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New taxonomic data on some populations of *Carabus* (*Macrothorax*) *morbillosus* Fabricius, 1792 (Coleoptera Carabidae)

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ABSTRACT In this work we give new taxonomic data on some, little known, populations of *Carabus* (*Macrothorax*) *morbillosus* Fabricius, 1792 (Coleoptera Carabidae). In particular, *C. morbillosus lampedusae* Born,1925 described from Lampedusa Island (Sicilian Channel, Italy) is reconsidered a valid subspecies and are designated the lectotype and paralectotypes. Similarly, *Carabus morbillosus bruttianus* Born, 1906 described from Southern Calabria is considered a distinct subspecies, including the populations of *C. morbillosus* from North-Eastern Sicily.

KEY WORDS Coleoptera; *Carabus*; taxonomy; W-Mediterranean.

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INTRODUCTION

Carabus (*Macrothorax*) *morbillosus* Fabricius, 1792 (Coleoptera Carabidae) locus typicus "Mauretania" is a widely W-Mediterranean distributed species (La Greca, 1964; 1984; Vigna Taglianti et al., 1993; Parenzan, 1994) including several populations, even insular, more or less fragmented and differentiated, widespread in Southern France, southern Spain, Morocco, Algeria, Tunisia, Corse, Sardinia, Tyrrhenian central Italy, Southern Calabria, Sicily, Sicilian islands, and Malta.

From the biogeographic point of view, as the whole subgenus *Macrothorax* Desmarest, 1850, *C. morbillosus* is considered a "Tyrrhenian" element (Jannel, 1941 Antoine, 1955; La Greca, 1964; 1984; Casale et al., 1982) with all connected hypotheses and opinions on the origin and spread of the group. Some populations also seem to be originated from passive transport and, later, acclimatized (see Casale et al., 1989).

Currently, in Italy, are reported: *C. morbillosus morbillosus* in Sardinia, Lampedusa and some stations in Central Italy; *C. morbillosus alternans* Palliardi, 1825 (locus typicus: Sicily) in Sicily, Sicilian islands, and Calabria (Casale et al., 1982; Vigna Taglianti, 1995; Vigna Taglianti et al., 2002). In the "European Fauna" (Vigna Taglianti, 2015) the populations of North Africa, Sardinia and Lampedusa are attributed to *C. morbillosus constantinus* Kraatz, 1899 (locus typicus: Constantine, Algeria).

Carabus morbillosus is an euriecious species living in open areas or with sparse vegetation, often in ruderal areas, urban gardens and crops, under stones and debris, from the sea level up to about 1000 m a.s.l. *Carabus morbillosus alternans* is found in forests and wooded fields, as oak and eucalyptus groves (Bosco Ficuzza, Piazza Armerina, Bosco di Santo Pietro, etc.). It is present almost all year long, mainly active from September to April-May.

In this work we provide new taxonomic data on some little known populations of *C. morbillosus*.

In particular, *C. morbillosus lampedusae* Born, 1925 described from Lampedusa Island, is reconsidered as "bona subspecies" and its Lectotype and Paralectotyes are designated; the same is also for *C. morbillosus bruttianus* Born, 1906, described from Southern Calabria to which we attribute also the populations of *C. morbillosus alternans* from North-Eastern Sicily.

ABBREVIATIONS AND ACRONYMS. ETZH: Entomological Collection of ETH, Zurich, Switzerland; ex/s: exemplair/s; RC: Ivan Rapuzzi collection, Prepotto, Italy; SC: Ignazio Sparacio collection, Palermo, Italy.

