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CONFIRMATION OF A NEW SPECIES OF *BUTHUS* LEACH, 1815 FROM SICILY (SCORPIONES, BUTHIDAE). BIOGEOGRAPHICAL IMPLICATIONS

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Abstract: A new species belonging to the genus *Buthus* Leach, 1815 (Scorpiones: Buthidae) is described from Palermo province, in Sicily. *Buthus trinacrius* **sp. n.** shows morphological affinities with *Buthus occitanus* (Amoreux), originally described from southern France, but, in some characters, also with some African *Buthus* species. For morphological, biogeographical and geological reasons, the new species could represent a link between African and European *Buthus* populations. If *Buthus* inhabited the Italian Peninsula in past geological times, it probably regressed and became extinct due to severe climatic modifications which took place since the end of the Tertiary period. Regarding the occurrence in Sicily of *Buthus*, surely still present on the island during the 19th century but maybe extinct now, a possible explanation could be the heavy urbanization of the Palermo region.
Key words: Scorpiones, Buthidae, *Buthus*, new species, geographical link, Sicily, Italian Peninsula.

Confirmación de una especie nueva de *Buthus* Leach, 1815 de Sicilia (Scorpiones, Buthidae). Implicaciones biogeográficas
Resumen: Se describe una especie nueva del género *Buthus* Leach, 1815 (Scorpiones: Buthidae) de la provincia de Palermo, en Sicilia. *Buthus trinacrius* **sp. n.** presenta afinidades morfológicas con *Buthus occitanus* (Amoreux), descrito originalmente del sur de Francia, pero, en algunos caracteres, también con algunas especies africanas de *Buthus*. Por razones morfológicas, biogeográficas y geológicas, la especie nueva podría representar una conexión entre las poblaciones africanas y europeas de *Buthus*. Si *Buthus* ha habitado la Península Italiana en eras geológicas pasadas, probablemente se replegó y se extinguió debido a fuertes modificaciones climáticas después del Terciario. En cuanto a la existencia en Sicilia de *Buthus*, seguramente presente en la isla durante el siglo 19 pero quizás ahora extinguido, una explicación posible sería la fuerte urbanización de la región de Palermo.
Palabras clave: Scorpiones, Buthidae, *Buthus*, especie nueva, conexión geográfica, Sicilia, Península Italiana.

Taxonomy / Taxonomía: *Buthus trinacrius* **sp. n.**

Introduction

In the last decade, following the preliminary revisions of the genus *Buthus* Leach, 1815 proposed by Lourenço (2002, 2003), several new species have been described, in particular associated to the '*Buthus occitanus*' complex.

Almost all new species, however, have been discovered and described from North African deserts (Lourenço, 2003) or from sub-Saharan regions (Lourenço & Leguin, 2012), with a few exceptions for the Middle East such as *Buthus yemenensis* Lourenço 2008, described from Yemen and *Buthus amri* Lourenço, Yağmur & Duhem, 2010 from Jordan (Lourenço, 2008; Lourenço *et al*., 2010).

Even more remarkable have been the discoveries of new species of *Buthus* from European countries. All started with the descriptions of *Buthus montanus* Lourenço & Vachon, 2004 and *Buthus ibericus* Lourenço & Vachon, 2004 from Spain (Lourenço & Vachon, 2004). The second species was subsequently confirmed also for Portugal (Teruel & Pérez-Bote, 2005; Armas & González-Moliné, 2009; Rossi, 2012). More recently, two other *Buthus* species have been described from European regions, *Buthus kunti* Yağmur, Koç & Lourenço, 2011 from Cyprus and *Buthus elongatus* Rossi, 2012 also from Spain.

