Bonn zoological Bulletin 71 (1): 23–28
2022 Cortés-Fossati F.
https://doi.org/10.20363/BZB-2022.71.1.023

ISSN 2190–7307
http://www.zoologicalbulletin.de

Research article
urn:lsid:zoobank.org:pub:C9BAD342-B492-42FD-B7CD-E810D76A82AF

Assessing the distribution of the Andalusian endemic *Berberomeloe payoyo* Sánchez-Vialas et al., 2020 (Coleoptera: Meloidae), with comments on its ecology

Fernando Cortés-Fossati

EcoEvo Group, Area of Biodiversity and Conservation. Universidad Rey Juan Carlos, c/ Tulipán s/n, E-28933, Móstoles, Madrid, Spain

Email: fernando.cfossati@urjc.es

urn:lsid:zoobank.org:author:F3D8E2DD-58F0-4116-80D4-A6A9248464B6

Abstract. Thanks to recent molecular studies, it was revealed that one of the biggest European beetles, the red-stripped oil beetle *Berberomeloe majalis* (Linnaeus, 1758) (Coleoptera: Meloidae) comprised a complex of nine different species. To improve the knowledge of this threatened group, chorology of the newly described microendemic *B. payoyo* Sánchez-Vialas et al., 2020 is updated in pursuit of a better knowledge and future adequate conservation strategies. 252 field sampling events were performed between 2012-2021. 668 specimens were studied. In the framework of the study, two citizen science projects were carried out. The first detailed distribution map and notes about the species' biology are provided.

Keywords. Biodiversity, blister beetles, entomology, Iberian endemism, insect conservation.

INTRODUCTION

Berberomeloe Bologna, 1989 is an endemic genus from the Ibero-Maghrebian region and includes some of the biggest European, which can reach a body length of up to 7 cm (Bologna 1989; García-París 1998; Cortés-Fossati 2018a). This genus has remained unchanged for thirty years including two species, the red-stripped oil beetle *Berberomeloe majalis* (L., 1758) and *B. insignis* (Charpentier, 1818). Recent molecular studies focused on *B. majalis* revealed a complex of nine morphologically and phylogenetically distinct species (Sánchez-Vialas et al. 2020). Among these nine species the new south-western Iberian microendemic *B. payoyo* Sánchez-Vialas et al., 2020 (Fig. 1) was described, being distributed in Cádiz province, Málaga, and Granada provinces (Andalusia, Spain) (Sánchez-Vialas et al. 2020). Currently, there are hardly any data and only scarce studies available about the natural history and biology of *B. payoyo* (Cortés-Fossati 2018a, b; Cortés-Fossati & Cervera 2018; Sánchez-Vialas et al. 2020). However, this information is crucial to design appropriate and specific conservation strategies. In this case – even though no Spanish oil beetle species is protected under any legal framework – it was important to consider that the only catalogued species within the genus, *Berberomeloe insignis*, was classified as vulnerable (VU) in the Andalusian and Spanish Red Book of Invertebrates (Barea-Azcón et al. 2008; Verdú et al. 2011). The species is affected by several impacts, mainly related with environment transformation (García-París & Ruiz 2008, 2011). These threats are observed for *B. payoyo* in some areas (Cortés-Fossati 2018a, b; Cortés-Fossati and Cervera 2018, sub *B. majalis*) but the information we have on the species is outdated and scarce , including its distribution range. Up-to-date distribution information and a georeferenced map are key tools in conservation (D'Amen et al. 2013; Della Rocca et al. 2020), especially in the cases of complexes of closely related species. This could reveal potential cases of sympatry or allopatry and clarify the geographic distribution ranges of each of the species of the *B. majalis* complex, improving knowledge and contributing to decrease the Wallacean shortfall, i.e., the lack of knowledge about the geographical distribution of species (Lomolino 2004; Cardoso et al. 2011). Therefore, the aim of this study is to provide a better understanding of the chorology and ecology of the Iberian *B. payoyo*.

MATERIAL AND METHODS

The dataset has been generated by 1) own sampling campaigns; 2) citizen science programs, and 3) available literature, from the oldest reported observation to the most recent, covering the period 1921–2021.