SYSTEMATICS

Carabus* (*Macrothorax*) *morbillosus lampedusae
Born, 1925

EXAMINED MATERIAL. *Carabus morbillosus lampedusae*. ETZH: male (Fig. 1). Length: 30.10 mm; width elytra: 10.85 mm; length elytra: 18.80 mm; width pronotum: 7.80 mm; length pronotum: 6.20 mm. Three labels: "Insel Lampedusa" (handwritten by Born on circular label); "53.565" (print label), "Carabus morbillosus lampedusae?" (handwritten in blu color, more recent and different calligraphy than original labels from Born); red label with present designation of the "Lectotype". Paralectotypes, 2 males (ETZH), two labels each specimens: "53.566" (print label); length: 30.50 mm; width elytra: 11.70 mm; length elytra: 19.00 mm; width pronotum: 7.60 mm; length pronotum: 6.20 mm. "Carabus morbillosus lampedusae?" (handwritten in blu color, more recent and different calligraphy than original labels from Born). "53.567" (print label); length: 30.30 mm; width elytra: 11.35 mm; length elytra: 18.80 mm; width pronotum: 7.95 mm; length pronotum: 6.00 mm. "Carabus morbillosus lampedusae?" (hand-written in blu color, more recent and different calligraphy than original labels from Born); red label with present designation of the "Paralectotype".

Other examined material. *Carabus morbillosus lampedusae*. ITALY, SICILY. Lampedusa Island (Agrigento), 15.V.1983, I. Sparacio legit, 3 males and 2 females (CS); idem, 10.II.2013, G. Maraventano legit, 2 males and 2 females (CS); idem, III.2014, T. La Mantia legit, 2 males and 4 females (CS); Lampedusa (RC), 1 female; Lampedusa Island, 4.II.1994, M. Romano legit, 2 males and 1 female (RC); Lampedusa Island, XI.2012, A. Corso legit, 3 males and 1 female (RC).

Carabus morbillosus costantinus. TUNISIA. Saouaf-El Fahs, 10.V.1992, 1 female (CS); Hammamet, 25.IV.1998, 2 males (CS); El Fahs-Zaghouan, 28.IV.1998, 2 females (CS); Tabarka, 3/9.VI.1996, 10.V.1992, 5 males and 6 females (CS); Tunisi, Cap Gammarth, 4.IV.2014, 5 males and 4 females (CS), Tunisia, Bezeste, III.1982, 1 male (RC); Tunisia, Ain Draham, 11/20.VI.2008, G. Sama & P. Rapuzzi legit, 1 female (RC).

REMARKS. *Carabus lampedusae* was originally described by Born (1925) as a subspecies of *C. morbillosus* from Lampedusa Island (Sicilian Channel, Italy) without designation of the holotype. We had the opportunity to examine three male specimens preserved in the Entomological Collection of ETH Zurich, ex Born collection from Lampedusa Island, and we have designated the lectotype and paralectotypes. All the three specimens are well preserved.

From the systematic point of view, *C. morbillosus lampedusae* was considered mostly a variety or a synonym of the nominate subspecies of North Africa (Luigioni, 1929 sub *morbillosus* v. *lampedusae*; Breuning, 1932-36: sub natio *costantinus*; Porta, 1949 sub var. *constantinus*; Magistretti, 1965 sub *C. morbillosus morbillosus* natio *costantinus*; Casale et al., 1982 sub *C. morbillosus morbillosus*; Deuve, 2004 sub *costantinus*).

Based on the examined material, we believe "*lampedusae*" a valid subspecies of *C. morbillosus*, separate either from North African populations, which is related to, or from the Sicilian ones, that are more differentiated in morphology. In particular, *C. morbillosus lampedusae* differs from the populations of North Africa by its squat and convex body-shape, a darker and less bright color, with a dominant chromatic variety characterized by dark pronotum and dark green elytra in the middle, and red on the sides; pronotum has wider and deeper basal dimples with hind angles more sinuate on the sides; the 1st elytral interstria shows shallow points, well distinct and little confluent.

Hence, *C. morbillosus lampedusae* would be comprised within the group of autochthonous species of Lampedusa, of apparent North African origin, morphologically differentiated in insularity