Buthus populations have never been recorded from the Italian Peninsula. However, in a short note about the genus *Buthus* presented in an article about scorpions from Egypt, Simon (1910) referred to the almost impossibility to distinguish *Buthus* populations from North of Africa with those from Spain and Sicily. Subsequently, only Werner (1934) in his chapter about scorpions on the Brown's Das Tierreich, cited once again Sicily as a possibly locality for *Buthus* populations: "Nordafrika von Senegal bis zum Roten Mer, Pyrenaen-halbinsen, Sudfrankreich, Italien, Sizilien...", probably following Simon's record. In the catalog of the scorpions of the world (Fet & Lowe, 2000) referred to Sicily with an inte-rrogation mark. Vachon (1952) in his monographic studies about the scorpions of North Africa did not refer to any Sicilian population of *Buthus*, although in some unpublished notes dated of 1950, he did listed the specimens cited by Simon (1910).

In several recent field trips to Sicily, respectively at the end of the summer 2012 by the senior author (WL) and on summers of 2010 and 2011 and in March 2013 by the junior author (AR), no *Buthus* specimen were located in the Island. - Presently only *Euscorpius sicanus* (C. L. Koch, 1837) seem to be found in Sicily -. Once back to Paris the senior author carried an intensive search on the old collections of the Muséum in Paris in order to possibly locate the specimens listed by Simon (1910). After several weeks of search, one jar with 2 males and one female were located in the collections and attested to correspond to the original material studied by Simon (1910), but also examined by Kraepelin in 1900 and Vachon on the 1940/1950s. All these authors identified the specimens as *Buthus occitanus* typicus.

The three specimens have probably been collected around the 1870/1880s, but a final date cannot be estimate with certitude. All specimens are very poorly preserved, but

most useful characters for a final diagnosis are yet available. After a careful analysis of all the characteristics presented by the specimens, we arrived to the conclusion that they do have affinities with *Buthus occitanus*, but present several quite distinct characters defining a new species which is described in the present note.

Methods

Illustrations and measurements were made with the aid of a Wild M5 stereo-microscope with a drawing tube (camera lucida) and an ocular micrometer. Measurements follow Stahnke (1970) and are given in mm. Trichobothrial notations follow Vachon (1974) and morphological terminology mostly follows Vachon (1952) and Hjelle (1990).

Taxonomic treatment

Family Buthidae C. L. Koch, 1837

Genus *Buthus* Leach, 1815

***Buthus trinacrius* sp. n.**

Fig. 1-9. Table I.

Sicily. According to Simon' notes the specimens were collected in the Province of Palermo during the 1870/1880s; collector unknown. Male holotype, 1 male and 1 female, paratypes deposited in the Muséum national d'Histoire naturelle, Paris (RS-3247).

Note 1: The specimens have been identified by Simon -1889-, Kraepelin -1900- and Vachon -1940/1950- as *Buthus occitanus*. In his study about the North African *Buthus*, Vachon (1952) did not refer to these specimens. 2. The specimens are old and poorly preserved; however, most useful characters can yet be observable.

ETYMOLOGY: The specific name refers to 'Trinacria', the ancient Greek name of Sicily.

DIAGNOSIS: Scorpion of small to medium size, reaching a total length of 57.6 mm in male and 59.8 mm in female. Coloration is faded but is globally yellowish to pale yellow; no spots are observable; legs and pedipalps without spots. Carinae and granulations very strongly marked, specially on carapace, tergites and metasoma; granulations moderately to weakly marked. Fixed and movable fingers with 10-10 rows of granules. Pectines with 29/30 teeth in males, 25 on female.

RELATIONSHIPS: *Buthus trinacrius* sp. n. belongs to the "*Buthus occitanus*" complex of species. It can be distinguished from the other species of *Buthus* and in particular from *B. occitanus* (Amoureux, 1789), species presently distributed in South of France and part of Spain, by the following characters: (i) *B. occitanus* is larger, measuring up to 70 mm in total length; (ii) the new species has a slightly reduced number of pectinal teeth; (iii) the new species has 10-10 rows of granules on the chela fingers whereas *B. occitanus* has 12-13; (iv) granulations and carinae are strongly marked in the new species; in particular on carapace, tergites and metasomal segments; ventral carinae on segment II and III and latero-ventral carinae on segment V has conspicuous lobular granules; anal arc is also strongly marked.

