown	Thin, transparent	Thick, membranaceous, purple-reddish, often banded	thin, transparent
Muscle scar	Circular, discontinuous, many strong scars	horseshoe-shaped	Circular, complete, quite strong, with sinus	Circular, complete, very faint, no sinus

Table 1. Shell features of the Mediterranean Umbraculida (adult shells).



Figures 1–3. *Umbraculum umbraculum*, Isola delle Femmine, Palermo, Italy, 65 mm (Figs. 1, 2), 35 mm (Fig. 3). Figs. 4–6. *Tyrodina perversa*, Krk is., Croatia, 25 mm. Figs. 7–8. *Anidolyta duebenii*, Capraia is., Livorno, Italy, 8.3 mm. Fig. 9. *Spiricella unguiculus*, Castelsardo, Sassari, Italy, 2.6 mm.



Figures 10–13. *Umbraculum umbraculum* juvenes, Corfu, Greece, 4 mm. Figures 14, 16, 19. *Tylodina perversa* juvenes, Elba island, Italy, 1.8 mm (Fig. 14), 3.6 mm (Figs. 16, 19). Figures 15, 17, 18. *Anidolyta duebenii* juvenes, Almeria, Spain, 3.2 mm.

teleoconch border. The teleoconch is more elevated, regularly conical, uniformly thin. The muscle scar forms a complete circle, it is very weak and almost invisible.

*Umbraculum umbraculum* and *T. perversa* young shells could be mistaken but protoconch size is resolute, also muscle scar sinus is important, already visible in few mm specimens. *T. perversa* and *A. duebenii* are obviously the most difficult species to separate having the protoconch of the same size but the colour of the nucleus and prominence could be useful tools to distinguish them. Moreover shell profile, thickness and muscle scars help distinguishing also very small shells. *Anidolyta duebenii* records are deeper than 100 m (the Naples record is unusually shallow) but bathymetry is misleading in order to separate it from *T. perversa*, as dead specimens of the latter can be found at depths greater than 250–300 m. Most *A. duebenii* records examined in collections are actually *T. perversa* originating from deep water.

*Spiricella unguiculus* is a very rare species, with a lusitanian distribution, recorded in literature for few scattered shells. Its biology and ecology are virtually unknown as no living specimens have been found so far. Its systematic position in Umbraculidae is doubtful judging by shell characters and only tentative lacking anatomical and molecular data (Tringali, 1990; Da Silva & Landau, 2007 and references therein; Cossignani & Ardochini, 2011). With the present note its range is extended to northern Sicily and southern Spain.

1. Protoconch larger than 600 $\mu\text{m}$ .....	..... <i>Umbraculum umbraculum</i>
- Protoconch smaller than 600 $\mu\text{m}$ .....	.....2
2. Protoconch smaller than 350 $\mu\text{m}$ , recumbent	..... <i>Spiricella unguiculus</i>
- Protoconch larger than 350 $\mu\text{m}$ , raised.....	.....3
3. Protoconch color uniform, less prominent.....	..... <i>Tyrodina perversa</i>
- Protoconch nucleus tinged, more prominent.....	..... <i>Anidolyta duebenii</i>

Table 2. Key of the Mediterranean Umbraculida based on the protoconch features.

*Anidolyta duebenii* is an uncommon species living in deepwaters, spanning from Norwegian Sea to Lusitanian seamounts and Mediterranean Sea (Warén & Di Paco, 1996; Beck et al., 2006). The few mediterranean records are from Spain and Corsica (Warén & Di Paco, 1996; Peñas et al., 2006; Peñas et al., 2008). It's now reported from Gulf of Naples and confirmed from Northern Tyrrhenian Sea.

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## New records of Ceratocanthinae (Coleoptera Scarabaeoidea Hybosoridae) from Arunachal Pradesh (India) with description of a new species of *Pterorthochaetes* Gestro, 1898

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### ABSTRACT

In order to publish data to be included in the forthcoming new edition of the Catalogue of Palaearctic Coleoptera, *Madrasostes feae* (Gestro, 1898) and *Pterorthochaetes dembickyi* n. sp. (Coleoptera Scarabaeoidea Hybosoridae Ceratocanthinae) are recorded from Arunachal Pradesh (India).

### KEY WORDS

Palaearctic region; *Pterorthochaetes*; *Madrasostes*; new species.

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### INTRODUCTION

After the publication of new data on Palaearctic Ceratocanthinae (Coleoptera, Scarabaeoidea, Hybosoridae) (Ballerio, 2014) to be included in the forthcoming second edition of the Catalogue of Palaearctic Coleoptera by Löbl and Smetana, some new data on Ceratocanthinae from Arunachal Pradesh (an Indian region belonging to the Palaearctic region) were obtained by examining unidentified material kept in ZFMK collection. The purpose of this note is therefore to describe a new species of *Pterorthochaetes* Gestro, 1898 and to provide new faunistic data on *Madrasostes feae* (Gestro, 1898) based on the aforementioned new Indian material.

Poggi (2010) demonstrated that the correct date of publication of the names contained in Gestro's revision of Asian Ceratocanthinae (which includes also *Pterorthochaetes* and *M. feae*) is 1898 and not 1899, as previously reported.

### MATERIAL AND METHODS

I refer to Ballerio (2013) 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; L: length; PL: maximum pronotal length at middle; PW: maximum pronotal width at middle; W: width; ZFMK: Zoologische Forschungsmuseum Alexander Koenig collection, Bonn, Germany.

### RESULTS

*Madrasostes feae* (Gestro, 1898) (Fig. 1)

EXAMINED MATERIAL. 1 male and 1 female (ZFMK): NE India, Assam-Arunachal border, Bhalukpong, 150 m, 27°00'48"N 92°39'08"E, L. Dembický leg., 1–8.V.2012.

REMARKS. First record for Arunachal Pradesh. *Madrasostes feae* was previously known from Nepal, NE India (Uttarakhand, Meghalaya and Sikkim), Myanmar, Thailand and Kampuchea (Ballerio, 2014).

***Pterorthochaetes dembickyi* n. sp.**

EXAMINED MATERIAL. Holotypus, male, in coll. ZFMK: NE India, Arunachal Pr., Etalin vicinity, 700 m, 28°36'56"N 95°53'21"E, L. Dembický leg., 12–25.V.2012. Allotypus in ZFMK, same data as holotypus.

DESCRIPTION OF HOLOTYPE (Figs. 3–6). HL: 0.9 mm; HW: 1.8 mm; PL: 1.6 mm; PW: 2.9 mm; EL: 3.3 mm; EW: 2.9 mm. Large sized *Pterorthochaetes*, surface shiny, setose; volant. Dorsum black, setation yellowish-brown, sternum reddish-brown, antennae and tarsi reddish-brown. Head: subpentagonal, wider than long, fore margin finely serrated, tip acute, interocular distance about 10 times the maximum width of dorsal ocular area, dorsal ocular area large, dorsal sculpturing of head distally made of very coarse and deep transverse wrinkles and proximally of impressed small dense mixed comma-shaped and horseshoe-shaped punctures centrifugally oriented, each one having a pore in the internal side, bearing an erect simple short seta.

Pronotum: wider than long (W/L ratio= 1.8), fore angles normally shaped, pronotal lateral margins fringed with a row of short simple setae, spaced out by an interval about their length or longer, disc of pronotum covered by dense impressed ocellate transverse small punctures larger at sides of disc and becoming horseshoe-shaped large punctures, with opening outwards, towards pronotal base and sides, each puncture with a pore in the middle bearing a gently clavate medium sized erect seta; punctation relatively dense, the distance between punctures being subequal to their diameter on disc and inferior to their diameter at sides.

Scutellum: punctures transversely horseshoe-shaped, sparse, thick and coarse. Elytra: shape oval, longer than wide (W/L ratio= 0.8); elytral surface covered by dense punctation, made of medium sized impressed horseshoe-shaped punctures with opening directed outwards, horseshoe branches short, punctures spaced out by an interval larger than their diameter, horseshoe-shaped punctures

mixed with a few simple shallow small punctures irregularly distributed. Each horseshoe-shaped puncture containing a pore bearing a gently clavate long erect seta.

Male genitalia: spiculum gastrale as in figure 11, parameres asymmetrical, as in figures 7–9, internal sac with an elongate narrow sclerite, as in figure 10.

VARIABILITY. Allotypus: overall morphology as in the description of holotypus. Sexual dimorphism as in all other *Pterorthochaetes*. Bursal sclerites slightly asymmetrical, with a dorsal sharp projection and shaped as in figure 12.

COMPARATIVE NOTES. *Pterorthochaetes dembickyi* n. sp. is mainly characterized by the shape of bursal sclerites, shape of parameres and of the sclerites of internal sac of aedeagus, which isolate the new species from all other known *Pterorthochaetes*. As regards outer morphology, the size, the setation of pronotal margins and the punctation pattern of elytra and pronotum allow us to place this new species near *P. septemtrionalis* Ballerio, 1999 and *P. yunnanensis* Ballerio, 2014.

The new species can be easily distinguished from *P. septemtrionalis* because the latter has much denser and larger elytral punctation, elytral horseshoe-shaped punctures have branches longer and the opening is directed mainly backwards (and not outwards as in the new species), while differences from *P. yunnanensis* are subtler, consisting in the shape and density of simple elytral punctures: in *P. yunnanensis* they are much more impressed and denser than in *P. dembickyi* n. sp., also horseshoe-shaped punctures are slightly denser and larger in *P. yunnanensis*. The strong differences in the shape of bursal sclerites and, for *P. septemtrionalis* and *P. dembickyi* n. sp., in the shape of parameres and of sclerites of internal sac of aedeagus (in *P. yunnanensis* the male is unknown) do not allow any confusion between the new species and *P. septemtrionalis* and *P. yunnanensis*.

ETYMOLOGY. Noun in the genitive case. Dedicated to Luboš Dembický, who collected the type series.

DISTRIBUTION AND HABITAT. Known only from the type locality in NE India (Fig. 2). The type series was collected under the bark of dead trees (L. Dembický, pers. comm.), in a montane broadleaf



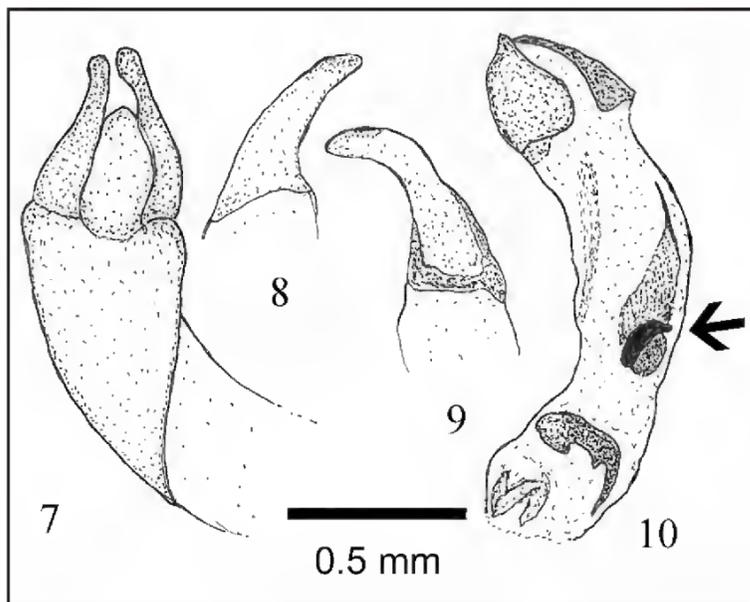
Figure 1. *Madrasostes feae*, specimen from Bhalukpong, habitus in dorsal view.



Figure 2. *Pterorthochaetes dembickyi* n. sp., type locality (photo by L. Dembický, 2012).



Figures 3–6. *Pterorthochaetes dembickyi* n. sp., holotypus. Fig. 3: extended, dorsal view. Fig. 4: enrolled, ventral view. Fig. 5: enrolled, dorsal view. Fig. 6: enrolled, lateral view.



Figures 7–10. *Pterorthochaetes dembickyi* n. sp., holotypus, parameres. Fig. 7. Dorsal view, Fig. 8. Lateral view. Fig. 9. Lateral view. Fig. 10. Internal sac (arrow indicates the elongate sclerite).