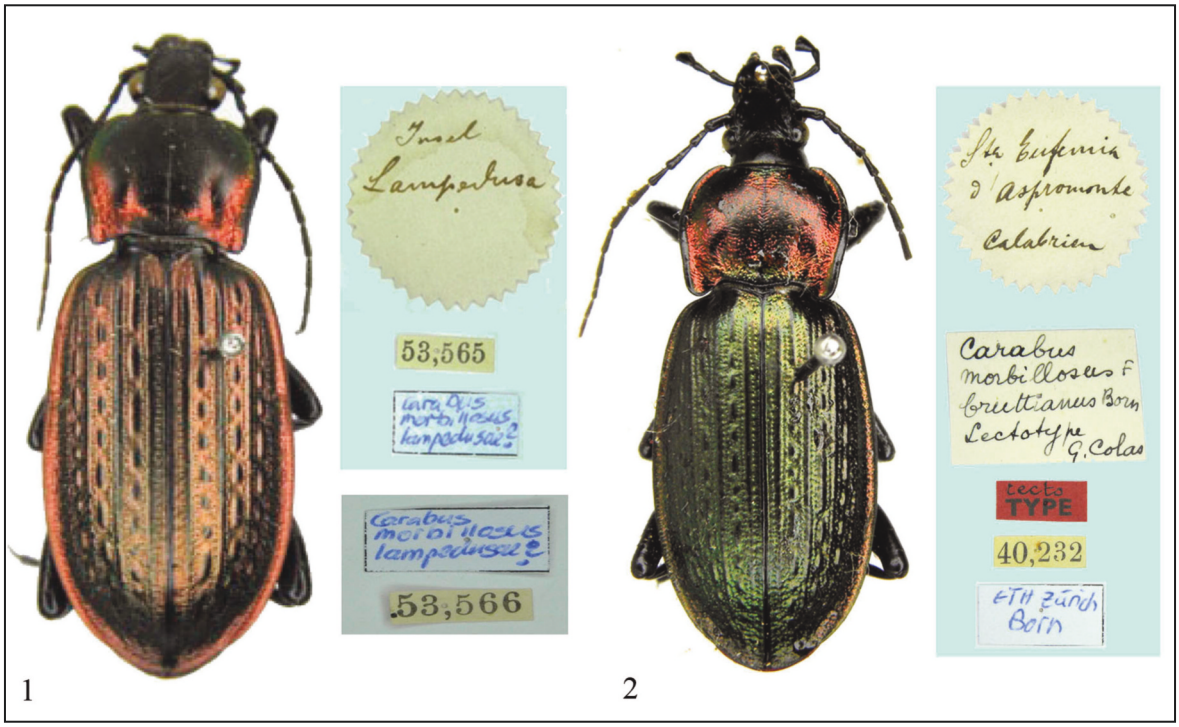

Figure 1. *Carabus* (*Macrothorax*) *morbillosus lampedusae* Born, 1925, lectotype with original labels.
Figure 2. *Carabus* (*M.*) *morbillosus bruttianus* Born, 1906 lectotype with original labels.

conditions. In the Conclusion section (see below), we report morphological characters that distinguish these populations to each other and those characterizing the populations under study in this work.

Carabus* (*Macrothorax*) *morbillosus bruttianus Born, 1906

Examined material. ITALY, CALABRIA. *Carabus morbillosus bruttianus*. Lectotype male, Sta Eufemia d'Aspromonte, Calabrien (ETHZ) (Fig. 2); idem, Paralectotype female (ETHZ).

Other examined material. Calabria. Reggio Calabria dintorni, I. Sparacio legit, 8.XI.1999, 5 males (RC); Reggio Calabria dintorni, 5.III.2004, I. Sparacio legit, 2 males and 1 female (RC); Reggio Calabria dintorni, 8.XI.1999, 6 males and 5 females (SC); Reggio Calabria: Campo Calabro, 8.XI.1999, 6 males and 2 females (SC); Torrente Zagarella, 8.XI.1999, 8 males (Fig. 5) and 11 females (SC); Gioia Tauro, 9.XI.1999, 13 males and 10 females (SC). ITALY, SICILY. Messina dintorni, 4.XI.2001, 13 males (Fig. 4) and 9 females (SC); Messina, Monte Ciccia, 4.III.2004, 7 males and 7 females (SC); Messina: Colle San Rizzo, 4.XI.2001, 3 males and 1 female (SC); Messina: Faro, 4.III.2004, 2 males and 2 females (SC); 3 males (SC); Messina, Torrenova, VIII.2013, A. Tetamo legit, 1 male (SC); Messina dintorni, 4.XI.2001, I. Sparacio legit, 1 male and 1 female (RC); Messina, Monte Ciccia, 4.III.2004, I. Sparacio legit, 2 males (RC); Lipari, Isole Eolie, V.2014, P. Lo Cascio legit, 3 males and 1 female (SC).