DESCRIPTION based on male holotype and paratypes. Measurements in Table I.

Table I. Morphometric values (in mm) of the male holotype and female paratype of *Buthus trinacrius* sp. n.

	♂(holotype)	♀(paratype)
Total length (Including telson)	57.6	59.8
Carapace:		
- length	6.4	6.8
- anterior width	4.4	4.7
- posterior width	7.0	7.6
Mesosoma length:	12.0	15.6
Metasomal segment I:		
- length	5.2	4.7
- width	4.5	4.6
Metasomal segment II:		
- length	5.9	5.4
- width	4.3	4.3
Metasomal segment III:		
- length	6.0	5.6
- width	4.2	4.2
Metasomal segment IV:		
- length	6.7	6.6
- width	3.7	3.9
Metasomal segment V:		
- length	8.0	7.8
- width	3.4	3.8
- depth	3.0	3.1
Telson:		
- length	7.4	7.3
- width	3.0	3.3
- depth	2.8	3.1
Pedipalp:		
- Femur length	5.4	5.7
- Femur width	1.7	1.9
- Patella length	6.6	6.8
- Patella width	2.4	2.8
- Chela length	10.7	11.4
- Chela width	2.0	2.5
- Chela depth	2.2	2.8
Movable finger: length	7.2	7.5

Coloration basically yellowish to pale yellow. Prosoma: Carapace yellowish; only the eyes are slightly marked by dark pigment. Mesosoma yellowish with paler stripes. Metasomal segments yellowish without spots over carinae; vesicle yellowish; aculeus yellowish at its base and reddish at its extremity. Venter yellowish; pectines pale yellow. Chelicerae yellowish without variegated spots; fingers yellowish with dark reddish teeth. Pedipalps yellowish; fingers with the oblique rows of granules slightly reddish. Legs pale yellow without spots.

Morphology. Carapace moderately to strongly granular; anterior margin straight. Carinae strongly marked; anterior median, central median and posterior median carinae strongly granular, with 'lyre' configuration. All furrows moderate to strong. Median ocular tubercle at the centre of carapace. Eyes separated by almost three ocular diameters. Three pairs of lateral eyes of small size. Sternum triangular and narrow; wider than long. Mesosoma: tergites moderately to strongly granular. Three longitudinal carinae moderately to strongly crenulate in all tergites; lateral carinae reduced in tergites I and II. Tergite VII pentacarinate. Venter: genital operculum divided longitudinally, which plate with a semi-oval shape. Pectines: Pectinal tooth count 30-30 in male holotype (paratypes with 30-29 in male, 25-25 in female); middle basal lamella of the pectines not dilated in both sexes. Sternites without granules, almost smooth with elongated spiracles; four carinae on sternite VII; other sternites acarinated and with two weak furrows. Metasomal segments with a weak setation; segments I to III with ten crenulated carinae, ventral