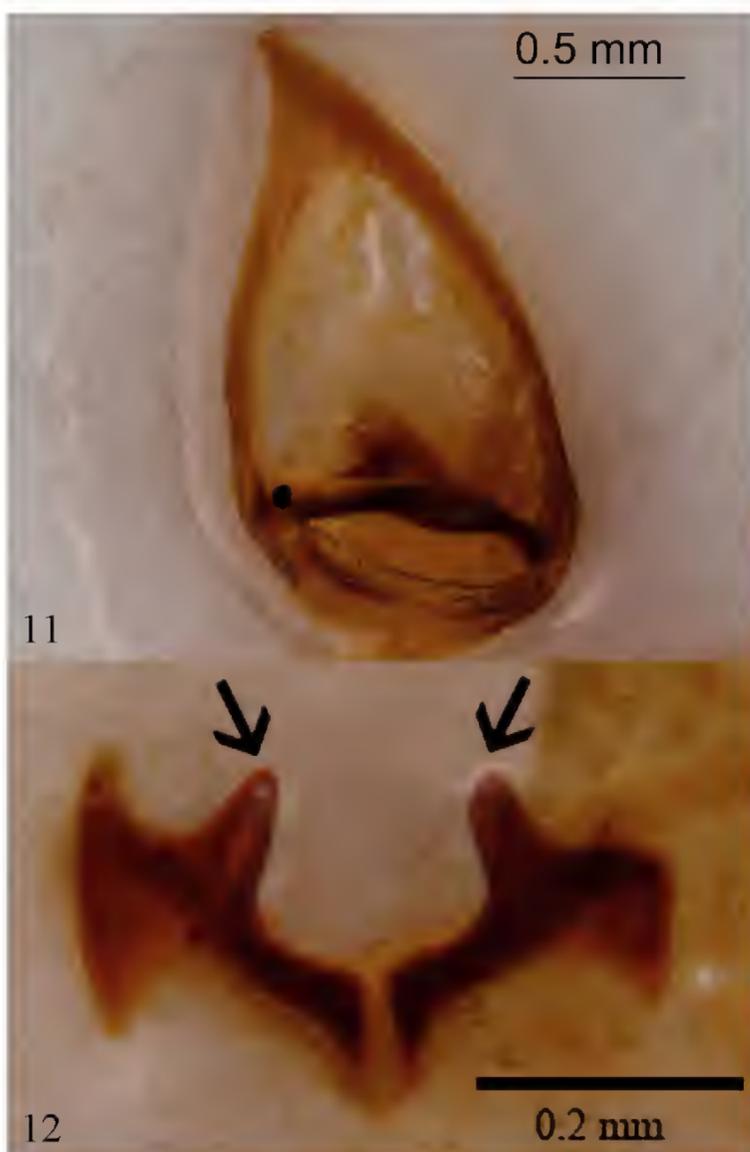


Figure 11. *Pterorthochaetes dembickyi* n. sp., spiculum gastrale of holotypus. Figure 12. *Pterorthochaetes dembickyi* n. sp., bursal sclerites of allotypus (arrows indicate the dorsal sharp projection).

forest near Etalin (Mishmi Hills), an area belonging to the Eastern Himalayan broadleaf forests ecoregion (Wikramanayake et al., 2002).

REMARKS. I examined other four females of *Pterorthochaetes* (ZMFK) from the type locality, which have bursal sclerites somewhat similar to the ones of *P. dembickyi* n. sp., although with dorsal projections stronger, blunter and longer. The outer morphology is quite different, the length is shorter (about 1 mm shorter), elytral horseshoe-shaped punctures are larger and pronotum has larger horseshoe-shaped punctures at the sides, with opening wider, and a few wrinkles near fore angles. Based on what we know about intraspecific morphological variation in the genus *Pterorthochaetes*, it is more likely that those females represent a distinct new species rather than an extreme variation of *P. dembickyi* n. sp. Because of this I excluded those females from the type series.

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## **Biological diversity of the National Park of El-Kala (Algeria), valorization and protection**

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### **ABSTRACT**

The National Park of El-Kala (PNEK, biosphere reserve) conceals a remarkable biological and cultural richness. The investigations carried out through its territory (1996-2010) made it possible to count 1590 vegetable species (distributed among spontaneous vascular and introduced plants, mushrooms, lichens, algae and phytoplankton) as well as 718 animal species. Several of these species, vegetable and animal, are protected in Algeria and belong to the red list of the I.U.C.N. (International Union for Conservation of Nature). The safeguarding and valorization of this richness require the installation of a management plan in adequacy with the International Conventions of biological diversity within the framework of the durable development, i.e. to protect and develop the natural wealth by involving residents of the park. The aim of this paper is to present a detailed study of the flora and fauna of the entire ecosystem of the PNEK. We insist on the considerable importance that flora and fauna bring to the socio-economic life of the area and to its inhabitants.

### **KEY WORDS**

durable development; National Park El-Kala; natural diversity; safeguarding; valorization.

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### **INTRODUCTION**

This work is an outline of a study entitled “Durable development in the protected area of Algeria, the case of the National Park of El-Kala (PNEK) and the bordering areas of important ecological interest”. The principal thing before any intervention of valorization or protection of the natural resources is to make a full inventory and analysis on the biological diversity of the PNEK.

On the basis of prospection on the ground and examination of several works and papers realized in the area (Aouadi, 1989; Debelair, 1990; Miri, 1996; Samraoui & de Bélair, 1997; Kadid, 1999;

Rezzig, 1999; Boutabia, 2000; Benyacoube & Chabi, 2000; Sarri, 2002) and other various documents on flora of Algeria (Battandier & Trabut 1902; Maire 1952; Quezel & Santa, 1962), we tried to inventory and make an assessment on the natural richness of the PNEK, as well as a collection of the various national and international legislative texts which can intervene for better management and protection of this protected surface.

The analysis of these data allowed us to make preliminary proposals, which concern the protection and the rational and durable use of this wealth with national and international interest, in order to ultimately pass to the phase of inquiries (Questionnar-

ies concerning the biodiversity and policy directives for the durable development).

**National Park of El-Kala**

Located at the extreme east of Algeria, the National Park of El-Kala extends on a surface of 76438 ha. It has some hills, not exceeding 600 m altitude and three lakes in North, West and East parts. The southernmost part is strewn with djebels which culminates with djebel El-Ghorra, 1202 m (Fig. 1).

The bioclimat is of the soft wet type with sub-wet heat, the annual temperatures minimal average reaches 9°C where as the annual maximum average is 30°C. The annual precipitations average ranges from 800 to 900 mm, often attaining a maximum of 1300 mm (Aouadi, 1989). According to Belouaham et al. (2009), the area’s humidity of El-Kala reaches 72.4% which is relatively significant due to the proximity of the littoral and the huge forests and the whole wetlands surface, which furrow the Park territory. Wind, usually frequent, move the dunes,

creating entirely bare spots. This is the case of the Lake Mellah outlet and te Messida beach.

The Park is characterized by two geological formations: the quaternary one, primarily represented by marine and river deposits, with the average Eocene corresponding to clays and sandstones of Numidia (mainly localized in the bottoms of valleys), and the Miocene corresponding to conglomerate sands and red clays principally localized in Southeast. The park’s grounds are those of the forest, brown washed with a variant of forest humus mull acid Moder. The National park of El-Kala was created in 1983 by decree n° 83-462 of July 23rd, 1983, classified as “Reserve of the biosphere”, by UNESCO, on December 17th, 1990.

The essential objective of the park is the protection and conservation of the floristic and faunal components as well as of both the natural environment and cultural-historical inheritance.

Relatively less marked by the impact of human activities, this park consists of a mosaic ecosystems which have great biological and ecological importance. Here we distinguish:

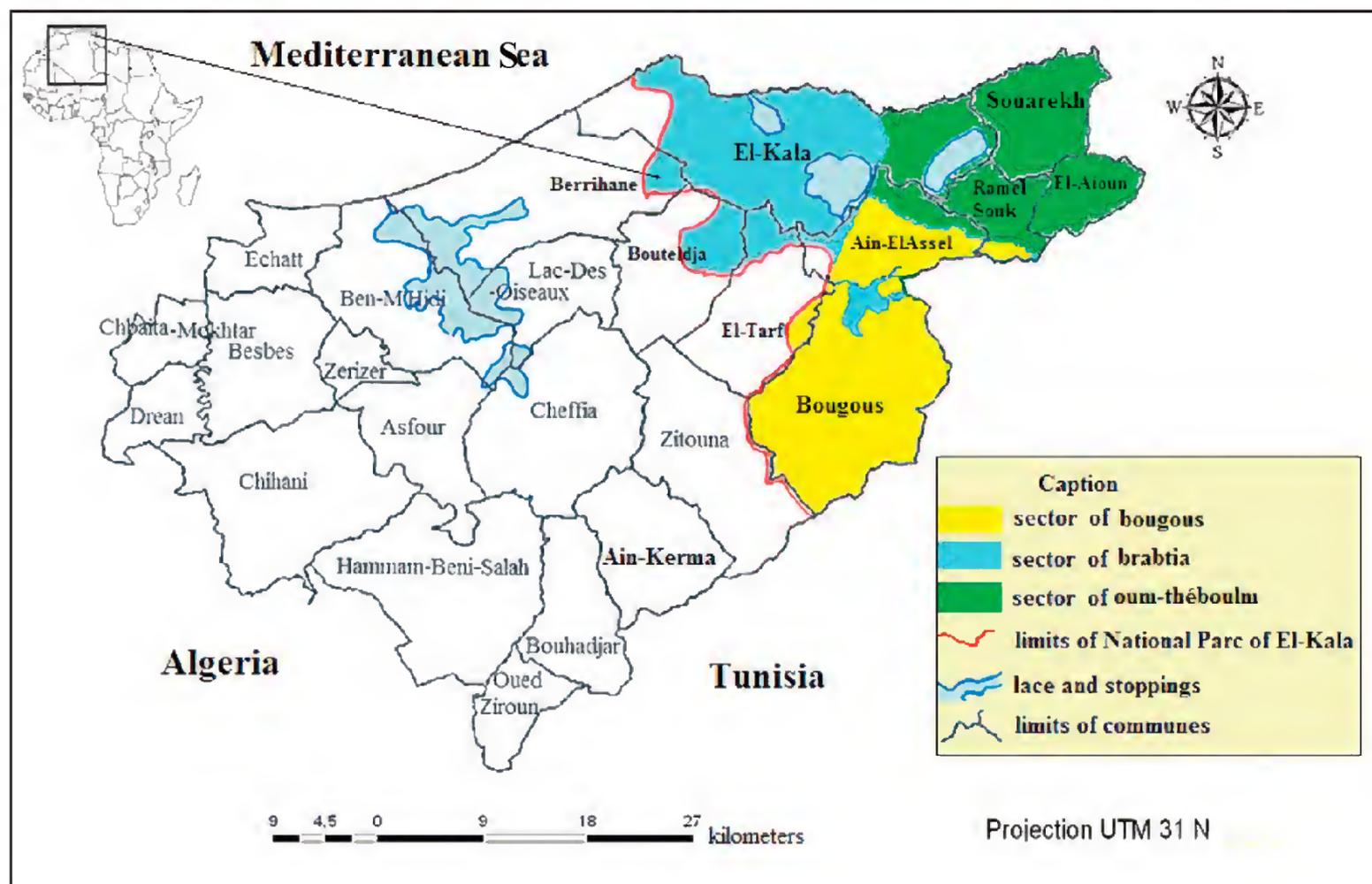


Figure 1. Study area: chart of the administrative limits of the wilaya of El-Tarf (Algeria) with the limits of the National Park of El-Kala.

- a marine ecosystem (length of 50 km), containing a particular flora and fauna (for example: red coral) not very disrupted (varied submarine habitats and absence of pollution).

- a dune ecosystem, consisting of a littoral dune cord still stable (20 to 120 m of altitude), the maquis of the kermes oak with some testifies of the floristic procession such as: *Quercus coccifera* L., *Juniperus phoenicea* L., *J. oxycedrus* L., *Pistacia lentiscus* L., *Retama monosperma* (L.) Boiss., *Ephedra fragilis* Desf., etc...

- a lake ecosystem, constituted by the low marshy plains and the lakes some of which are classified as "Ramsar Sites": lake Oubeira, (2200 ha), lake Tonga (2600 ha), lake Mellah (860 ha, the only lagoon in Algeria which communicates with the sea), Marais of Bourdim (11 ha), Blue lake (3 ha) and Black lake (6 ha).

These appreciated water tanks constitute a shelter of biological richness and are of great interest for the park habitats.

- As far as concerns the forest ecosystem, populating the mountainous zone, of average altitude, intersected by interior depressions and dominated by important relieves, the oak cork represents the climactic forest on siliceous ground. It is replaced in altitude (700 m) by the Zeen oak (*Quercus faginea* Lam.).

The National Park of El-Kala is one of the most prestigious protected zones of the Western Mediterranean. It is characterized by the presence of truly peculiar natural conditions which make it a place of uncommon biological richness. For this reason, it can be considered as one of the highest relictual places of the geological and biogeographical history of the Mediterranean area (Benyacoubé & Chabi, 2000).

## MATERIAL AND METHODS

This work is the result of a set of field and bibliographical investigations, including observation on the field made by us, along with the follow up of several actions, realized through the territory of the park, joined to the consultation of several papers (thesis, dissertation, reports, expertise, etc...) realized in the territory of the park and its nearby, as well as of all available data on the flora of Algeria and North Africa.

## RESULTS AND DISCUSSION

### *Floristic diversity of the National park of El-Kala*

The natural vegetation which we meet in different ecosystems of the National Park of El-Kala is represented by the cork oak which dominates with other tree species including Zeen oak, Kermes oak, Pine of Alep, glutinous Alder, Wilows, white Poplar, and other introduced species as *Eucalyptus*, the Acacias, the Maritime pine and the bald cypress. The floral diversity of the national park of El-Kala is represented by 1590 botanical species. This figure includes the spontaneous botanical species, mushrooms, algae, lichens, phytoplankton and the introduced or cultivated vegetable species (Tables 1, 2).

The vegetable kingdom is also rich and varied. The lower plants (Algae, Foams, mushrooms, Lichens) remain less studied. We count however more than 175 (Sarri, 2006) species of mushrooms including Truffles (560 for Algeria) and 117 species of Lichens (Boutabia, 2000). The Higher Vascular plants, more than 1050 species (3750 for the flora of Algeria), were better inventoried including 382 rare and 27 protected species.

The region of El-Kala is itself a "biological crossroads", in time (since it reflects the succession of the climates of Quaternary) and in space (it is characterized by habitats overlap and biogeographic interpenetrations). Species and their status are reported in the Tables 1, 2.

### *Biogeography of the vascular vegetable species listed in the PNEK*

Several authors (see for example: Paccalet, 1981; Ozenda, 1982; Guittonneau, 1982; Quezel, 1957, 1978, 1983, 1993; De Belair, 1995, 1996) were interested in the study of the biogeography (of plants and animals) considered by International Conventions one of the criteria of appreciation of biological diversity.

For example, Quezel (1978; 1983; 1993) reported that septentrional Africa (Mediterranean and Saharan) represents at the present time the part of this continent where biological and ecological diversity is most significant (Belouahem et al., 2009) (Figs. 3–6).