Carabus morbillosus alternans. ITALY, SICILY. Palermo. Carini, 9.X.1978, 3 males and 4 females; idem, 1.V.1979, 1 male (SC); Palermo, 18.X.1978, 1 male and 1 female; idem, 7.II.1979, 1 male; idem, 30.III.1980, 1 female (SC); Palermo: Sferracavallo, Grotta Conza, 3.XI.1978, 2 females (SC); Godrano, 25.XI.1978, 1 male and 2 females (SC); Palermo: Sferracavallo, 14.I.1979, 2 males; idem, 13.V.1980, 1 female (SC); Piana degli Albanesi, 8.II.1979, 3 males and 3 females; idem, 6.II.1992, 1 male and 3 females; idem, 15.IV.1995, 1 female (SC); Palermo: Favorita, Vallone del Porco, 3.III.1979, 1 male and 2 females (SC); Bosco Ficuzza, 21.XI.1979, 1 male (Fig. 3) and 1 female; idem, 9.II.1987, 1 female;

idem, 28.I.1989, 1 female (SC); Altofonte, 1.III.1981, 1 male and 1 female (SC); Altofonte: Poggio San Francesco, 13.III.1981, 1 male (SC); Cefalù, 7.XI.1987, 1 female (SC); Palermo: Mondello, 18.IX.1988, 1 male (SC); Capaci, 25.II.1989, 1 female (SC); Monreale: Giacalone, 12.I.1992, 3 males and 1 female (SC); Ficuzza: Bivio Lupo, 25.II.1992, 1 male; idem, 13.XI.2001, 2 males (SC); Santuario di Gibilmanna, 23.X.1994, 1 male (SC); Lercara Friddi: S. Caterina A.D., 24.X.2004, 2 males (SC); Bagheria: Monte Catalfano, 14.X.2006, 1 female (SC); Roccamena: Maranfusa, 25.IV.2008, 1 female (SC); Prizzi, 12.VI.2009, 1 male and 1 female (SC); Palermo: Micciulla, 4.IV.2010, T. La Mantia legit, 1 male (SC); Rocca Entella, 18.XI.2011, 3 males (SC); Ficuzza: Gorgo del Drago, 25.XI.2012, 2 females (SC); Diga Poma, 10.XI.2013, 1 male and 1 female (SC); Trabia: Pizzo Cane, XI.2014, 2 males and 1 female (SC); Cefalù, Settefrati, VI.1984, 1 male (RC); Ficuzza, Godrano, XI/XII.2010, I. Rapuzzi & L. Caldon legit, 70 exs males and females (RC); Palermo, 13.III.1992, 1 female (RC); Gibilmanna, 500 m, VII.1984, 1 exs (resti) (RC); Piana d. Albanesi, 700/800 m, III.1988, 1 male and 1 female (RC); Isnello, 700 m, III.1988, 2 males (RC). Trapani. Erice, 12.XI.1972, M. Romano legit, 1 male and 1 female (RC); Campobello di Mazara, Cave di Cusa, 28.XI.2009, 3 males and 3 females (RC); Mazara costiera, 13.I.1985, 1 male and 2 females (RC); Capo Granitola, 30.I.1986, V. Castelli legit, 2 males and 3 females (RC); Mazara, 3.II.1985, V. Aliquo' legit, 1 male and 1 female (RC); Selinunte, 24.XI.2002, I. Rapuzzi & L. Caldon legit, 2 males and 6 females (RC); Segesta, 15.II.2011, I. Rapuzzi & L. Caldon legit, 4 males and 2 females (RC); Santa Ninfa, XI.2009, I. Rapuzzi & L. Caldon legit, 1 male and 1 female (RC); Mazara del Vallo, 28.XI.1979, 2 males and 3 females (SC); San Vito Lo Capo (Trapani), 14.X.1984, 3 males (SC); Monte Cofano, 14.X.1984, 1 female (SC); Castellammare del Golfo, 12.XII.1984, 2 males and 1 female (SC); Cave di Cusa, 14.XII.2003, 2 males; idem, 31.XII.1988, 3 females (SC); Foci Fiume Belice, 20.IV.1989, 1 female (SC); Foci Fiume Birgi, 6.XI.1993, 1 female (SC); Selinunte, 3.XII.1995, 1 male and 1 female (SC); Valderice, I.2014, 4 males

Figure 3. *Carabus* (*Macrothorax*) *morbillosus alternans* male, Bosco Ficuzza, Palermo, Sicily. Figure 4. *Carabus morbillosus bruttianus* male, Messina surroundings, Sicily. Figure 5. *Carabus morbillosus bruttianus* male, Torrente Zagarella, Reggio Calabria, Calabria (Photos by M. Romano).