1) Field sampling campaigns were carried out from 2012 to 2021, from January to August to safely cover the time interval in which imagos of the species are present in the field (from March to July in southern Spain: Bologna, 1989). Specimens were identified according to Sán-

Received: 08.03.2021
Accepted: 02.03.2022

Corresponding editor: D. Ahrens
Published: 08.03.2022

chez-Vialas et al. (2020). The species presents distinctive morphological and biogeographical characteristics that allowed all individuals to be identified (Sánchez-Vialas et al. 2020). The first is that the taxonomic identity of the species is very clear in most of the area it occupies, being restricted to the south-west of the Iberian Peninsula. Secondly, *B. payoyo* presents among other characteristics (for more details, see identification key and description in Sánchez-Vialas et al. 2020) narrow, coloured post-tergal bands (Fig. 1A), poorly impressed punctures on the head (Fig. 1B), and anterior angles of the pronotum are not expanded (Fig. 1C). These features differentiate *B. payoyo* from the other species of the complex present in eastern Andalusia (*B. indalo* Sánchez-Vialas et al., 2020 and *B. tenebrosus* Sánchez-Vialas et al., 2020). Specimens that could not be reliably determined based on their morphology, as happened in four cases, were excluded from the study. 252 samplings events were carried out in 86 different sampling points. 668 specimens were studied in the field in 29 different locations. All populations/records were georeferenced. The number of individuals, colouration of post-tergal bands, and biological/behavioural observations were also noted.

2) Additional observations were received by the author by mail, or were uploaded by citizens to two different Citizen Science Programs in which the author was administrator ("Proyecto Biodiversidad de Andalucía", hosted in collaboration with iNaturalist.org and the "Proyecto Meloidata", hosted in collaboration with Observation.org), and were also included in the database. Likewise, the veteran Spanish nature conservation association Biodiversidad Virtual (biodiversidadvirtual.org) provided their observations concerning the species from its internal database. Only those observations were considered, in which the specimens could be reliably identified from photographs that had georeferencing and date.

3) The only seven publications that provided location data were considered for this study (Bologna 1989; García-París 1998; Pérez-Moreno et al. 2003; García-París et al. 2003; Percino-Daniel et al. 2013; Cortés-Fossati 2018, Sánchez-Vialas et al. 2020). In most cases, due to the age of these works, there was not a very high spatial precision in them, so the locations have subsequently been referenced estimating their position with the data provided in these works. On the other hand, in works before 2020, only locations have been considered in which, according to Sánchez-Vialas et al. (2020), the taxonomic identity of the species *B. payoyo* is clear, that is, the province of Cádiz, and certain areas of Malaga and Granada.

The resulting distribution map was generated with software QGIS ver. 3.16.1-Hannover (GIS Development Team 2020) using a EPGS:4326-WGS 84 coordinate system and the layers "Terrestrial 10×10 km grid" from Ministerio para la Transición Ecológica y el Reto Demográfico (miteco.gob.es) and "Líneas límite provinciales" from the Instituto Geográfico Nacional (centrodedescargas.cnig.es). In a complementary way, notes about ecology and conservation of the populations studied were registered.

RESULTS & DISCUSSION

An updated chorology of the species is provided based on 154 different locations (Appendix: Table S1), allowing to establish a well-represented distribution map, since a large part of its potential distribution area has been covered (Fig. 2). This total number has been formed by data from fieldwork, citizen science and literature. During field sampling, the species was present in 29 locations of 86 sampled, belonging to 14 different municipal districts. Citizen science programs functioned satisfactorily, obtaining 84 valid observations from this source, belonging to 84 different locations. It could be noted that, especially in rural areas, villagers generally have a good knowledge about genus *Berberomeloe*, a phenomenon already observed for the Cádiz region (Cortés-Fossati 2018a, Cortés-Fossati & Cervera 2018) and for the Iberian Peninsula (García-París et al. 2016) probably due to the ethnopharmacological uses that the hemolymph of these animals has historically developed (Percino-Daniel et al. 2012). This fact may be the main reason why this program has given reliable results. Finally, the literature review provided 41 locations, only eight of them georeferenced.