VEGETABLE SPECIES	STATUS OF SPECIES	N. of species by details	N. of species by groups
VASCULAR PLANTS	Species without status	674	1050 *
	Species appearing in the red list (IUCN)	20	
	Protected species	27	
	Spontaneous medicinal species	58	
	Useful spontaneous species	19	
	Endemic species - endemic of North Africa	80	
	Watery and cultivated species	85	
	Fodder species	87	
MUSHROOMS	Species without status	175	175
LICHENS	Species without status	65	117
	Protected species	52	
ALGAE	Species without status	70	70
THEPHYTOPLANKTON	Species without status	93	93
INTRODUCED SPECIES	Decorative introduced species	62	77
	Medicinal cultivated species	15	
SAILOR	Species being reported on appendices II and III of ASP Protocol (Convention of Barcelona)	08	08
	<b>TOTAL</b>	<b>1590</b>	<b>1590</b>

Table 1. Floristic diversity of the National Park of El-Kala, Algeria.

\*: 1050 for PNEK (3750 for Algeria) including 382 rare, 122 families (128 for Algeria) and 392 kinds (907 for Algeria)

In the present study we report several plants of different biogeographic origins (Fig. 2). In particular, the species of Mediterranean origin are most numerous (445 species which accounts for 42.38%) followed by 5.24% of species of tropical origin which shows the first origin of the site. The specific biological diversity observed within the National park of El-Kala (which belongs to Algerian Numidia) is related to the favorable ecological conditions which allow the preservation of these species.

In fact, in sub-littoral Numidia both the high temperatures in summer and the accentuate humidity, due to the dune barrier, combine together to create a real subtropical climate. On the other hand, wintry weather conditions (low T°C and high pluviometry) contribute to create a remarkable moderate climate (Belouahem et al., 2009).

NOTE. The presence of the two protected vascular plants *Euphorbia dendroies* L. and *Orchis provincialis* Balbis is uncertain;

- the truffle *Terfezia arenaria* (Moris) Trappe (1971), reported in the littoral dunes of the territory of the park, represents some sort of curiosity;

- the very few studies on the flora in this region make our study very difficult;

- the document on flora of Algeria should be updated as based on data by Quezel & Santa (1962-63);

- floristic list may change at any time due to the large area and its ecological characteristics.

#### ***Fauna diversity of the National park of El-Kala***

The most important groups of animals we observed in the National Park of El-Kala include

Subdivisions biogeographic	Numbers by geographical category	Percentage
Mediterranean species	445	42.38
Species of transitions	280	26.66
Scandinavian species	125	11.90
Endemic species	75	7.14
Cosmopolitan species	64	6.10
Tropical species	55	5.24
Species without indications	6	0.57

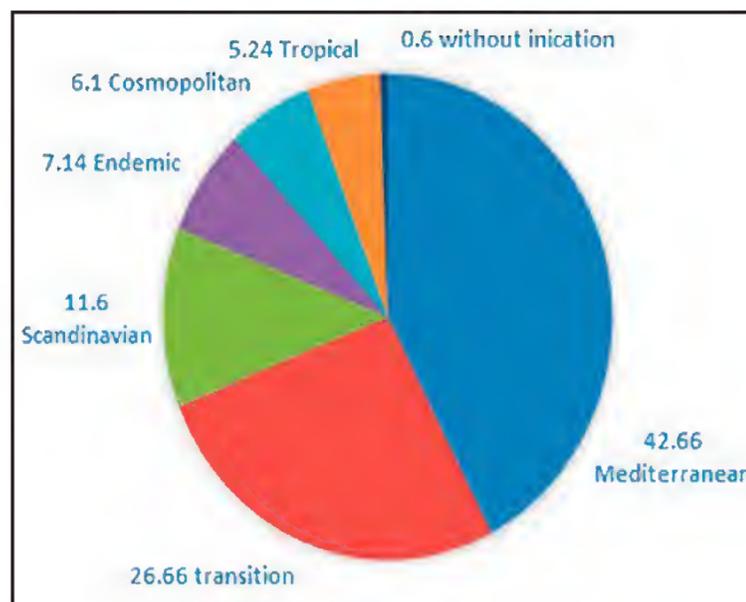


Table 2. Frequencies and number of species inventoried in the PNEK by biogeographic subdivisions.

Figure 2. Biogeographic spectrum of the National Park of El-Kala, Algeria (expressed in %).

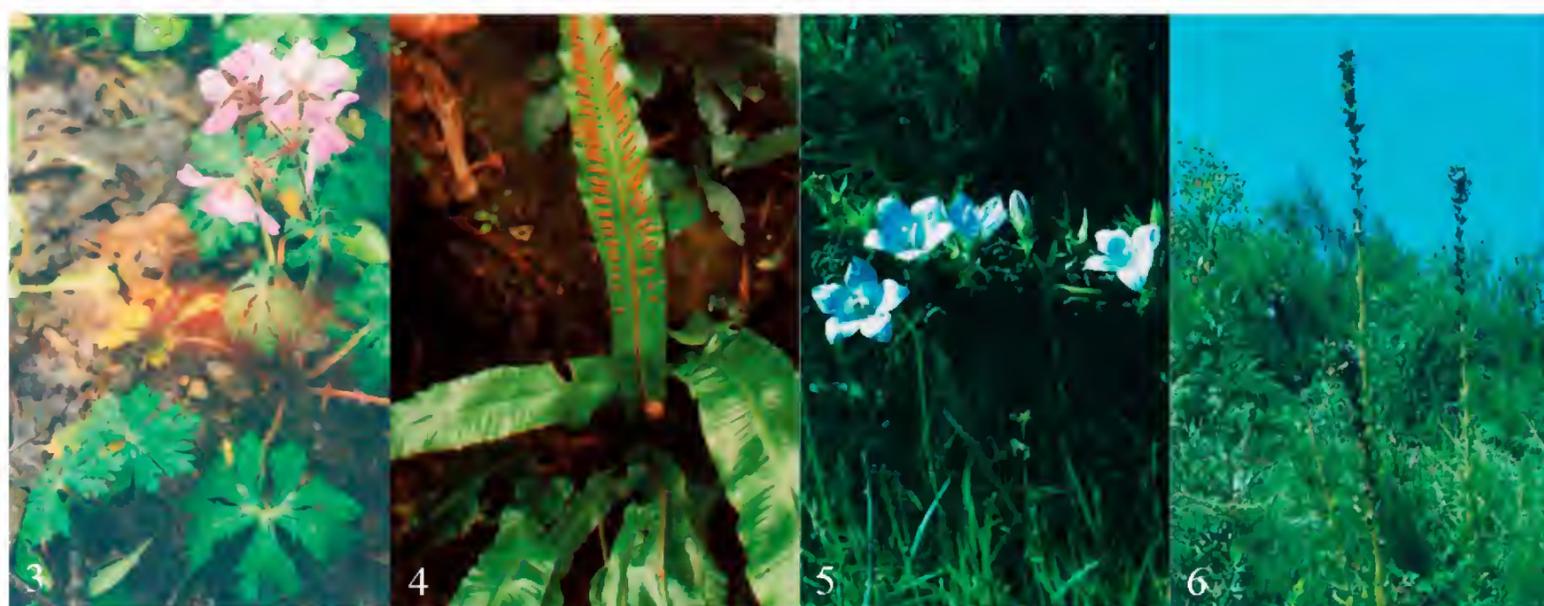


Figure 3. *Geranium atlanticum* B.R., endemic of N-Africa. Figure 4. *Scolopendrium vulgare* Sm., very rare species. Figures 5, 6. *Campanula alata* Desf., endemic of Algeria-Tunisia, Red List-IUCN.

mammals, insects, reptiles, Amphibians, birds and fish. We counted up to 706 animal species including the zooplankton (Table 3). The National Park of El-Kala is one of the last refuges for the stag endemic to Algeria and Tunisia. Forty years ago, there were more than 300 individuals. This number fell considerably because of the hunting and the forest fires. Currently, its number does not reach 30 individuals; maybe less. Several animal species are endemic to the region, others are more widely distributed, but they do not live any more in the area. The faunistic list can change at any moment seen the importance of the zone for its surface and ecology (Figs. 7–9).

### **Protection and valorization of the richness**

The years lived in the National Park of El-Kala, allowed us to gather information about the needs and the socio-economic activities of the inhabitants as well as a considerable knowledge on its natural and even cultural potential.

### **Rational and durable exploitation of the flora**

Several examples can be enumerate:

- the cork oak for its cork;
- heathers for the clothes industry of pipes and ornament;

- fruit trees of forest (Olive-tree, Cane-apple bush, Myrtle, Hawthorn...) for food purposes;
- the medicinal plants (Bay-tree sauce, Lavender, Myrtle...) have great potentials (they can be employed directly, i.e. roots, leaves, flowers, or by extraction of essential oils and/or substances to be used for pharmaceutical products);
- decorative plants (including ferns, and many Liliaceae;
- mushrooms (including truffles) for food purposes;
- olive oil and mastic tree oil.

All plants quoted above can become an important source of incomes for the residents (inhabitants of the park) and thereafter for the investors.

Within the framework of the valorization of the flora, we also record the various scientific works in phytochemistry done by national researchers, which one of the Authors participated to by collecting and identifying several samples: *Genista aspalathoides* Lamk ssp. *erinaceoides* (Lois.) Maire, *Genista ferox* Poirret, *Genista ulicina* Spach, *Genista tricuspidata* Desf., *Serratula cichoracea* (L.) DC., *Halimium halimifolium* (L.) Willk., *Matricaria chamomilla* L., etc...

The idea is to create small eco-exploitation

farms or eco-companies which cultivate, protect, exploit, and trade local products (at the finished or raw state) in a rational and long-lasting way through their own territory (in the short and medium term) and, in the future, towards abroad (in the long term).

#### *Rational and durable exploitation of fauna*

Among the animal species occurring within the Park, the least protected and valued are water birds, sea and freshwater fish (as the eel), mollusks (as the clam of the Melah lake) and the deer (*Cervus elaphus barbarus* Bennett, 1833). The extraction of the Coral requires some precautions because it is in permanent reduction. To avoid the disappearance of the stag from the National Park of El-Kala and even from the whole Algeria, a program was set up for breeding it in captivity and in a so-called "bilateral" semi-captivity, between the National Park and the hunting center of Zéralda, with the aim of ensuring its existence, perennality and releasing them periodically. Until 2002 it produced more than 50 individuals.

These results, which are very satisfactory and encouraging, let us think and suggest that, although it ensures a good protection of this animal, with a rigorous application of legislative texts and the mul-

ANIMAL SPECIES	NUMBER OF SPECIES	OTHER DETAILS	PROTECTED SPECIES
MAMMALS	43 (107 for Algeria in [6])	Terrestrial 39 Sailors 04	17
REPTILES ET AMPHIBIANS	24 (82 for Algeria)	Reptiles 19 Amphibians 05	03
INSECTS	215	All groups 215	13
BIRDS NICHOR AND MIGRATING	214 (402 for Algeria in [16])	water and forest birds 117 birds navy 12 Raptors 25	26 and 31 02 25
FISH	128	marine fish 104 fresh water fish 24	09
ZOOPLANKTON	94	Mollusques (clams) 55 Crustacées (crustaceans) 33 Brachinopodes (brachiopods) 03 Tuniciens (tunicates) 03	
TOTAL	718	718	126

Table 3. Faunal diversity of the National Park of El-Kala, Algeria.

tiplication of breeding programs, in a short time we could get to the point where we could see the meat of the stag for sale from the butcher. Meat which, in turn, would come from regular regulated and paying hunting tourism.

Or, still, one can quote another economic activity practised in the territory of the park representing a good source of job and currency, i.e., the harvesting of snails, which are generally sold at 200 DA for kilo to Tunisians.

#### *The legislative arsenal protecting national parks (protected areas)*

A collection of 133 legislative texts was carried out. This arsenal of texts reflects the importance of the national natural inheritance of the national park of El-Kala. These texts give a great support to the management of the whole protected area of the Country. In reality, these laws are constantly disregarded (are not met) and do not give any real indication neither to managers nor to administrations and residents.

## CONCLUSION

The originality of the National Park of El-Kala returns especially to its biological diversity. A floristic diversity of 1590 vegetable species including 1050 vascular seedlings (27 protected, 80 endemic and 20 species appearing in the red list (IUCN)), 175 mushrooms, 117 lichens (52 protected), 70 algae, 93 species of phytoplankton, 77 species of vascular introduced and cultivated plants as well as eight vegetable sailors species being reported on Appendix II and III of Protocol of the Convention of Barcelona.

The faunal diversity is marked by 718 animal species including 43 species of mammals (17 protected), 24 reptiles (3 protected) and Amphibians, 215 insects (13 protected), 214 species of birds (87 protected), 104 marine fish species (9 protected), 24 fresh water fish species and 92 species of zooplankton. To preserve this originality, the study recommends creating small Eco-exploitations farms or eco-companies, which exploit and at the same time protect this floristic and faunistic richness. One should not forget that the flora and fauna not only represent an important source of incomes for the in-



Figure 7. Delicious Lactaire; possibility of potential significant culture. Figure 8. Exploitation of light for drying of the cork. Figure 9. The Barbary stag in semi captivity.

habitants of the park but also can contribute to in the economic development of country. The knowledge of faunistic and floristic diversity and of the distribution methods of the fauna and flora of a territory,

allows us to have an effective tool for control and management of the natural habitats.

It is up to people having in charge and managing the protected areas, and a good information helps in directing reasoned actions of maintenance of the Territory. The park of El-Kala is a national heritage. Unfortunately, today we are witnessing a series of irresponsible and irrational behaviors that demonstrate a lack of education and environmental awareness. It is important that people understand that the peculiarities of PNEK reflect the deep meaning of Numidia and Krumiria (Northeast Algeria) and therefore this park is a treasure that must be protected and defended.