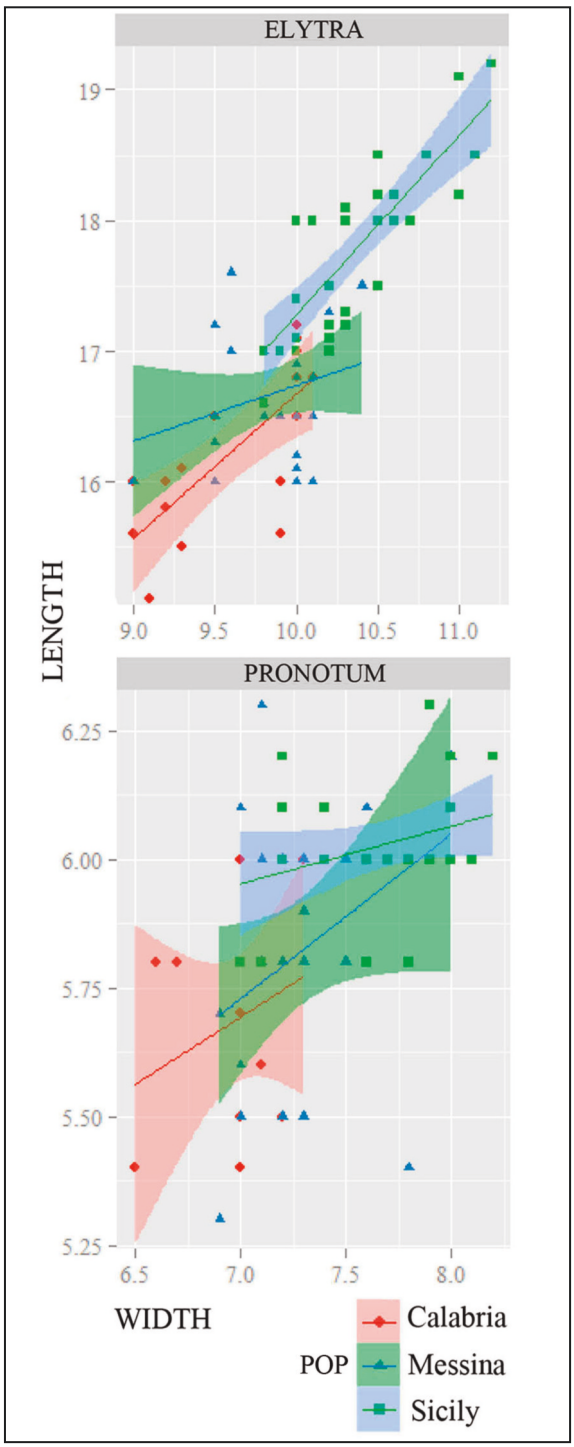

Figure 6. Scatterplot of the relationship between length and width of elytra (upper) and pronotum (bottom) for three populations examined. Are shown the regression lines with the associated confidence intervals (95%). Values of Correlation coefficents for width/length of elytra in the three populations are: Calabria 0.68*, Messina 0.25, Sicilia 0.78*. Those for width/length of pronotum are: Calabria 0.15, Messina 0.42*, Sicilia 0.46*. (* P≤ 0.05).

Pronotum	Standardized coefficients		Pooled- within-groups correlations	
	Root 1	Root 2	Root 1	Root 2
Elytra Lenght	-0.782	1.007	-0.971	0.239
Pronotum Width	-0.305	-1.238	-0.790	-0.613
Eigenval	1.346	0.038		
Cum.Prop	0.973	1		

Table 1. Standardized coefficients (left) e Pooled-within-groups correlations (right) for the two variables selected by correspondence analysis.