According to previous literature (Bologna 1989; García-París 1998; Cortés-Fossati 2018a, b) *Berberomeloe payoyo* is a diurnal xerophilous species, inhabiting diverse Mediterranean habitats (see Sánchez-Vialas *et al*. 2020), being also distributed in suburban landscapes with degraded vegetation (Cortés-Fossati 2018a, b). Nevertheless, the species seemed to have preference on open areas, steppe lands and meadows with presence of bare soil patches and not very dense, pioneer vegetation where females oviposit (Cortés-Fossati 2018; Fig. 3). Here, its presence can be massive (up to 200 individuals registered in 0.27 ha in a single day). During evening time individuals have been observed on several occasions to leave the foraging area to hide under leaf litter or grass in areas of denser vegetation where they spend the night (pers. obs.). Adults are present in the field from the end of February to mid-July, being very rare outside this period (e.g., one single adult record in January cited by Sánchez-Vialas et al. 2020). Highest abundance occurred between end of March and end of May (Fig. 4). Earliest oviposition was observed at the end of March (03/21/2017 in Puerto Real). Offspring hatched between 20 and 26 days later (three replicates carried out in March 2014, March 2017, and May 2017 in the laboratory in translucent 10L terrariums in sand substrate with natural conditions of light, humidity, and temperature). Characteristic of first instar