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## Sloth bear, *Melursus ursinus* Shaw, 1791 (Mammalia Ursidae), from India: conservation issues and management actions, a case study

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### ABSTRACT

One of the 12 mega biodiversity centres of the world, India is unique in having four of the eight bear species (Mammalia Ursidae) that are found in the world. They are brown bear (*Ursus arctos* Linnaeus, 1758 s.l.), Asiatic black bear (*Ursus thibetanus* Cuvier, 1823), sun bear (*Helarctos malayanus* Raffles, 1821) and sloth bear (*Melursus ursinus* Shaw, 1791). The abundance of sloth bear in India, which is also present in Sri Lanka with the endemic subspecies Sri Lankan sloth bear, *M. ursinus inornatus* Pucheran, 1855, is determined by its location within the global distribution range, quantum, quality and continuity of habitat available and the anthropogenic pressures the species faces. Bears in India are threatened due to poaching for bear parts, retaliatory killings to reduce conflicts and habitat loss due to degradation and fragmentation. In addition to these concerns, the rehabilitation of communities that eke out a living on dancing bears has made bear conservation a challenge in India. Deforestation and hunting are major threats to bears in India. Unless urgent conservation measures are taken and degraded forest areas are restored, we suspect that sloth bear may soon become endangered in India.

### KEY WORDS

Bear-human interactions; conservation; habitat; management; sloth bear.

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### INTRODUCTION

In the world, there are about 5,416 species of mammals distributed in about 1,229 genera, 153 families and 29 orders (Wilson & Reeder, 2005). Four hundred and twenty species of mammals (7.75 % of the world's mammals) are known from India (Nameer, 2008). Among the mammals carnivores are the most widely distributed terrestrial animals on earth (Schipper et al., 2008). Bears are mammals that belong to the family Ursidae G. Fischer de Waldheim, 1817 and represented by seven living species

that are widely distributed in a variety of habitats throughout the Northern Hemisphere (Table 1). Bears are found on the continents of North America, South America, Europe and Asia. Out of seven known species of bears, five are seen in India which includes Himalayan brown bear, Himalayan black bear, Malayan sun bear, brown bear and sloth bear. Common characteristics of modern bears include a large body with stocky legs, a long snout, shaggy hair, plantigrade paws with five non-retractile claws and a short tail. The lips are free from the gums and protrusible. Bears rely principally on their sense of

No.	Scientific name	Common name	Status
1.	<i>Ursus americanus</i> Pallas, 1780	American black bear	Least concern
2.	<i>Ursus arctos</i> Linnaeus, 1758	Brown bear	Endangered
3.	<i>Ursus thibetanus</i> Cuvier, 1823	Asiatic black bear	Vulnerable
4.	<i>Helarctos malayanus</i> Raffles, 1821	Sun bear	Vulnerable
5.	<i>Melursus ursinus</i> Shaw, 1791	Sloth bear	Vulnerable
6.	<i>Ursus maritimus</i> Phipps, 1774	Polar bear	Vulnerable
7.	<i>Tremarctos ornatus</i> (Cuvier, 1825)	Spectacled bear	Vulnerable

Table 1. Seven species of bears in the world  
(Source: I.U.C.N., 2012).

smell however the eye sight and hearing are comparatively poor (Prater, 1971). Bears are placed in the order Carnivores but, except for the largely carnivorous polar bear, bears are omnivorous, feeding mostly on plant material, insects, fish, and mammals. They are generally large, stocky, and powerful animals. All bears are plantigrade, walking on their entire foot. Their activities are mainly governed by the availability of food items and directly components within their habitat (Joshi et al., 1999b).

Sloth bear (*Melursus ursinus*) is one of the four bear species found in India and is entirely tropical in distribution and possesses several morphological, physiological and behavioural adaptations to the tropical habitat. Most sloth bears are found in India and Sri Lanka (in this island with the endemic subspecies *inornatus* Pucheran, 1855, Sri Lankan sloth bear) but they have also been reported from Bangladesh, Nepal and Bhutan (Garshelis et al., 1999a; Johnsingh, 2003; see also <http://www.bearbiology.com>). In India, sloth bears are found from the foothills of Himalayans to the Southern end of Western Ghats (Yoganand et al., 2006). They are also found in the Brahmaputra Valley of Assam (Cowan, 1972; Krishnan, 1972; Brander, 1982). It may still occur in the wet forest regions of eastern Bangladesh (Khan, 1982; Servheen, 1990) border-

ing the Mizoram state of India, from where it has been reported (Yoganand et al., 1999). They apparently favour drier forests and have been reported to prefer areas with rocky outcrops. In India, 90% of sloth bear populations are confined in the dry and moist deciduous forests of which the former account for 50% of the sloth bear populations. Sloth bear also occur in tropical evergreen forests, scrub lands and rocky hills. The bear lives in a variety of habitat such as Teak forest and Sal forest, lowland evergreen forest and the hill country up to elevation of 1700 m and riparian forests and tall grass areas on the floodplains of Nepal (Joshi et al., 1997).

However, their relative abundance varies across these vegetation types, as indicated by their higher abundance in deciduous forests, followed by dry deciduous, scrub and evergreen forests. Recent local extirpations and population declines have also been reported from the north-western populations (in the state of Rajasthan), a few isolated forests in the northern Western Ghats and adjoining areas, along the north-western Shivalik hills (no recent record of sloth bears to the west of the river Ganga), the northern forested areas of the state of West Bengal bordering Sikkim and Bhutan, and in the north-eastern states of India (Yoganand et al., 1999). To suit the tropics, it has no underfur; however, it has a long coat that perhaps helps in defending it from insect bites and also perhaps to exaggerate its size to predators (such as tiger and leopard) or conspecifics.

The sloth bear's low metabolic rate and high thermal conductance (McNab, 1992) may be advantageous in the hot climates where it lives, in that it reduces heat production and facilitates heat loss. Sloth bears seem to also have a behavioural adaptation to avoid hot weather conditions in their habitat by reducing daytime activity.

Clutton-Brock & Harvey (1983) suggested as advantages of having large body size, we speculate that the large body size of the sloth bear might help it to conserve heat; to travel great distances in search of its dispersed, seasonal food; to enhance the ability to survive on qualitatively poorer food of insects and fruits; to enable it to break hard termite mounds and to dig deep into social insect colonies; or to help it store fat and live on it during periods of shortage and during parturition denning. The potential sloth bear distribution range in India was estimated to be about 200,000 Km<sup>2</sup> (Johnsingh,

2003; Akhtar, 2004; Chauhan, 2006). But the recent surveys indicate the distribution range to be 400,000 Km<sup>2</sup>.

Sloth bear is small bear with a shaggy coat especially over the shoulders with grey and brown hairs mixed in with the dark black coat. It has a distinctive whitish or yellowish chest patch in the shape of a wide U, or sometimes a Y if the lower part of the white hairs extends down the chest. The snout is light coloured and mobile. It is thought that the reduced hair on the muzzle may be an adaptation for coping with the defensive secretions of termites. Adult males weight 80-140 Kg and females weight 55-95 Kg (Prater, 1980; Garshelis et al., 1999b). Physical adaptations for digging and eating insects include long, slightly curved claws, a broad palate for sucking, the absence of two front upper incisors and large protrusible lips (Harris & Steudel, 1997). Its vernacular name is bhalu (Hindi), Karadi (Tamil and Malayalam). Mating generally takes place between May and July and the cubs are born between November and January (Jacobi, 1975; Laurie & Seidensticker 1977; Joshi et al., 1999b).

The actual period of pregnancy is shorter, as the fertilised egg is implanted after a period of delay (Puschmann et al., 1977). Similar to what is observed in the temperate bear species. In captivity, mating pairs come together for only one or two days during which time there may be considerable vocalizing and fighting. Gestation lasts from six to seven months. Most litters consist of either one or two cubs, but litters of three cubs have been reported. Cubs are born in earth dens and apparently do not leave them until they are two to three months old. The cubs stay with their mothers who carry them on their backs until they are nearly two or more years of age (Joshi et al., 1999b).

Bears are usually solitary with the exception of courting individuals and mothers with their cubs. They are generally diurnal, but may also be crepuscular or nocturnal, particularly in and around human habitations. Bears have excellent sense of smell and are good climbers and swimmers. Many bears of northern regions go into a period of dormancy during winters colloquially called hibernation. Sloth bears are one of the largest termite-eater among mammals. A significant portion of their diet consists of ants and termites (Schaller, 1969; Eisenberg & Lockhart, 1972; Laurie & Seidensticker, 1977; Joshi et al., 1999a) and hence the sloth bear is con-

sidered as the only myrmecophagous among Ursidae. Since some Ursids disperse seeds they are considered to be important seed dispersers for many tropical plant species where fruits form major part of their diet (Baskaran, 1990; Willson, 1993; Farley & Robbins, 1995; Welch et al., 1997; Auger et al., 2002; Kitamura et al., 2002; Sreekumar & Balakrishnan, 2002; Koike et al., 2008). Around the world, bears and humans have co-existed for centuries as evident from the references of bears in ancient art, culture, folklore, epics, religion and literature. Bears are good indicators of habitat quality as they occupy the position of an apex predator in a few ecosystems. They are unique in the sense that they could feed on plants, prey on other species as well as scavenge dead animals.

Sloth bears feed extensively on termites and have special adaptations for doing this. The naked lips are capable of protruding and the inner pair of upper incisors is missing and the inner pair of lower incisors is missing, which forms a gap through which termites can be sucked. The sucking noises made by feeding in this manner can apparently be heard from over 100 meters away. They also eat eggs, other insects, honey combs, carrion and various kinds of vegetation including fruits (Gokula et al., 1995; Joshi et al., 1997). The sloth bears consume plant species included *Cassia fistula* L., *Zizyphus oenoplia* (L.) Mill., *Glycosmis pentaphylla* (Retz.) DC., *Holigarna arnottiana* Wall. ex Hook. f., *Ficus* spp., *Syzygium cumini* (L.) Skeels., *Grewia tilifolia* Vahl, *Mangifera indica* L., *Bridelia retusa* (L.) A. Juss. and *Cardia dichotoma* G.Forst. (Sajeev, 2013).

As a result of the continued habitat destruction and degradation, sloth bear populations have declined or become fragmented all over and as a result, they have become locally extirpated in some areas (Cowan, 1972; Krishnan, 1972; Servheen, 1990; Murthy & Sankar, 1995; Garshelis et al., 1999a; Singh 2001; Johnsing, 2003). Sloth bear is included in Schedule I of India Wildlife Protection Act-1972 and Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (C.I.T.E.S.).

## POPULATION STATUS AND HABITAT

The Central Zoo Authority (C.Z.A.) is statutory Ministry of Environment & Forests, Government of

India established in 1992 to oversee the functioning of zoos in India and provide technical assistance. There are 70 Zoos and five Rescue Centers housing a total number of 795 individual (as on 31st March, 2012) bears in captivity for the purpose of conservation, education to the public and for their lifetime care (Table 2). The distribution and details of the bear species housed in various Indian Zoos & Rescue Centers are shown in figure 1 and Table 3.

## CONSERVATION ISSUES

### I. Threats to the species

Sloth bear is protected by inclusion in Schedule 1 of the wildlife (Protection) Act 1972. The sloth bear population in India is threatened largely by poaching (Garshelis et al., 1999b). Bears have been poached for gall bladder and other parts, which are often exported to South-East Asian countries as an ingredient to Traditional Chinese Medicines. In the last five years, poaching and hunting has become uncommon as reported by the Government of India. Incidence of sloth bears getting killed by road and railway hits and electrocution were also noted. In

Odisha, based on only the recorded cases by the forest department, the total number of sloth bears killed is over 30 in last five years.

A number of sloth bears (n=8) died in the state due to road and train accidents in last five years as recorded by the forest department. It is also reported that the bears might be poached/hunted in some areas but access to these areas is limited due to security issues. Trade of live bear cub and bear body parts poses a direct threat to the animal and its future survival in the state. With adjoining state like Chhattisgarh, Maharashtra and Odisha reporting presence of illegal trade routes, the trade is likely to exist in Madhya Pradesh as well. Sidhi, Shivpuri and Shahdol districts of Madhya Pradesh are considered sloth bear cub poaching hot spots. The reasons for the lack of information on illegal trade can be attributed to:

- a. Infrequent poaching of sloth bears in the region.
- b. Strong networking among the defaulters that help them get by unnoticed by the authorities.
- c. Because reporting poaching is considered a disgrace.

The sloth bear has the most widely recorded

SL. No.	Species of Bear	Male	Female	Un-known Sex	Total	No. in Zoos	No. on Rescue Centers	No. of Zoos	No. of Rescue Centers
1	Sloth bear <i>Melursus ursinus ursinus</i> Shaw, 1791	292	267	3	562	251	311	40	3
2	Himalayan black bear <i>Ursus thibetanus laniger</i> (Pocock, 1932)	106	95	22	223	211	12	53	2
3	Himalayan brown bear <i>Ursus arctos isabellinus</i> Horsfield, 1826	3	1	1	5	5	0	1	0
4	Malayan sun bear <i>Helarctos malayanus malayanus</i> Raffles, 1821	1	3	0	4	4	0	2	0
5	European brown bear <i>Ursus arctos arctos</i> Linnaeus, 1758	1	0	0	1	1	0	1	1
	<b>TOTAL</b>	<b>403</b>	<b>366</b>	<b>26</b>	<b>795</b>	<b>472</b>	<b>323</b>	<b>97 (70)</b>	<b>6 (5)</b>

Table 2. Statuses of bears in Indian Zoos (as on 31st March, 2012).

distribution range than any of large carnivore in Central India (Jhala et al., 2011). The erstwhile state of Madhya Pradesh (undivided Madhya Pradesh including Chhattisgarh) had largest sloth bear population in this country with the bear inhabiting an area of 135,395 Km<sup>2</sup> of the forest (Rajpurohit & Krausman, 2000).