	Means of Canonical Variables	
Pop.	Root 1	Root 2
Calabria	1.480	0.256
Messina	0.570	-0.235
Sicily	-1.283	0.067

Table 2. Means of Canonical Variables for the three examined populations.

		Cases		
	Percent correct	Calabria	Messina	Sicily
Calabria	56.3	9	7	0
Messina	73.1	4	19	3
Sicily	76.7	0	7	23
Total	70.8	13	33	26

Table 3. Classification Matrix. The first column shows the percentages of observations properly attribuited to each population using discriminant analysis. The remaining columns show the number of cases falling into each population (diagonally, cases correctly classified).

and 3 females (SC). Agrigento. Agrigento, 21.I.1973, 1 male (RC); Agrigento: Valle dei Templi, I.1972, 1 male and 1 female (RC); Agrigento: Valle dei Templi, 9.II.1987, 1 female; idem, 2.I.1989, 1 male and 1 female (SC). Caltanissetta. Monte Capodarso: F. Imera meridionale, 5.VI.2006, 1 male (SC); Ponte Cinque Archi, 14.II.2015, 2 males (SC). Enna. Valguarnera (Enna), 25.IX.1979, 1 male (SC); Piazza Armerina: Monte Rossomanno, 10.III.2008, 1 female (SC); Piazza Armerina, XI.2009, I. Rapuzzi & L. Caldon legit, 1 female (RC). Syracuse. Vendicari, 18.VIII.1993, 2 males and 1 female (SC); Priolo, 28.XI.2010, 3 males; idem, 5.III.2011, 1 fe-