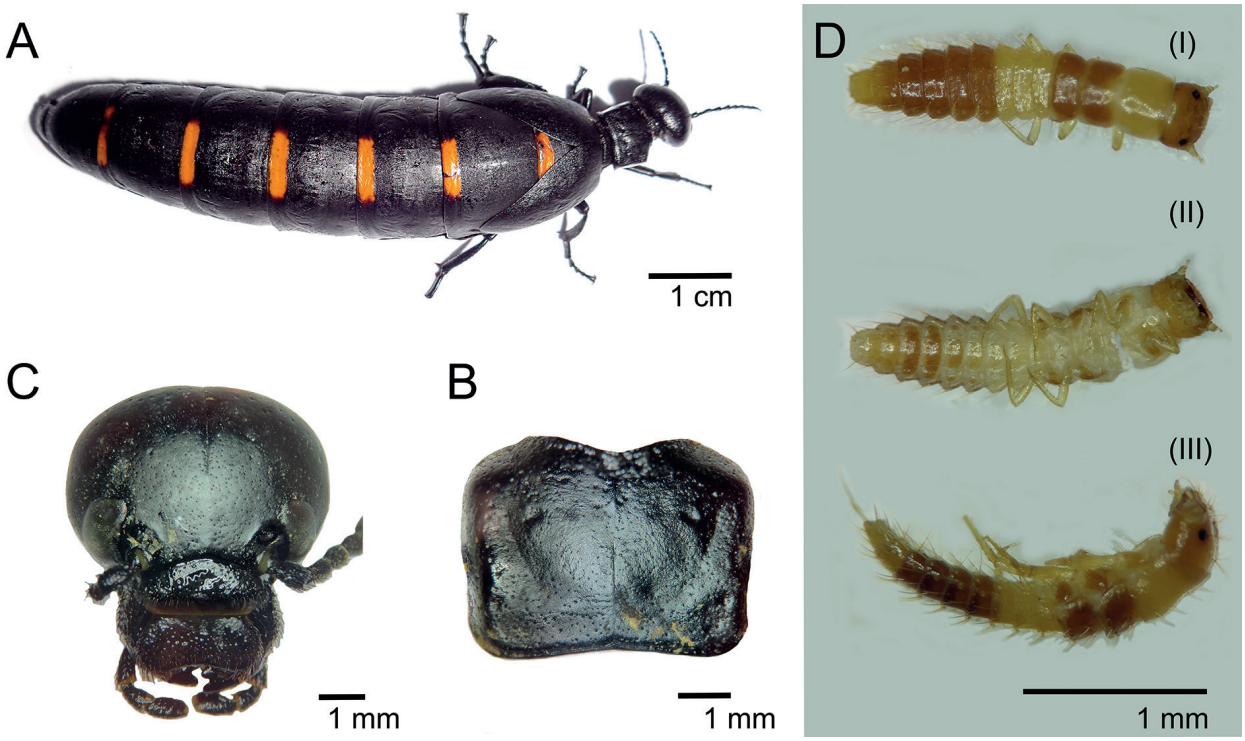

Fig. 1. *Berberomeloe payoyo* Sánchez-Vialas et al., 2020. **A**. Imago from Puerto Real, Cádiz. Dorsal view. **B**. Pronotum. **C.** Head front view, with characteristic punctures. **D**. First instar larva in dorsal (I), ventral (II) and lateral view (III). Instars were damaged during collection, lacking their terminal long chaetae, partially visible in III.

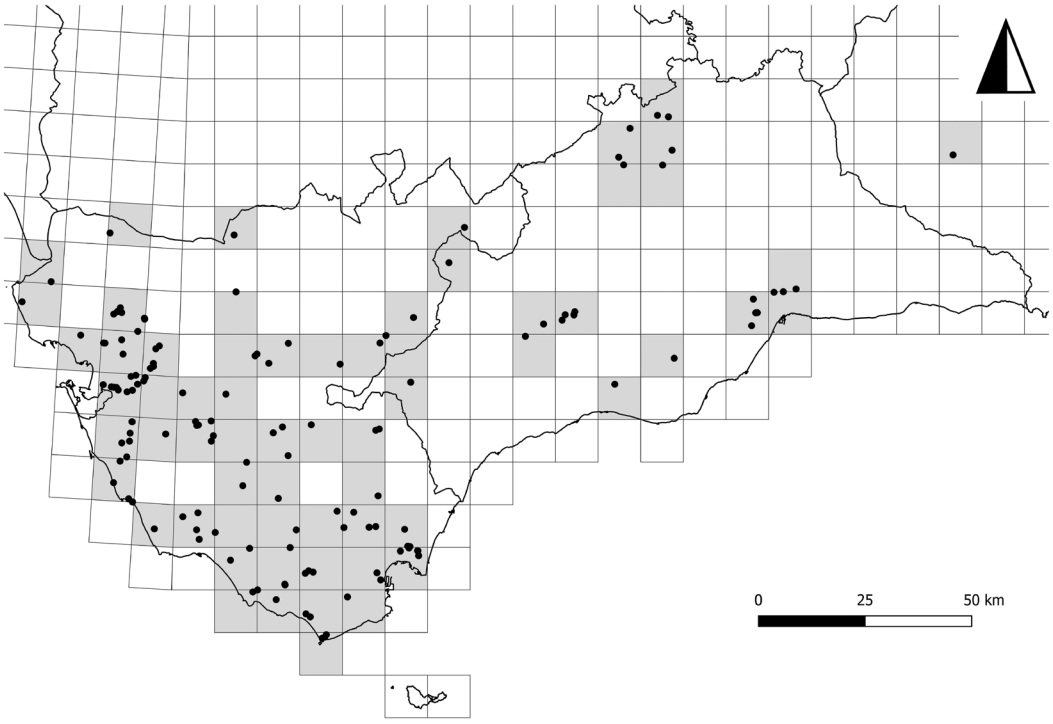

Fig. 2. Distribution of *Berberomeloe payoyo* composed with data from sampling campaigns, citizen science records and literature records.

Fig. 3. Typical environment where the species seems to have preference, consisting of open areas with no dense vegetation (Medina Sidonia, Cádiz).

larva (Fig. 1D) corresponds to the description made by Bologna (1989) for the larvae from the *B. majalis* complex, not observing appreciable differences.