In Central India, sloth bear is locally considered as one of the most feared and dangerous wild animals (Bargali et al., 2005). Sloth bear seem to have a very low tolerance toward humans. Majority of the HBC cases have occurred either when the human enters sloth bear habitat or when the sloth bear enters kitchen gardens in the village homesteads. Maximum conflict cases have occurred in the month of March and early April, which coincides with Mahua, *Madhuca indica* (J. Konig) J.F. Macbr., season when both bears and human compete for the same resource. The conflict intensity may raise up to 2.23 cases per day during this period, while in other months; it comes down to 1.4 cases/day (Sarkar, 2006).

In Maharashtra, however, bear-human conflict especially in district of Chandrapur, Gondia, Gadchiroli, Bhabdara, Akola and Amravati in the Vidarbha region is on the rise. In Tamil Nadu, only one poaching case was recorded across the state during the past five years in Gudalur Forest Division. Apart from this, two more bears were killed possibly due to conflict in 2010-2011. A total of 20 cases of conflict have been recorded in the state in the last five years (2006-2011) including 19 cases of human injuries and one case of human death. However, much information on human-bear conflict is lacking from this state.

Other edibles valued by bear as well as humans are Jamun, *Syzygium cumini* (L.) Skeels., Bair, *Zizyphus* spp., Tendu, *Diospyros melanoxylon* Roxb, Bel, *Aegle marmalos*, (L.) Corrêa, Chironji, *Buchanania lanzan* Spreng., and honey. Therefore, when both human and bear share the same space and depend on the same resources, the conflict (human injuries and human death) becomes inevitable. Because of such negative interaction, attrition levels among the locals rise, often leading to considerable number of bears being persecuted and killed in retaliation. No poaching of bear or incident of trade in bear or bear parts has been recorded by the forest department of Gujarat in last five years.

## II. Threats to the habitats

Implementation of Schedules Tribes and Forests Dwellers Act, 2006 will also have an impact on bear converted into arable land. Change in cropping pattern is also harming the bear food availability in the area. Due to fragmentation of forests, sloth bears often enter villages to ride agriculture and forage on wild ficus and horticultural produce being processed (Mango, Anona, Mahua, Ground nut, Maize and Sweet potato). Some villagers are now resorting to alternate crops that do not attract bears. Large source of bear food is being removed from around villages intentionally which ultimately will have a bearing on sloth bear population in Chhattisgarh (Akhtar et al., 2006a).

Outside the protected areas, sloth bear habitat in territorial forest divisions is facing habitat degradation due to various activities including anthropological pressures from local communities, quarrying of granite and sandstone, diversion of forest land for non-forestry purposes and illegal cultivation by local communities. Due to habitat fragmentation, Sloth bear populations are getting encircled by agriculture activity around foothills of hillocks whereby they get confined to hill portions like in Jaffarghat Fort and Warangal District in Andhra Pradesh. The sloth bear habitat between India and Nepal is connected through northern Bihar (Terai Arc Landscape) and the sloth bear population in central and eastern Indian landscape are connected through southern Bihar. These sloth bear occupied areas under threat due to various anthropogenic reasons, which needs special management emphasis (Gupta et al., 2007).

The potential sloth bear habitat range in Arunachal Pradesh is about 1500 Km<sup>2</sup>. Here, sloth bear habitat is threatened due to slash and burn or jhum cultivation, deforestation and encroachment. Construction of roads and infrastructure development, tea plantation and development of human settlements in foothills and adjacent plains have also threatened the potential sloth bear habitat, leading to habitat loss and degradation (Choudhury, 2011).

The sloth bear habitat in Gujarat mostly occurs in terminating mountain ranges of Arawalis, Sapuda and Sahiyadri with dry deciduous to moist forest types. Fruits and other parts of more than 35 plant species have been reported from here, which are consumed by sloth bears (Mewada, 2011).

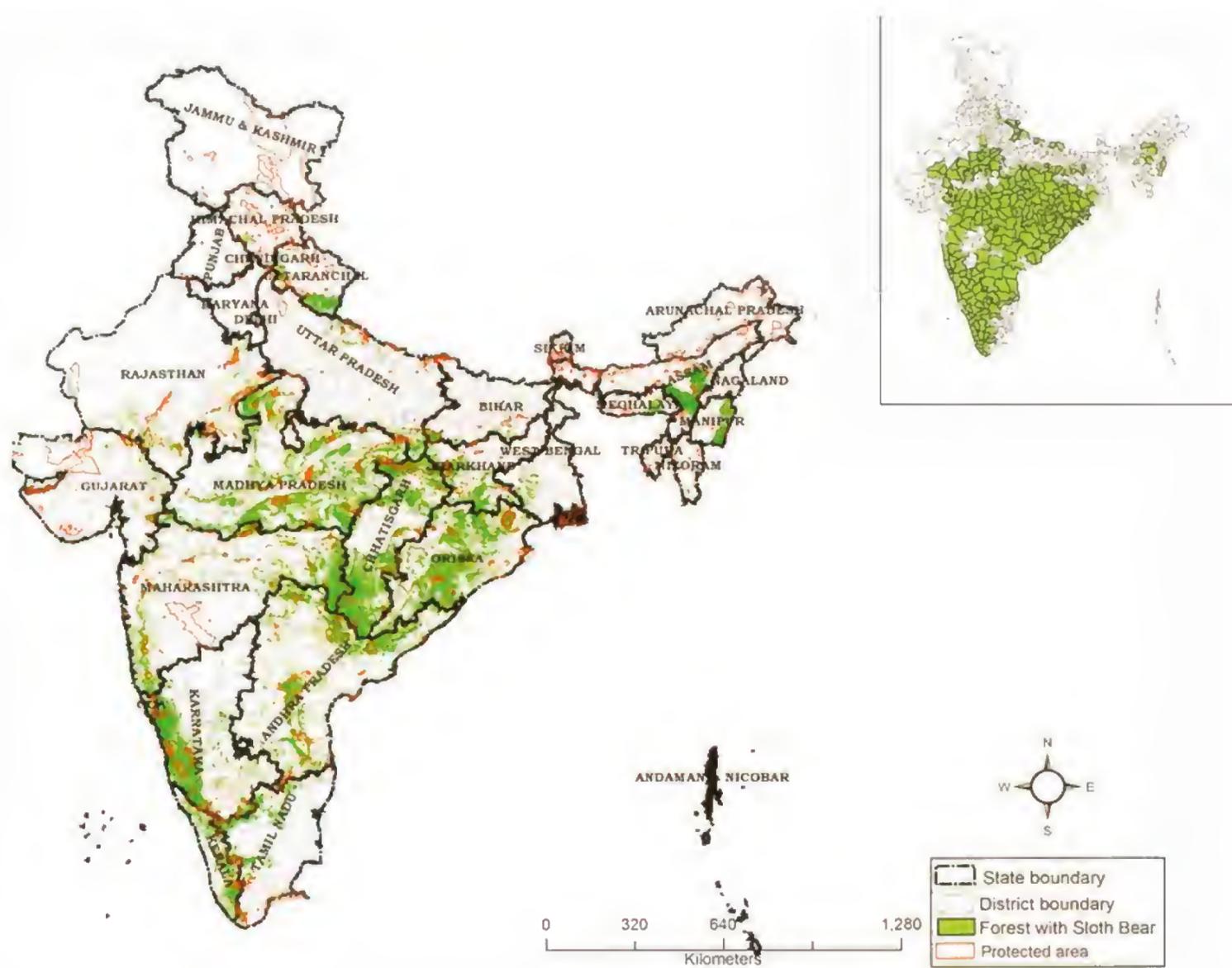


Figure 1. Sloth bear, *Melursus ursinus ursinus*, distribution in India.

The main issues with the available bear habitat in the state are pressure on the habitats by livestock grazing, tourism and developmental activities and mining, which are reported as major factors leading to habitat degradation and fragmentation of forest patches. Out of seven forest divisions with sloth bear population in this state, forest patches in four divisions are unprotected and not declared as sanctuaries.

## MANAGEMENT ACTION

Stakeholder involvement in various aspects of wildlife management can yield many benefits (Chase et al., 2000). The specific conservation recommendations for minimizing bear-human conflicts and bear habitat conservation are as following.

### I. *Protection to the species*

The sloth bear is listed in Schedule I of the Indian Wild Life (Protection) Act (Govt. of India, 1972; Govt. of India, 2003), Vulnerable (I.U.C.N., 2012). Special powers accorded to the forest staff in Assam have enabled them to patrol the protected areas more effectively than other parts of the country. However, in areas outside the protected areas, lack of and inadequately trained staff hampers protection measures.

There is no specific strategy for protection of sloth bear in Bihar (Govt. of Bihar, 2012), Haryana and Gujarat. However, being found in the protected areas of the state, the species gets the highest degree of legal safeguard. Lack of reliable information network restricts intelligence-based enforcement to control poaching and illegal trade. Majority of bear habitats fall outside the jurisdic-

tion of protected area network of the state, they lack protection equipments, trained man power and local rescue team. In Andhra Pradesh, the sloth bear is listed in Vulnerable (A2 cd+4cd; C1) category of I.U.C.N. Red List of threatened species (Garshelis et al., 2008).

## II. *Habitat management*

The development projects such as roads, irrigation dams, hydro-electric project in the wildlife sanctuaries are the major threats to bear habitat in the state of Kerala, Tamil Nadu and Karnataka. The impact of such developmental activities on sloth bear status and distribution is not known and often is ignored. In Gujarat, forest field staffs manage habitats in almost all the forest divisions, which include regular monitoring, plantation programs, often with committee's involvement. Eco development committees, village development committees, stakeholders groups are formed in each forest division to carry out habitat restoration and improvement programs. Community forestry programs, wherein local people learn the value of planting and protecting trees, could expand habitat for sloth bears, and could also reduce the bear-human interactions. The strength of this approach is that it is instigated from the bottom up (i.e., people do it because it benefits them, rather than because it is mandated), but it also must be supported from the top down (Poffenberger, 1990).

## III. *Management of bear-human interactions*

No specific management actions have been taken for sloth bear human interaction in many of the states such as Arunachal Pradesh, Assam, Bihar, Jharkhand, Gujarat, Rajasthan, Meghalaya, Nagaland and Uttrakhand. In Chhattisgarh, there is a policy for compensation by financial reimbursement in case of human mauling or killing by wild animals but not for crop depredation; in Maharashtra, Madhya Pradesh, Uttar Pradesh, West Bengal and Goa state there is a policy for ex-gratia for crop damage or human casualties due to bear of Rs 1,00,000/-, and up to Rs 75,000/- for permanent disability due to bear attacks. In addition to the reimbursement of medical expenses, forest department also provides compensation for the loss of man days incurred by the victim as a welfare scheme.

In Maharashtra, sloth bear is known for its aggressiveness, both towards humans and towards other large mammals. The survey conducted by Wildlife Trust of India indicates that between 2006 to 2011, Gondia has reported the maximum number of human sloth bear conflict cases (65) followed by Chadrapur (36) and Bhandara (26). Desai et al. (1997) reported that bear-human interactions are very common issue in all districts of Gujarat except Panchmahal district. The Gujarat states recorded 127 human sloth bear interaction cases in the last five years, of which 95 were cases of human injuries with one casualty (Mewada, 2011). Seshamani & Satyanarayan (1997) have reported that Jharkhand has a long history of the human-bear conflict but the State does not have effective strategy to deal with the human-bear conflict. According to Karnataka Forest Department records, the bear-human conflicts are severe in five districts namely Chamrajnagar, Chickmagalur, Tumkur (maximum), Chitradurga and Bellary. In Kerala the forest department has provided proper guidance to villagers living around bear-bearing areas such as Periyar Tiger Reserve and Parambikulam Tiger Reserve on how to avoid interaction with sloth bear. The questionnaire survey results shows that in only five out of 34 forest divisions recorded sloth bear-human conflict namely Kannur, Wayanad, Palghat, Ernakulam and Kollam. Incident of poaching, confiscation and retaliatory killings seem to be few in the Odisha and Tamil Nadu states (Baskaran et al., 1997). Other measures to mitigate human bear conflict include promotion of awareness through various awareness programmes and hoarding on sloth bear conservation. In addition in few states forest departments have provided drums and crackers to villagers to chase bears away from villages. Andhra Pradesh Forest Department has made a provision to have a Conflict Management Team at the Circle level. In the recent years remote drug delivery devices (tranquilizing equipments) have been purchased in Valmiki Tiger Reserve (Govt. of Bihar).

## IV. *Research and Information*

Scientific information on sloth bear is restricted to a few status surveys, conflict surveys and short studies (Gopal, 1991; Johnsingh, 2003; Chauhan & Rajpurohit, 2006; Dharaiya & Ratnayeke, 2009; Dharaiya, 2010; Choudhury, 2011).