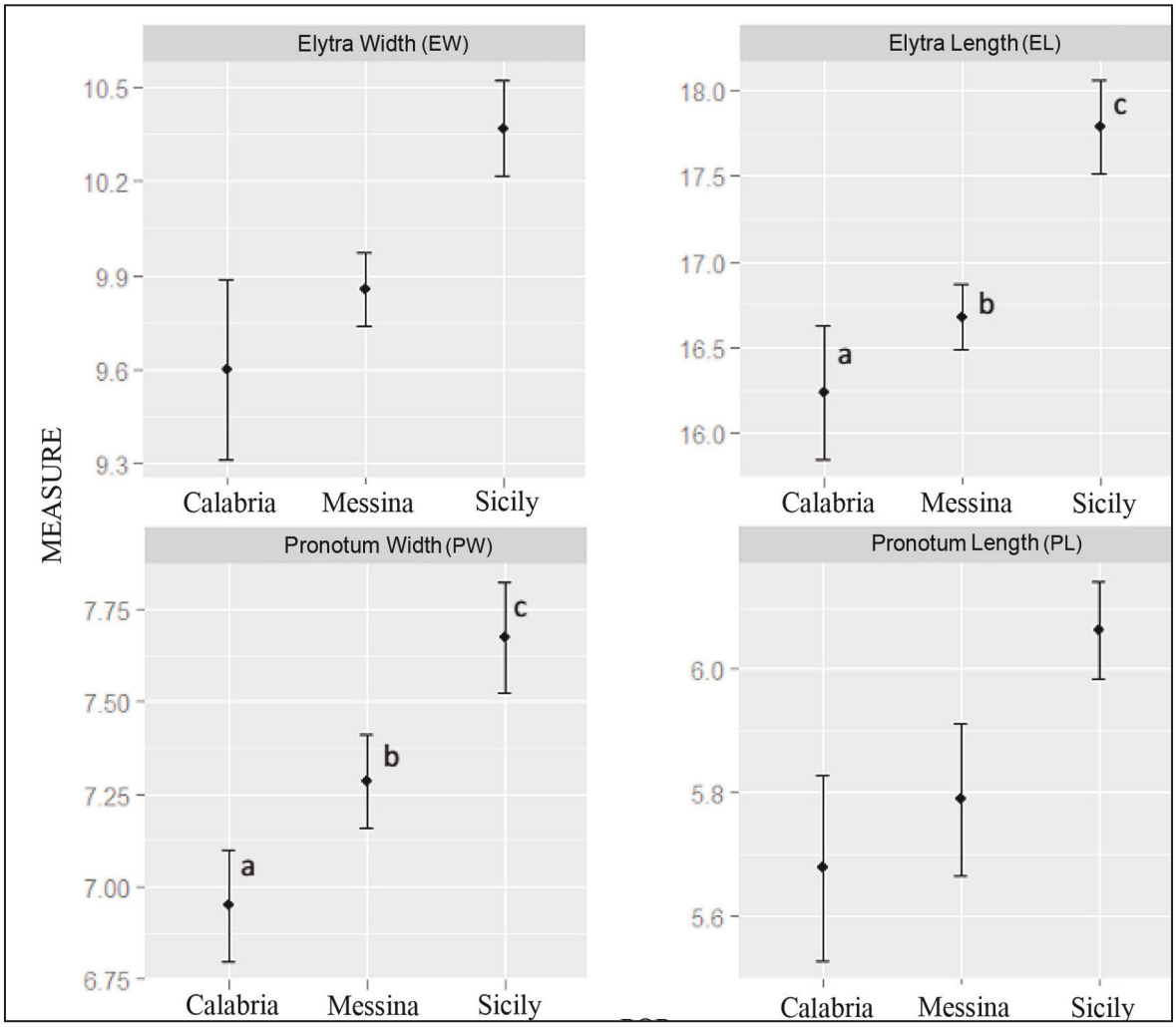

Figure 7. Comparison of means, and confidence intervals (95%) among the three popultions for the four variables examined. For the variables selected by discriminant analysis (PW and EL) are shown the values of significance in multiple comparisons. PW: Messina/Calabria t = 3.211**; Sicilia/Calabria t = 7.426***; Sicilia/Messina t = 4.772***. EL: Messina/Calabria t = 2.412*; Sicilia/Calabria t = 8.520***; Sicilia/Messina t = 6.983***.

male (SC); Magnisi, 28.XI.2010, 2 males and 1 female (SC); Palazzolo Acreide, 5.III.2011 (SC); Vizzini, 14.II.2015, 1 male (SC). Messina. Nebrodi Mts., North from Capizzi, 1250 m, 23.VII.1991, 1 male (RC).

DISCRIMINANT ANALYSIS. We also made a biometric study on 30 male specimens of *C. morbillosus alternans* from Sicily, with the exception of the north-easternmost regions, 16 male specimens of *C. morbillosus bruttianus* from Southern Calabria and 26 males attributed to *C. morbillosus bruttianus* from Messina surroundings. The following measures were examined: pronotum width (PW), pronotum length (PL), elytra width (EW), and elytra length (EL). In figure 6 are shown the graphs of the relationships between length and width of elytra and pronotum for the three populations. Our findings showed significant results when comparing *C. morbillosus alternans* and *C. morbillosus bruttianus* (Calabria and Messina); whereas slight differences were observed between the two populations of *C. morbillosus bruttianus* from Calabria and Messina.

In order to identify which one of the four morphometric characters used allows to distinguish the three populations of *C. morbillosus* it was used the discriminant functions analysis. Variable selection was done by the "Forward stepwise". The res-

ulting model shows a discriminating value not high but still significant (Wilks' Lambda: 0.4107060 approx. F (4.136) = 19.05342; p <, 0000). Variables selected from the analysis are: EL and PW. Partial lambda values (0.761599 and 0.932681, respectively) indicate that EL followed by PW have the most discriminating power among the three populations examined. The analysis produced two linear functions, Root1 and Root2, the first appears negatively correlated mainly with "elytra length" and, to a lesser extent, with "pronotum width" (Table 1) and discriminates the population of Calabria from that of Sicily (Table 2). The second is negatively correlated with pronotum width (Table 1) and, although possess a low discriminatory power, partially contributes to distinguish the population of Calabria from that of Messina (Table 2).

In addition, the Mahalanobis distance between the centromeres of the three populations, although it is significant for all comparisons, shows high values only between Calabria and Sicily (Messina/Calabria 1,116 *; Sicily/Calabria 8,004 ***; Sicily/Messina 3,673 *** . (P: *** ≤ 0.001; ** ≤ 0.01; * ≤ 0.05). The classification matrix (Table 3) shows that more than 70% of the specimens from Messina and the rest of Sicily are properly classified, while this percentage drops to around 56% for specimens from Calabria.