Based on the findings, it is also possible to conclude the absence of this species in the coastal strip and marshy ecosystems, at least, in tidal influence areas and beach sand substrate (after 113 samplings and studying all the data provided by third parties, absent in the tidal zone and marshes of Algeciras, Barbate, Cádiz, Chiclana de la Frontera, Chipiona, Conil de la Frontera, Puerto Real, Puerto de Santa María, Sanlúcar de Barrameda, Tarifa). As expected, no sympatry cases with other *Berberomeloe* species were detected in Cádiz, but a genetic study of the possible contact areas is necessary, in this case, the limit zone of distribution in the east, since there may be cases of introgressive hybridization that do not allow the individuals to be correctly identified morphologically, and even, hybrid populations may be present.

Intraspecific variation of the populations was detected, in terms of the post-tergal band colouration, which can range from light orange to reddish orange and even vermilion red, the orange-coloured form being probably the most common in Cádiz province (Appendix: Table S2,- Fig. S2). No populations with mixed specimens of different band colours have been detected. No completely black morphotype specimens were observed.

According to personal observation, imagos feed on leaves of different pioneer and herbaceous plants species as well as young shoots. However, they seem to show preference on flower petals of certain plants species such as those of the genus *Echium* L. (Boraginaceae). Throughout this study, also repeated feeding on diverse Asteraceae (highlighting *Carduus* L., *Galactites* Moench, and *Pallenis* Cass), and on *Oxalis pes-caprae* L. (Oxalidaceae) has been observed. *Berberomeloe payoyo* has also been observed feeding on *Erodium* L'Hér. ex Aiton (Geraniaceae), *Plantago* L. (Plantaginaceae) and *Lysimachia* (L.) U. Manns and Anderb. (Myrsinaceae).

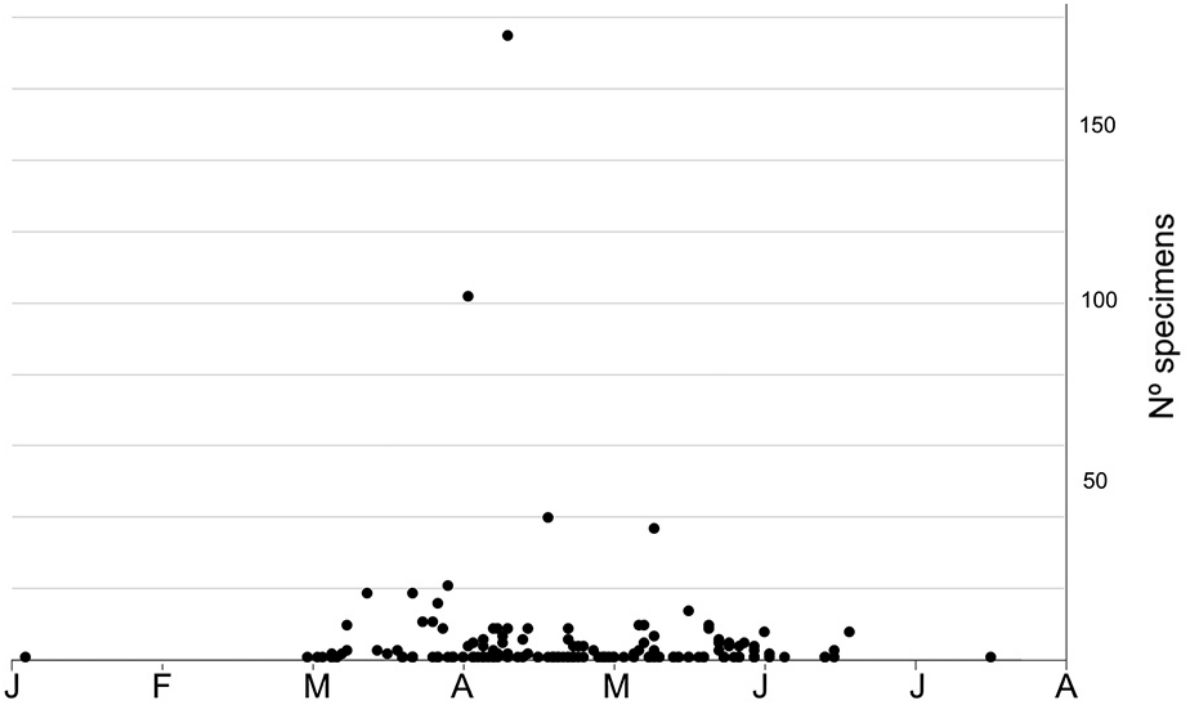

Fig. 4. Phenology of imago of *Berberomeloe payoyo*, built from the database generated for the study. Literature or citizen science data that lacked the number of observed individuals by date have been plotted as n = 1.