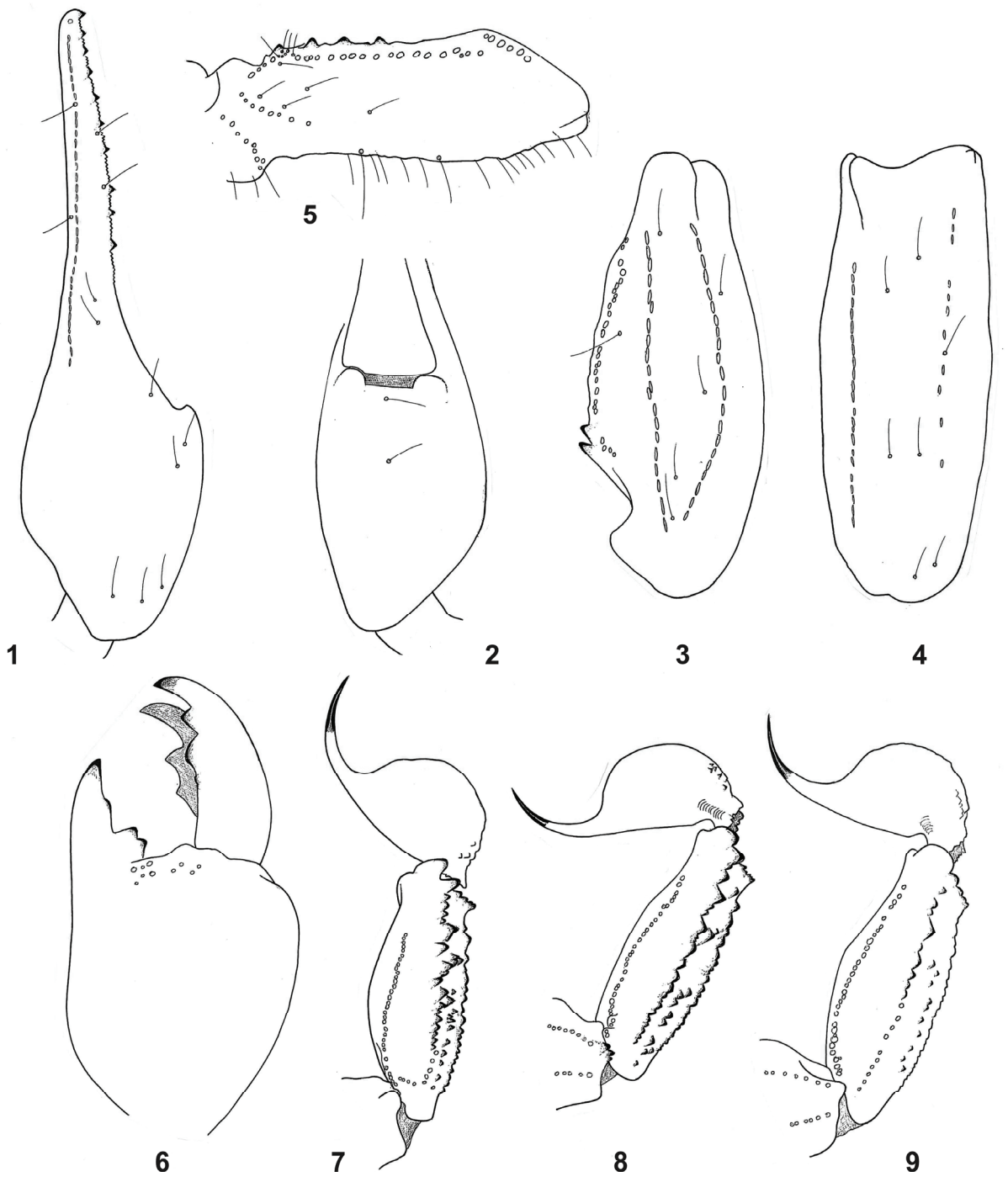

Fig. 1-5. *Buthus trinacrius* sp. n. Female paratype. Trichobothrial pattern. **1-2**. Chela dorso-external and ventral aspects. **3-4**. Patella, dorsal and external aspects. **5**. Femur, dorsal aspect. **Fig. 6-8.** *Buthus trinacrius* sp. n. Male holotype and female paratype. **6**. Chelicera, dorsal aspect (male). **7-8**. Metasomal segment V and telson, lateral aspect (female and male). **Fig. 9**. Idem, *Buthus occitanus*, male from Banyuls, South of France.