SL. NO.	ZOO NAME	MALE	FEMALE	UNSEX	TOTAL
1	Agra Bear Rescue Facility, Agra	139	129	0	268
2	Alipore Zoological Garden, Kolkata	1	2	0	3
3	Amtes Animal Ark, Wardha	1	2	0	3
4	Arignar Anna Zoological Park, Vandalur, Chennai	4	4	0	8
5	Aurangabad Municipal Zoo, Aurangabad	1	1	0	2
6	Bhagwan Birsa Biological Park, Ranchi	5	3	0	8
7	Bondla Zoo, Usgao	2	2	0	4
8	Children Park & Zoo, Gadag	1	0	0	1
9	Dr. K. Shivarma Karanth Pilikula Biological Park, Mangalore	0	1	0	1
10	Dr. Shyamaprasad Mukharjee Zoological Garden, Surat	2	2	0	4
11	Gandhi Zoological Park, Gwalior	0	1	0	1
12	Indira Gandhi Park Zoo, Rourkela	1	1	0	2
13	Indira Gandhi Zoological Park, Visakhapatnam	2	6	0	8
14	Indira Priyadarshini Sangrahalaya, Anagodu, Davangere Taluk	0	1	0	1
15	Jaipur Zoo, Jaipur	3	1	0	4
16	Jhargram Zoo, Jhargram	0	4	0	4
17	Kamla Nehru Prani Sangrahalaya Zoo, Indore	1	1	0	2
18	Kamla Nehru Zoological Garden, Ahmedabad	1	0	0	1
19	Kanan Pandari Zoo, Bilaspur	4	3	0	7
20	Kanpur Zoological Park, Kanpur	1	1	0	2
21	Karuna Society For Animals and Nature-Rescue Centre, Dist. Anantapuram	2	2	0	4
22	Lucknow zoological Park, Lucknow	1	2		3
23	Maharajbag Zoo, Nagpur	1	1	0	2
24	Mahendra Chaudhury Zoological Park, Chhatbir, Chandigarh	3	2	0	5
25	Maitri Baagh Zoo, Bhilai	2	1	0	3
26	Mini Zoo A. M. Gudi Balvana, Chitradurga	0	2	0	2
27	Nandankanan Biological Park, Bhubaneshwar	4	3	0	7
28	National Park, Bannerghatta Zoological Garden, Bangalore	59	45	0	104

Table 3. Records of sloth bear, *Melursus ursinus ursinus*, in India zoos (continued).

SL. NO.	ZOO NAME	MALE	FEMALE	UNSEX	TOTAL
29	National Zoological Park, Delhi	2	2	0	4
30	Nehru Zoological Park, Hyderabad	5	4	0	9
31	Pt. Govind Ballabh Pant High Altitude Zoo, Nainital	0	0	0	0
32	Rajiv Gandhi Zoological Park and Wildlife Research Center, Pune	3	1	0	4
33	Ramnabagan Mini Zoo, Burdwan	1	1	0	2
34	Sakkarbaug Zoo, Junagarh	3	2	0	5
35	Sanjay Gandhi Biological Park, Patna	4	2	0	6
36	Sri Chamarajendra Zoological Gardens, Mysore	5	5	0	10
37	Sri Venkateswara Zoological Park, Tirupati	3	2	0	5
38	Tata Steel Zoological Park, Jamshedpur	1	2	0	3
39	Thiruvananthapuram Zoo, Thiruvananthapuram	1	1	1	3
40	Tiger & Lion Safari, Shimoga	1	1	0	2
41	Van Vihar National Park, Bhopal	19	17	0	36
42	Vanavigyan Kendra, Hunter Road, Hanamkonda, Warangal	1	1	2	4
43	Wild Animal Conservation Centre, Mothijharan, Sambalpur	2	3	0	5
	<b>TOTAL</b>	<b>292</b>	<b>267</b>	<b>3</b>	<b>562</b>

Table 3 (continued). Records of sloth bear, *Melursus ursinus ursinus*, in India zoos.

A few intensive studies on sloth bear ecology were carried out in Panna National Parks (Yoganand et al., 2005) and North Bilaspur Forest Division (Akhtar & Chauhan, 2000; Akhtar, 2004; Bargali, 2004; Akhtar, 2006; Akhtar et al., 2008; Mewada, 2011). However, there is lack of even basic information on sloth bear presence/ absence for many areas in North-Eastern states. Information on population estimates, relative abundance and monitoring are wanting.

#### V. Capacity Building

Apart from some wildlife managers and front-line staff, most of the field managers and staff require capacity building. Other stakeholders require sensitization and training in order to help

protection on sloth bear, its habitat and reducing sloth bear-human conflict.

#### VI. Awareness Campaign

The majority of the local people are uneducated as they are primitive tribes of the region and still attached with their ancient culture. Education should be provided not only for the necessity of protecting forest habitats in order to ensure the survival of sloth bear, but also for highlighting the benefits to people in protecting and managing valuable resources. Sloth bear must be included as a key species in ongoing awareness campaigns. Local people, Joint Forest Management Committees, Eco-Development Committees, Eco-Clubs and school children should be sensitized about sloth bear

conservation. Policy makers, judiciary and enforcement agencies may be sensitized on Wildlife crime and law enforcement. Good quality audio-visual materials and collaterals (posters, brochures, stickers, etc.) in local language may be produced and distributed. Awareness campaign should focus on highlighting damagers in collecting the minor forest produce from the areas where bears have their dens.

### VII. *Legislation and Policy*

Apart from the awareness and involvement of local people, the administrative reforms are also required for effective conservation of bears and habitat. Despite an array of Policies and Legislation, conservation efforts for sloth bear and its habitat have faced limitations due to want of site specific policies or flexibility in adaptation of existing policies.

### CONCLUSION

Some of the recommendations proposed by stake holders to control poaching/hunting of bears included: (i) creating awareness and using local communities to curb bear hunting/poaching for the illegal trade in bear parts or live cub trade; and (ii) strengthening existing network of informers, and various law enforcing agencies, including monitoring of wildlife crimes at Inter-State check posts and international borders. To reduce bear-human interactions, the following were recommended: (i) awareness creation on bear behaviour and the philosophy of co-existence in addition to strengthening of indigenous conflict reduction measures to reduce crop and livestock depredation by bears; and (ii) strengthening the conflict management teams with equipment, training, and capacity building and improvement in the current mechanism of assessment of economic losses of crop /livestock depredation by bear and other wildlife. For bear habitat management the recommendations were to: (i) continue protection to bear habitats and prevent habitat loss due to conversion for agriculture/ horticulture and developmental projects; (ii) restore degraded bear habitats through existing government programmes using local communities; and (iii) identify critical bear habitats and corridors outside PA network and manage them as Community or Conservation

Reserves with approval and support from local communities. Similarly, recommendations for research, capacity building, conservation educate and legislation and policy have been made.

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## **Biodiversity of Sudan: between the harsh conditions, political instability and civil wars**

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### **ABSTRACT**

More than 90% of the area of Sudan is classified as desert and semi-desert ecosystems, and desertification is spreading with global climatic changes. Also the country is suffering from 60 years of chronic civil wars and instability. Consequently these situations have severely affected the status and trend of biological diversity of the country to critical thresholds (i.e. extinction) as many reports show. Improved knowledge of the current status of biodiversity in response to such conservation challenges is critically important. In this review, my aim is to highlight the recent conservation challenges of Sudan as they relate to desertification and civil wars, and to look at the big picture of the impacts of these challenges to biodiversity conservation in Africa. I then present examples of urgent management interventions and research needs for better biodiversity conservation. The primary message of this paper is to confirm the possibility of making conservation actions in these vulnerable areas. It is never too late as long as there is peace and willingness. This framework could be a model to tackle and analyses biodiversity conservation issues in similar cases in the region.

### **KEY WORDS**

Africa; Biodiversity conservation; desertification; dry-lands; political instability; Sudan.

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### **INTRODUCTION**

The news coming from Sudan is always about civil war, political conflicts, awful statistics about the refugees and displaced people and rarely optimistic. In addition to the political instability, environmentally the country is one of the most fragile, dry and desertified areas in Sub-Saharan Africa, which leads to high vulnerability to global climatic changes and extreme events such as drought and flooding (I.P.C.C., 2013). The United Nations Convention on Combating Desertification (U.N.C.C.D.) defined dry lands (arid, semi-arid and dry sub-humid zones) as areas other than polar and sub-polar regions in which the aridity index (i.e. the ratio of

annual precipitation to potential evapo-transpiration) falls within the range of 0.05-0.65 (U.N.C.C.D., 1994). According to this definition, about 93% of the area of the country is classified as dryland (Table 1), which extends from hyper arid and arid zones in the north to the semi-deserts in the middle to low rainfall woodlands savanna in the deep south and south east (Goda, 2007; Mustafa, 2007).

In addition to the dominant harsh conditions there are some areas with unique ecological conditions such as mountains, the Nile strip and wetlands depressions. These areas support vegetation communities and natural habitats that are critical to maintaining biological diversity, particularly wildlife and forest resources (Mukhtar & El

Wakeel, 2002). The forest resources in Sudan were estimated by F.A.O. in 1990 to be about 19% of the total area of the northern part of the country, but the current report of U.S.A.I.D. in 2012 showed the total forested areas of the country have been reduced substantially to about 11.6 % (Fig.1).

Despite the habitat loss and degradation, these forests are still playing vital environmental roles in biodiversity conservation and combating desertification as well as supporting the livelihood of local communities. For instance the forest products consumption survey conducted by the Forest National

Aridity Zone	Ecosystem type	Area (Square Km)	% (Area of the Sudan)	Annual Rainfall (mm)	Aridity Index (R=P/PET)
Hyper-arid	Desert	776000	41	< 20	< 0.05
Arid	Semi-desert	630000	33	20 - 100	0.05 – 0.20
Semi-arid	Grassland Savanna	340000	18	100 – 300	0.21 – 0.50
Dry sub-humid	Low rainfall woodland Savanna	65000	3	300 – 500	0.51 – 0.65
Sub-tropic	High rainfall woodland Savanna	70000	4	500 – 800	> 0.65
<b>Total</b>		1881000	100		

Table 1. Classification and extent of dry lands in Sudan adapted from Ayoub (1998), Mustafa (2007) and Badri (2012).

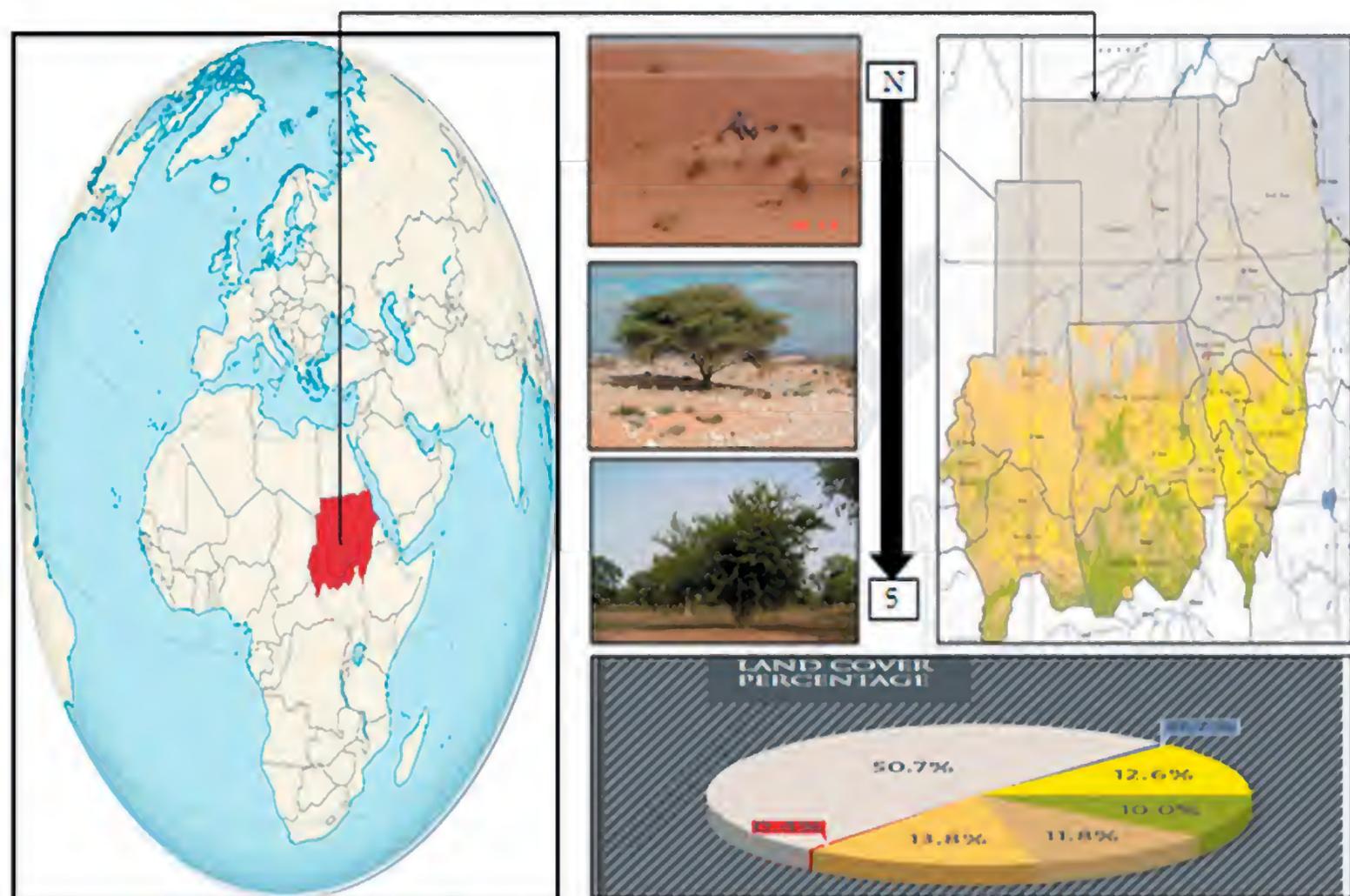


Figure 1. The location of Sudan in Africa (left). The map of land cover showing the ecological gradients from the desert in the north to rainy savannah in the deep south (right). The area of the country divided between 50.7% as desert, 13 % agricultural lands, 12.6 % grass lands, 10% forests cover, 1 % Water resources. ~ 1% others (i.e. urban areas). Adapted from F.A.O. (2012).