To assess whether the averages of each of the two variables identified with the discriminant analysis significantly differ among the three populations, it has been carried out the analysis of variance (Fig. 7). Multiple comparisons were performed with the correction of Turkey. For both characters ANOVA was significant (pronotum width: Df = 2/62, F = 23.61, P <1e-04 ***. Elytra Length Df = 2/62, F = 37.14, P <1e-04 * **). Multiple comparisons between populations are highly significant except for the comparison Messina/Calabria for EL that is barely significant (p = 0.0477).

Remarks. Born (1906) describes *Carabus morbillosus bruttianus* from Calabria, locus typicus St. Eufemia d'Aspromonte, distinguishing it from the Sicilian populations of Palermo known as *C. morbillosus servillei* (= *C. morbillosus alternans*). Subsequently both Porta (1923) and Luigioni (1929) report it as a distinct "variety" of *C. morbillosus* from Calabria. In particular, Porta (1923) reiterates the morphological differences already reported by Born (1906) in its original description. However, latest Authors consider *C. morbillosus bruttianus* as a synonym of *C. morbillosus alternans* of Sicily (Magistretti, 1965; Casale et al., 1982; Vigna Taglianti, 1995; Vigna Taglianti, et al., 2002).

The examination of numerous specimens from different places near Reggio Calabria (Southern Calabria), allowed us to confirm the morphological characteristics of this taxon, which results morphologically distinct from the neighboring populations of *C. morbillosus alternans* of Sicily. Populations attributable to *C. morbillosus bruttianus* are also present near Messina (north-eastern Sicily), described as *C. borni* Krausse, 1908 (= sicanus Csiki, 1927; nom. pro *borni* Krausse). Porta (1923) reports this taxon as a distinct "variety" of North-Eastern Sicily, thus distinguishing it, geographically, from the remaining populations of South-Western Sicily.

The populations of Messina are, in fact, morphologically distinct from the remaining Sicilian ones attributed to *C. morbillosus alternans* and, rather, similar to the Calabrian populations of *C. morbillosus bruttianus* from which differ only in a few minor characters, especially by color and shape of pronotum.

CONCLUSIONS

Actually, the *C. morbillosus* population of Sicily, Sicilian islands, and the nearby Southern Calabria, turns out to be more diversified than considered up to now. In most of the islands, is confirmed the presence of *C. morbillosus alternans* which is very well-differentiated and distinct from all the other races of the species; *C. morbillosus bruttianus* is present in Southern Calabria, in the territories of North-Eastern Sicily (Messina and surrounding area) and, as to our knowledge, even in Lipari in the Aeolian Islands. In Lampedusa Island there is an island subspecies, *C. morbillosus lampedusae*, similar to North African populations of *C. morbillosus*.

At the moment, the populations covered by this work can be distinguished as outlined below:

1. Pronotum wider and arched forward with maximum width in the fore third. Primary intervals salient and very short, secondary ribs raised and wide, tertiary intervals broken down into lines of evident granules, 1st elytral interstria with small tubercles

and confluent points in the form of irregular furrow. Aedeagus apex distinctly more elongated, narrow and slightly curved.....*morbillosus costantinus*

-. Squat and convex body-shape, less bright in color and dark. Pronotum with basal dimples large and deep, sinuate at sides before hind angles. Primary intervals wider, 1st elytral interstria with points on the surface,well separate from each other.....*morbillosus lampedusae*

2. Pronotum distinctly narrower forward with maximum width at the center. Primary intervals elongated and slightly salient, secondary ribs depressed, tertiary intervals less raised than secondary ones; 1st elytral interstria with wide points, deep, very distinct, sometimes juxtaposed with each other. Apex of aedeagus shorter, wider and curved. Shape great and flattened on the back, brilliant; elytra elongate, rounded and dilated in the rear third; elytra apex short and sightly sinuate at sides... .....*morbillosus alternans*

-. Smaller and convex on the back of the elytra, less shine; pronotum narrower and slightly rounded forward with maximum width in the fore half; disc with evident points and transverse wrinkles thin and sparse; elytra short and ovalish, primary intervals in granules shorter and less raised; elytral apex stretched and clearly sinuate at sides..... .....*morbillosus bruttianus*

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