strongly marked on II-III with lobate granules; segment IV with eight carinae, crenulated; the first four segments with a smooth dorsal depression; segment V with five carinae; the latero-ventral carinae crenulate with 3-4 strong lobate denticles posteriorly; ventral median carina only slightly divided posteriorly; anal arc composed of 8-9 ventral teeth, and two spinoid lateral lobes, better marked on female. Intercarinal spaces weaky granular, almost smooth. Telson with a few minute granulations, almost smooth; aculeus curved and shorter than the vesicle, without a subaculear tubercle. Chelicera dentition as defined by Vachon (1963) for the family Buthidae; external distal and internal distal teeth approximately the same length; basal teeth on movable finger small and partially fused; ventral aspect of both fingers and manus covered with long dense setae. Pedipalps with a weak setation; femur pentacarinate; patella with eight carinae; all faces weakly granular to smooth; chela smooth, with vestigial carinae. Fixed and movable fingers with 10-10 oblique rows of granules. Internal and external accessory granules present, strong; four accessory granules on the distal end of the mova-

ble finger next to the terminal denticle. Legs: tarsus with two longitudinal rows of thin and long setae ventrally; tibial spur strong on legs III and IV; pedal spurs moderate on legs I to IV. Trichobothriotaxy: trichobothrial pattern of Type A, orthobothriotaxic as defined by Vachon (1974). Dorsal trichobothria of femur arranged in β (beta) configuration (Vachon, 1975).

Biogeographical and ecological implications

The tectonic evolution of the western Mediterranean Sea since the Oligocene was the subject of several studies for almost a century (Rosenbaum et al., 2002) and the most interesting aspect regarding the current distribution of animals and plants in the region is the possible existence of 'land-bridges' as a real link between Africa and Europe; for this reason, they are also called 'continental-bridges'. During the Messinian Salinity Crisis, in the late Miocene (5.96 to 5.33 Ma) many plants had the opportunity to expand across the Mediterranean since the desiccation of the Sea during this age formed land bridges that facilitated this process (Fernández-Mazuecos & Vargas, 2011).

The two possible points of contact between North-Africa and South Europe, in ancient age, are the strait of Gibraltar and the Sicily channel. Presently the distance between continents in the area of Gibraltar is still little (only 14 km from Punta de Tarifa and Punta Cires) instead the distance between Sicily and Tunisia is at least of about 100 km. However, the reconstruction of Western Mediterranean Sea made by geologists (Rosenbaum *et al*., 2002) showed clearly that Sicily was linked to Africa for a long time.

Recently, with the aim to confirm a possible land-connections, biologists did genetic fingerprinting on plants of the genus *Linaria* across Mediterranean and the well-supported subdivision of its range between Iberian clade and northern African clade is congruent with lineage isolation that followed the opening of the Strait of Gibraltar in the early Pliocene (Fernández-Mazuecos & Vargas, 2011). Concerning a post-Messinian land-bridge between Sicily and Africa, genetic fingerprinting on plants of the genus *Ambrosina* attest this theory (Troia *et al*., 2012). In fact the data show a strong genetic affinity between populations from Sicily and Tunisia giving evidence of a past, but relatively close to recent time continuity between the two groups of populations and consequently also between the two areas.

Regarding a possible connection between Africa and Europe in scorpion fauna, Lourenço *et al*. (2012) described a new species of *Buthus* from the region of Al-hamra, in northern Morocco, very near to Southern Spain, and noted that the most closely related species was *Buthus ibericus* Lourenço & Vachon, 2004, previously described from Cadiz province in Spain but common also in Southern Portugal (Sousa *et al*., 2010); thus *Buthus confluens* Lourenço, Touloun & Boumezzough, 2012 could be the first possible link between Moroccan and European populations and the confirmation of a *Bu-thus* population from Sicily could be an important additional proof of an ancient connection between Europe and North-Africa (fig. 10).

Buthus is generally considered an African element and the route used in this genus in its dispersal to Europe from Africa is generally considered to be the Iberian Peninsula (Sousa *et al.*, 2010; Fet, 2010). The presence of *Buthus trinacrius* sp. n. in Sicily could be represent a not yet discussed route of colonization from Africa to Europe.