Corporation (F.N.C.) in 1995 showed that forests are the main sources of sawn timber, round poles, building materials and 87.5% of energy (fuel wood) to the country. Also about 100 indigenous trees species provide direct food, oil, honey, fruit, fodder, gum, fiber, medicine, and tannin agents to the people (Badi, 2004). Takona (1999) and Siddig & Abdellhameed (2013) emphasized the great socio-economic, cultural and heritage values of biodiversity of Sudan, and the value of local markets based on wildlife products, forest products and fibers crafting materials as an employment opportunity for many people, especially in rural areas.

Although there are a few efforts by local governmental agencies and NGOs, there are many critical challenges facing biodiversity of Sudan. First, political instability and civil wars led the country to lose about 70% of its biodiversity that was concentrated in the southern part, as it became independent state in 2011 as republic of South Sudan. Severe wars continue in about 50% of the rest of the country (8 states out of 15). Second, the combination of socio-economic (e.g. food insecurity and refugees) and global environmental factors (e.g. climate change, drought and desertification) plus the lack of integrated plans exacerbate the decline of biological diversity of the country to critical thresholds (i.e. extinction). The need to know the current status of biodiversity in response to such complex political and environmental challenges is critically important. Nimir, (1995), Takona, (1999), Funk et al. (2011) and Badri (2012) pose many logical questions on this topic. I suggest that the most important questions include: What is the current state of biodiversity of the country in the light of these wars and harsh conditions? What and where are the hot spots of conservation? What are the subsequent challenges facing biodiversity? And most importantly, how can these challenges will be solved?

This review comes to bring attention to the impacts of wars combined with harsh conditions on biodiversity as regional theme with a particular case of Sudan after July 2011 based on recent governmental and international agencies reports working in Sudan as well as the domestic literature. The specific aims of this paper are two-fold. First, I display and diagnose the most serious challenges of biodiversity conservation in the country based on my point of view. Second, I present a vision of solutions as a suggested framework for biodiversity conser-

vation, including a top ten management strategies and urgent research needs.

## CONSERVATION CHALLENGES

The critical challenges facing biodiversity in Sudan are similar to elsewhere in the continent, and have been listed in Takona (1999), Goda (2000), Abdelhameed & Nimir (2007), Nur (2007), U.N.E.P. (2007), and Badri (2012). Although I generally agree with these previous studies about these problems, I argue that political conflicts and civil wars is a challenge that substantially affects everything in the country including biodiversity. In the following points I show how continuous conflicts and unrest directly impact biodiversity conservation:

### *Species loss and mass extinctions*

Almost 60 years of violence led the country to lose its southern part, and continues in more than 50% of the rest of the rest of the country (9 states out of 17). In addition, there are intermittent military tensions in the border between Sudan and South Sudan from time to time. Consequently, hundreds of individuals of many taxa have been killed as a direct effect of shootings and fire set by fighters. Also, several species (e.g. Gazelles and Ostrich) have declined due to overhunting by the militants who use them as a primary food source in the woods. Recent IUCN (2013, e.g. Tables 5) Tables of endangered species indicate the absence of information for about 114 animals' species (i.e. data deficit) and 127 species reported as threatened, including 19 plants and 108 animals (16 mammals, 18 birds, 3 reptiles, 21 fishes and 50 invertebrates). Many ecologically important species went extinct since 1980s or are thought to be extirpated from their natural territories in Blue Nile, South Darfur and the Nuba mountains regions. Species endangered because of these conflicts and other stressors (e.g. drought) include top predators: cheetah, *Acinonyx jubatus* Schreber, 1775; African lion, *Panthera leo* Linnaeus, 1758; greater spotted eagle, *Aquila clanga* Pallas, 1811; imperial eagle, *Aquila heliaca* Savigny, 1809; houbara bustard, *Chlamydotis undulata* (Jacquin, 1784); and lesser kestrel, *Falco naumanni* J.G. Fleischer, 1818. Herbivorous on the endangered list are *Hippopotamus*, *Hip-*

*popotamus amphibius* Linnaeus, 1758; Barbary sheep, *Ammotragus lervia* Pallas, 1777; Dorcas gazelle, *Gazella dorcas* Linnaeus, 1758; red-fronted gazelle, *Gazella rufifrons* Gray, 1846; Soemmerring's gazelle, *Gazella soemmerringei* Cretzschmar, 1826; African elephant, *Loxodonta africana* Blumenbach, 1797; and African spurred tortoise, *Geochelone sulcata* (Miller, 1779), as well as several bats like Trevor's free-tailed bat, *Mops trevori* (Allen, 1917); horn-skinned bat, *Eptesicus floweri* (de Winton, 1901); and lappet-faced vulture, *Torgos tracheliotos* (Forster, 1791) (Badri, 2012).

### ***Habitat loss and fragmentation***

Habitat loss and fragmentation due to excessive deforestation and agricultural expansion in forest lands. The Sudanese Forest National Corporation (F.N.C.) estimated that vast forested areas of the sub-humid zones in southern Darfur and Kordofan have been cleared by refugees and displaced people for use as fuel wood and building poles. Approximately 1 million hectares was cut down during 2005-2010 in both Sudan and South Sudan (F.A.O., 2005; Gaafar, 2011). Also according to the U.N. mission in Sudan, millions of people from both Sudans have become internally displaced and refugees as a direct impact war, surviving hard conditions and depending largely on the already poor forests for shelter and livelihood.

### ***Insufficient governmental support***

For decades, the government's major concern always is to deal with wars. There is not enough government effort or budget allocated to develop conservation programs. It is no secret in Sudan that for decades, the budget of the ministries of defense and interior is about 50-60% of the total, with the rest divided among more than 25 ministries. Furthermore, the latest trends in international arms transfers showed that Sudan is classified among the top three African countries in weapons imports, after Algeria and Morocco, receiving 9% of the total continent's imports (Wezeman & Wezeman, 2014). These numbers show the priorities of the government, and why ministries like environment and physical development, higher education, and science and technology receive less than 1% of the total budget annually.

### ***Redundant and weak institutions***

Redundant and weak institutions are responsible for managing natural resources and enforcing conservation policies. It is surprising that many ministries are formed to accommodate opposition and former militia leaders who agree to participate in the government and not because of the technical need for these ministries. Thus the issues of biodiversity are divided among at least 5 ministries and unfortunately none of them is fully functional. For example it is primarily follow to Ministry of the Environment and Physical Development, but it has redundancies with the Ministry of Agriculture (especially at the state level), Forest National Corporation, the Higher Council of the Environment and Natural Resource and Wildlife Protection Administration in the Ministry of Interior.

### ***Data deficits***

A general problem in Sudan is information gaps in almost all sectors, particularly the current biodiversity status and geographical distribution (What is where? What are the trends?). For example, there are no current detailed studies about the state of biodiversity of some important ecosystems such as Blue Nile state (e.g. Al-Angeesena area) and South and West Darfur states (e.g. Radom National park). Because of the unsecure conditions, it is not surprising that the data collection (e.g. species diversity) for conservation (e.g. habitat restoration) is extremely rare and sometimes impossible. This shortage of information makes conservation planning haphazard and interventions cannot even begin.

### ***Accelerating natural disturbances***

Desertification is a familiar scenario in almost 70% of the country and one of the biggest challenges not only because of its fast annual creeping rate but also because it is encroaching on vast habitat areas (Table 1). The high rate of deforestation, soil erosion, forest fires and few reforestation efforts are primary drivers of this phenomenon. In addition, the I.P.C.C. 5th report classified Sudan as one of the most vulnerable spots to climatic changes since the country is at the defense line of the sub-

Saharan region and has high deforestation rates. Consequently extreme events such as drought, flooding and fire are likely to increase severely (Badri, 2012). Conflicts result in more stochastic deforestations and unplanned use of natural resources which ultimately increase the risk of erosion and desertification.

#### *Absence of local communities in establishing*

Absence of local communities in establishing and adopting participatory conservation projects. Community involvement varies from place to another, but for the time being the general public, is concerned more about safety, peace, poverty alleviation, and food security rather than conserving biodiversity.

#### *Political restrictions*

Political restrictions from the government over the NGOs working in environmental fields. Due to these tensions some NGOs are having difficulties implementing their conservation projects because the government wants them to do it according to its agenda which is not necessarily the same as the NGO's plans.

### **THE BIG PICTURE OF BIODIVERSITY CHALLENGES IN AFRICA**

The truth is that the circumstances (i.e. civil wars and instability) threatening the biodiversity of Sudan occur elsewhere, not only in neighboring countries (e.g. South Sudan, Libya and Central Republic of Africa) but also in the majority of the African countries (e.g. Mali and Somalia). Unfortunately, political instability, spreading wars and chronic conflicts, millions of refugees and displaced people, severe levels of poverty and low education are the largest common denominator among most countries of the region (Swatuk, 2007; Nur, 2007). Furthermore, these countries have weak conservation institutions with no clear plans aggravated by budget issues. Because conservation in general needs committed governments, people living in a safe and healthy environment, and available resources, it is not surprising that issues of biodiversity conservation are a low priority in Africa.

The other dimension of this dilemma is that we do not know when these decades of unrest and conflicts are going to stop (though the reasons behind them are well known) so that development can begin. Meanwhile, the consequences of such deterioration of biodiversity in African countries on the global environment and biodiversity become more severe and uncertain. For instance, U.N.E.P. (2013) reported that the globally important and richest tropical areas in Africa such as Lake Victoria, Congo basin and the Nile fall in regions where conflicts have raged for decades and consequently no detailed biodiversity updates or related environmental data are available. The ecological significance of this area is not limited to global water budget and winter habitat for several western migratory birds. The region is also considered an important sink for carbon dioxide, thus significant to the global carbon budget and all global climate change (U.N.E.P., 2006).

While the governments and the oppositions in countries like Mali, Libya, Egypt, Somalia and Sudan are so busy in fighting each other and allocating most resources and efforts to this, apparently they have forgotten to be united against drought and desertification as the biggest enemy these countries and their people have ever faced. The region has the most severe deforestation worldwide, since vast areas being cleared by millions from local communities who were forced by wars, poverty and lack of development to use forests as their only source for shelter, livelihood, energy, and building materials. There is much to lose: more than 70% of the African tropical forests are located in Democratic Republic of Congo, Rwanda, Burundi, Central African Republic, Sudan and South Sudan, where deforestation related to conflicts is happening every day (Montagnini & Jordan, 2005).

It is important to mention the influences of this continental unrest on the ability of international partners (e.g. U.N.E.P., U.N.D.P., W.W.F., World Bank, U.S.A.I.D., Conservation International, and WCS) to continue funding biodiversity and environmental conservation projects in Africa. Not only is there the direct risks of performing field work or wasting money, but part of this discouragement is because it is very unlikely that conservation plans will achieve the goals of the projects in a sustainable manner.

Despite this dark picture of biodiversity in Africa, there are a couple of bright spots. There is tremendous progress in some countries such as South Africa, Kenya and Tanzania whom just passed through a long history of similar political tragedies but ended up as successful stories. South Africa, after years and years of violence, is a good example of how stability can make development possible. Among several paths of reforms, biodiversity conservation was launched following simple principles based on strong governmental authority and involvement of universities and research centers, local communities and NGOs in planning and management of natural resources. By 2012, official South African reports stated that 9.3 million people come to the country from all over the world for wildlife and ecotourism, which is a great achievement in biodiversity conservation.

My second example is Kenya that came a long way from crises to become the largest center of international and regional environmental organizations in the continent. 'Those trees make Kenya, Kenya!' is a familiar slogan to Kenyans and people who visit Kenya. It represents the vision of the country regarding the environment and indicates awareness and adoption by local communities. Establishing community based-ecotourism organizations is an impressive and creative example that shows what can be done when a committed government works together with responsible NGOs and engaged citizens.

Let me conclude by mentioning the interesting lesson of Tanzania in biodiversity conservation and its significance in stabilizing the economy of the country. There is no doubt that Tanzanian government, with local and international partners, has worked very hard to develop the current working plan for managing protected areas and positioning them as a primary source of income to the country. This wonderful model of managing natural resources is not only a plan for biodiversity conservation, but also made Serengeti, Arusha and other 12 national parks among top tourism areas in the world. The Tanzanian government announced in 2013 that the country has joined the club of 1-million wildlife tourists per year, which is a big achievement. There are also other encouraging attempts by few countries including Zimbabwe, Botswana, Namibia, and Zambia who are relatively stable with well-developed biodiversity plans.

## TOP TEN PROPOSALS FOR BETTER BIODIVERSITY CONSERVATION

The big message I want to convey by this paper is that conservation action is still possible. It is never too late as long as there are peace, stability, willingness, and overall the governmental commitments and engaged citizens and NGOs, no matter how few the resources. Countries can maximize the use of land resources for the benefit of people at the same time as aiming towards sustainable biodiversity conservation. Consistent with this belief and drawing from success stories mentioned above and call by recent reports e.g. U.N.E.P. & I.E.S. (2007) and Badri (2012), I suggest some strategies (Fig. 2) to improve the existed efforts. These would be a great start towards better biodiversity conservation in Sudan as well as elsewhere in the region where conflicts and unrest continue.

### *Management strategies*

1. Governance and Government commitment towards natural resources conservation by supporting annual budgets and strengthening the institutions that formulate and implement the conservation plans with systematic monitoring and evaluation protocols.

2. Improving environmental educational programs especially at secondary and higher education levels by addressing the recent globally important issues (e.g. climate change, endangered species) as annual updates in the curriculum. More broadly, major needs of the education system of Sudan are strengthened policies, curriculum reforms to match international trends (e. g. millennium goals), training of faculty (teachers) and assistant staff, and improved government commitment and funding. I urge adoption of some international (similar educational models) standards such as quality assurance systems that include strict monitoring and evaluation system of the educational process.