Very recently, additional genetic studies on *Euscorpius sicanus*, a species common in Sardinia, Sicily, South Italy and also sometimes reported from North-Africa, have shown that the populations of *E. sicanus* in Tunisia are not the result of a recent introduction by human activities but that this presence in North-Africa represents a relict population (Graham *et al*., 2012). In that genetic study, the specimen from Tunisia was estimated to have diverged from the specimen from Sardinia sometime between the Late Miocene and late Pliocene, with a mean divergence date estimate of 5.56 Ma, and these data could support again the theory about land-bridges between North-Africa and Southern-Europe.

The question if *Buthus trinacrius* sp. n. is still present in Sicily is open. Di Caporiacco (1950) in his monography about the genus *Euscorpius*, discussed about the possible presence of *Buthus* in Italy and concluded that the old Italian records are probably erroneous since no Italian *Buthus* were present in the Italian museums' collections. Only recently we were able to check if any Italian *Buthus* is present in the European museums' collections that could host the specimens cited in the old records. In our knowledge no *Buthus* specimens from Sicilia are present in the collections of the biggest Italian Museums (Milano, Torino, Genova, Firenze, Bergamo, Verona and Palermo) and also in the Museum of Wien, in Austria, where Werner worked. The type material found in the Muséum in Paris, cited by Simon are, for the moment, the only known specimens of *Buthus trinacrius* sp. n. deposited in a Scientific Institution.

Presently in Palermo and Trapani Provinces (both in Western Sicily) there are large areas of xeric habitat, typical for the genus *Buthus*, but it is possible that the relict population of *Buthus trinacrius* sp. n. could be by now already totally vanished or could become soon extinct due to the important urbanization of the region and city of Palermo, since the species of this genus are not sinantropic as other Buthidae species may be. A similar situation was reported also for *Buthus orientalis* in Egypt, near the city of Alexandria (Lourenço & Simon, 2012).

Taxonomic, ecological and biogeographic comments added to the note after revision by referees

In their revision of the original manuscript, two anonymous referees address a number of questions. We attempt to reply to these questions here.

1. Sicily could be a wrong original locality due to a mislabelling problem?

We are convinced that this is not the case. E. Simon, even if he was not always very attentive with types, was very much worry about the origins of the material he could study. Two pertinent examples connected to the genus *Buthus* can be cited: **a**. The existence of a *Buthus* species from Cyprus in his collection, what was rejected by other authors, but finally described by Yağmur et al. (2010), based on recently collected material. **b**. the recent description of a *Buthus* species from Alexandria, also based on material from the Simon's collection (Lourenço & Simon, 2012).

2. The Sicilian population could represent an African species introduced to Sicily in recent historical times by human agency?

Fig. 10. Map of Europe showing the distribution of *Buthus occitanus* (dashed area) and the type localities of the known species: *B. elongatus* (circle); *B. ibericus* (square); *B. kunti* (asterisk); *B. montanus* (triangle); *B. occitanus* (cross potent); *B. trinacrius* sp. n. (rhombus).

We disregarded this hypothesis for two main raisons: **a**. The Sicilian new species is not co-specific to any known African population of *Buthus* from North Africa, and in particular to those distributed in Tunisia. To recall that most North African species of *Buthus* have recently been revised by the first author (Lourenço, 2003). **b**. If some scorpion species can 'travel' via human agency and create newborn colonies such as examples from the genera *Isometrus*, *Centruroides* and *Euscorpius*, others are only sporadically transported by humans. A few cases of transportation from Africa to Europe are detected every year, but to our knowledge they did not concern the species of *Buthus*, *Androctonus* or *Leiurus*. This is probably due to the low opportunistic capacity of the large species of these genera (Lourenço, 1991).

3. The new species is compared only to *Buthus occitanus*?

This is not precisely true. Other species from Europe were compared on the preliminary taxonomic analysis and proved to be relatively distant from the new species from Sicily. It happens that the most related species is *B. occitanus* which was used in the resumed relationships.

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