3. Adoption of research and scientific methods to identify conservation priority areas (e.g. ecosystem level vs. population level) but also select among many adaptation strategies (e.g. water harvesting vs. enclosures for habitat restoration).

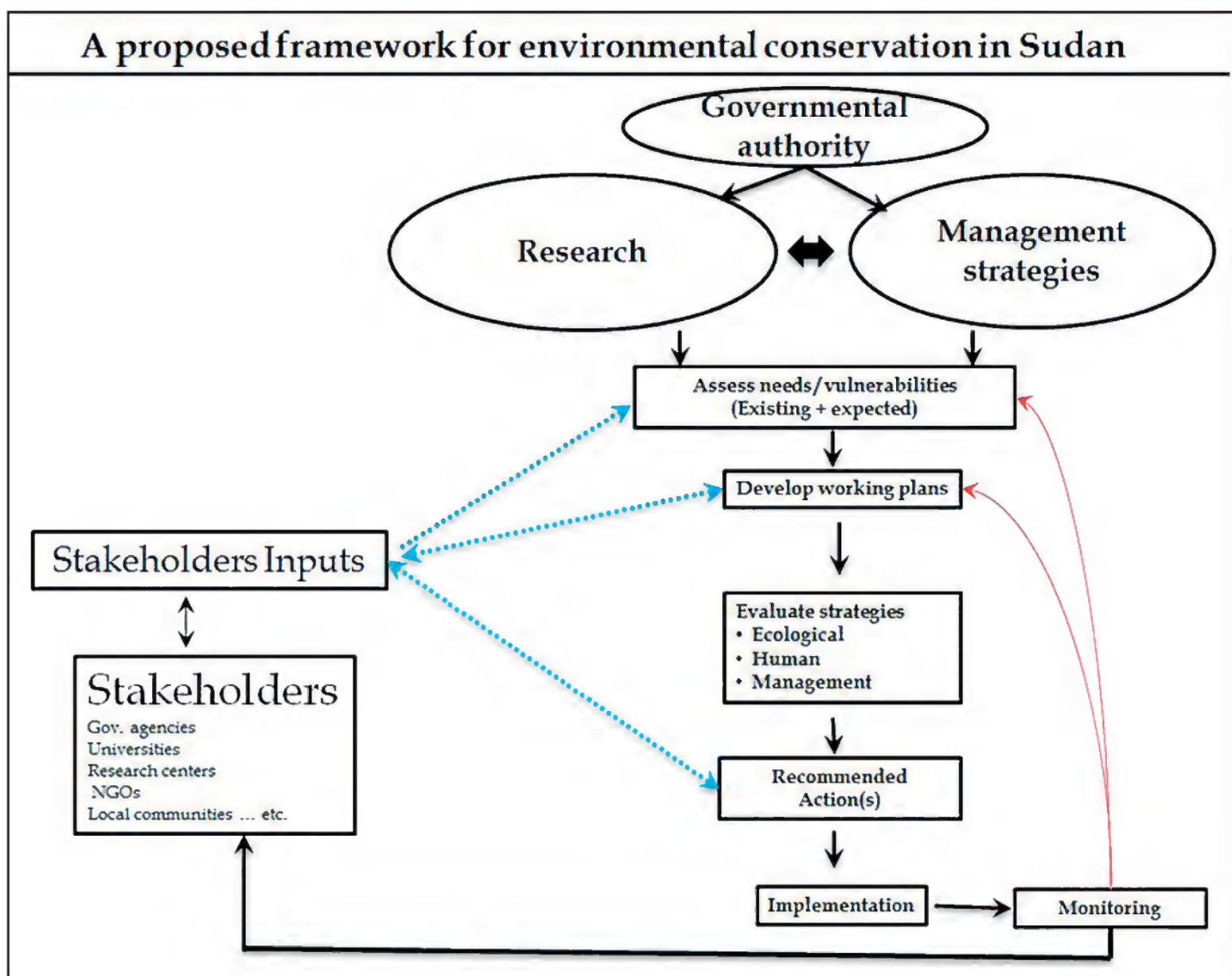


Figure 2. A proposed framework for environmental conservation in Sudan based on the role of the government in initiating research and management plans with consideration of environmental stakeholders.

4. Use of technology in management planning such as remote sensing, GIS, radio collars, camera traps, and acoustic monitoring to improve management and inform decision makers.

5. Adoption of long-term monitoring programs by focusing on specific focal ecosystem indicators (e.g. abundances, composition and richness) and key climatic variables (e.g. amount and length of rainy season) at permanent plots across the country. These monitoring data will be good indications not only for detecting current conditions and trends, but also could alert managers to early warning signals of ecosystem change.

6. Involvement of indigenous communities and nongovernmental stakeholders in conservation planning and implementation. This community

involvement could be achieved by using a citizen science approach that can play two roles at once. While involvements of local communities will likely increase the awareness about certain environmental issues (e.g. risk of deforestation) it could be a cost-effective way to collect biodiversity data such as species occupancy information.

7. Capacity building, especially for natural resources managers, focuses on improving awareness for the reasons to protect biodiversity, identifying hot spots, and building monitoring skills and a documentation system for conservation projects.

8. Enforcing and updating legislation so that conservation efforts are based on the power of law. One sad example though is that National park like Radom is the biggest protected area in the country

but most of its area is dominated by drug cartels farming activities; furthermore there is no government authority inside the park to take actions.

9. Strengthen networking and international partnerships with powerful agencies such as Wildlife Conservation Society (W.C.S.), World Wildlife Fund (W.W.F.), and Nature Conservancy and others to take advantage of their experience in conservation elsewhere.

10. Activating the commitments of Sudan in international environmental conventions (e.g. United Nations Convention on Environment and Development, U.N.C.E.D., United Nations Framework Convention on Climate Change, U.N.F.C.C.C., Convention of Biological Diversity, C.B.D., Convention on international Trade in Endangered Species of Wild Fauna and Flora (C.I.T.E.S.) and protocols (e.g. Kyoto and Ramsar) and following national action guidelines.

### ***Urgent research needs***

My suggestions for management interventions emphasize the adoption of research and scientific approaches. I believe that research must play a key role in the next era of conservation biology in Sudan. Research would diagnose major causes of the deterioration of biodiversity and reveals the hot spots of decline during the past. In addition, research will establish baseline information, identify priorities, and inform future management and investment of resources.

Although the importance of research and science-based decisions has been urged by many authors and reports previously (e.g. Abdelhameed, 2007; Zakialdeen, 2009; Funk et al., 2011), like all things in Sudan, research has encountered many obstacles ranging from funding, to weak institutions and facilities, to absence of master plans, to research capacity (e.g. training). Identifying the most pressing research questions will help to focus limited resources. Based on the work of Sutherland et al. (2009) regarding the top hundred most important questions to conservation of global biodiversity, I scaled down to Sudan and adapted a list of top ten research questions about biodiversity of the country.

The questions are:

### ***1. Desertification and drought***

Studies on the causes of desertification are relatively better and more focused than studies of strategies of control. Despite these efforts there are many research gaps at the country level such as: Where do the greatest effects of desertification occur? What is the encroachment rate of the desert and where does mostly occur (i.e. how many km/yr.)? Also, important related questions remain unanswered, for example: What is the frequency and duration of drought periods? Are there socioeconomic impacts of desertification and drought? What are these impacts and where?

### ***2. Climate change***

The concern with climate change in dry lands is how to adapt to it in the context of the myriad problems already facing these areas. For instance, how to allocate limited resources among many urgent needs - for example, choosing between water harvesting techniques or establishing refugia in protected areas - needs to be studied and choices based on objective (i.e. quantitative) criteria. To design effective studies, it is important that to determine the methods of evaluating the vulnerabilities and effectiveness of adaptations and mitigation measures at any ecosystem.

### ***3. Biodiversity, population dynamics and conservation hot spots***

There is an absence of biodiversity information in Sudan; the I.U.C.N. (2013) reported zeros for many taxa to indicate a data deficit. Therefore, to assess the conservation status of species and to make a baseline for any further questions, we need to know who is where and how many of them are there, particularly at the protected areas. For endangered species, we need to assess the status and likelihood of extinction by conducting a population viability analysis (PVA), a widely adopted technique in conservation biology (Lindenmayer et al., 1993; Vie et al., 2009). Additional key studies that relate conservation and populations dynamics include studies of population characteristics other than abundance. For example, fecundity, age classes and sex ratio data, especially for threatened species, are keys to understanding the population dynamics.

Understanding how human activities (e.g. deforestation by refugees), environmental (e.g., fire) and biological (e.g., disease) disturbances impact populations, communities and metapopulation process are also important.

#### **4. Forest ecology, wetlands and habitat assessment**

Issues like seed germination and natural regeneration of some threatened trees species such as a desert date (*Balanites aegyptiaca* Del.) and *Boswellia papyrifera* Del. are of great concern and should be a priority area of research. Also there is an absence of studies in important areas like the temporary wetlands and flood plains of the Nile. These are thought to be rich ecosystems supporting several fauna and flora species as well as an essential source of livelihood to millions of people living at the Nile strip and tributaries.

#### **5. Ecological modeling and forecasting**

Modeling, simulations and other statistical techniques can be employed to craft very sophisticated ecological questions (e.g. what if) and to improve our understanding about possible future scenarios. Modeling techniques can also integrate data and predictions over large spatial scales (i.e. landscape level).

#### **6. Environmental education**

I believe that education is the right way to start making real changes in biodiversity conservation in the country. However, the current education system is broken and needs to be reformed on scientific basis starting by asking questions like: Does our education meet standards at the levels of international criteria (e.g. international education policies of the U.N.E.S.C.O.)? How could we develop a quality assurance system for higher education institutions generally in Sudan in a cost-effective way? I think by answering these questions we can make sure our environmental education meets the international quality standards in higher education with a monitoring and evaluation system.

#### **7. Environmental risk assessments**

Despite the political instability and unrest, Sudan has witnessed some developmental projects

such new dams, highways and establishment of urban centers. The call here is that biodiversity and risk assessments studies should be considered whenever similar projects are being planned (El-Meghraby, 2009). As violence and conflicts continue in many parts of the country, there is a need to know what exactly the effect of these wars is on biodiversity. I suggest that knowing the effect of a particular civil war that has a certain number of refuges on the surrounding forest cover would be useful to predict the future dynamics of the habitat affected by war.

### **CONCLUSIONS**

Biodiversity is of critical importance to the livelihood of people and is also of high ecological value. Despite its importance, biodiversity in Sudan, as many other resources, has been a victim of political instability and continuous civil wars since the 1950s. Absence of strong governance and policies, and socioeconomic factors have contributed to this substantial deterioration. In addition, the harsh setting, drought, desertification, flooding, fire, habitat destruction and recent climate change have played a great role in reducing habitats and populations.

Despite these stressors on biodiversity and the lack of current information about the ecosystems, communities and populations, conservation efforts must proceed with effective management actions. Urgent management actions at this point should include governance and governmental commitment (e.g. funding, facilities, policies), adoption of research and improving environmental education, adoption of technology and long-term monitoring programs, and involving local communities and NGOs in planning and enforcement of legislations. The government must also stay committed to international environmental conventions and protocols (i.e. U.N.C.E.D., U.N.F.C.C.C., C.B.D., C.I.T.E.S.), Finally, I recommend capacity building and training of conservation practitioners. This would have great value especially if it is conducted in the context of international partnerships with other prominent conservation agencies (e.g. U.S.A.I.D., W.C.S., W.W.F., and The Nature Conservancy).

The research need at this point is to create the bench marks to build upon. Not only questions concerning species richness and abundance are

important. It is also critical to know the effects of different disturbance factors (e.g. desertification and human aspects) on the ecosystems, habitats and populations. Studies investigating the role of biodiversity in the livelihood of local communities as well as the role of communities in conservation should be a priority. The Nile needs more in-depth investigations about its faunal and floral diversity, biogeochemistry, water chemistry and the effects of heavy agricultural and urbanization activities on the environment of the both banks of the Nile. Also areas affected by the conflicts, especially where the effects of refugees and internally displaced people could affect the resources must be a priority of research.

In conclusion, I believe that all researchers and conservation biologists in Sudan share with me the same positive feelings and responsibility about the country's biodiversity and resources. I hope this work to lead to new initiatives from both the government agencies and conservation biologists. I truly want this report to motivate in-depth work and collaborative efforts that will substantially improve the status of biodiversity in Sudan as well as be a model for conservation in the region.

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*Amphidromus (Syndromus) laevus nusleti* n. ssp. (Gastropoda Pulmonata Camaenidae)

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*Agrilus (Agrilus) flechtmanni* n. sp. (Coleoptera Buprestidae)

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LISD - urn:lsid:zoobank.org:act:F12E5C1F-677C-4CCC-842A-48ECE1BC3893

*Paraamphiope* n. g. (Echinoidea Clypeasteroidea)

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LISD - urn:lsid:zoobank.org:act:D3B0F499-CD5C-40E5-A542-A22983781202

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LISD - urn:lsid:zoobank.org:act:B4178B65-CC11-4EF3-AFEF-F39FA97F017F

*Sculpsitechinus* n. g. (Echinoidea Clypeasteroidea)

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LISD - urn:lsid:zoobank.org:act:092F6063-EDD7-4541-B467-E3849258B4E7

*Pseudoapterogyna euphytus lamantiai* n. ssp. (Coleoptera Melolonthidae)

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LISD - urn:lsid:zoobank.org:act:B84231D6-2621-4A12-8957-9CC46F282717

*Pseudoapterogyna michaelis* n. sp.

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*Pterorthochaetes dembickyi* n. sp. (Coleoptera Scarabaeoidea Hybosoridae)

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LISD - urn:lsid:zoobank.org:act:D2EA7A7D-CEB6-4890-80DA-11313C850B9F