No studies have been conducted on the conservation status of the species. However, data collected during this work suggest that populations near cities undergo a negative anthropogenic pressure. The ecosystems of the Cadiz and Málaga provinces are highly transformed and fragmented, except for some well-preserved natural cores such as Grazalema, Los Alcornocales or Sierra de las Nieves Natural Parks. Agriculture and an aggressive urbanistic process occupies most of the area, increasingly taking ground in its development over the years. In this way, in Cádiz it is very frequent to observe populations of *B. payoyo* located on croplands and peri-urban regions with a clear degree of deterioration (Cortés-Fossati 2018a). Totally or quasi-isolated populations due to human infrastructures have been observed (e.g., diverse populations in Chiclana de la Frontera, Puerto Real, Jerez de la Frontera, Sanlúcar de Barrameda) since the species has a very low dispersal rate and a low capacity to colonize new areas (García-Paris 1998; Sánchez-Vialas et al. 2020). Use of steppe lands or zones dominated by colonizing pioneer r-strategist plant species as uncontrolled waste dumps, urban pressure, and the agricultural fields as well as the use of chemicals are probably affecting populations, threats already proposed as impacts for other Meloidae (García-París & Ruíz 2008a, b, 2011; Ruíz & García-París 2008a, b). In these zones, populations seem degraded and with lower population densities. Also, road kills have been observed very frequently, a phenomenon also observed for the Madrilenian *Berberomeloe* populations (García-París et al. 2006; pers. obs.). Even possible local extinction of some populations has been observed during this work. In 2012, an expansion to a mega commercial area was carried out in Jerez de la Frontera (Area Norte and Area Sur, see Appendix: Table S1). The species has no longer been observed there since 2016, also not appearing again in the adjoining crop fields. Moreover, a population located in a cropland in Torre del Puerco (see Appendix: Table S1), completely disappeared in 2017 after changes in land use in the area. However, geographical situation of this population suggests it could be derived from another nucleus, located on a semi-natural shrubland in front of the sampling point, found behind several linear structures that fragment the area (two walkways and a road). So, if transformation will not continue, there could be a possibility that the beetle will return to the area. Finally, during 2017, in Puerto Real: Parque Entrevías (see Appendix: Table S1), the species apparently disappeared after diverse human interventions, e. g., illegal deposit of debris and the installation of a pipeline that flooded the study area. As of 2018, a large decline in number of individuals was observed. After that season, no specimen has been observed in the area. However, there are no data on dynamic populations that allow calculating possible regressions or the real status of the species, so it would be necessary to carry out studies focused on conservation ecology.

CONCLUSIONS

Berberomeloe payoyo Sánchez-Vialas et al., 2020 is a microendemic restricted to the south-west of the Iberian Peninsula that is well represented throughout its area of distribution. Information collected provides an update on the distribution of *B. payoyo* and some ecological notes that improve the knowledge about the species. The information regarding its ecology and biological cycle seems to fit very well to what was already stated by Bologna (1989) when the genus was described (Bologna 1989; García-París 1998; García-París et al. 2003; Cortés-Fossati 2018). At least, peri-urban populations seem to suffer from negative human impacts, e.g., habitat fragmentation and change in land use. Future works on the conservation ecology of the species are needed.

Acknowledgments. Thanks to the reviewers and journal editors for their constructive feedback. To Consejería de Medio Ambiente y Ordenación Del Territorio of Junta de Andalucía government for allowing this research providing their support and required permissions. This research could not be possible without field assistants Irene Martín-Rodríguez, Juan Manuel Muñoz-Ocaña, Alberto Leandro Aranda Quirós and Fernando Cortés Márquez. I would like to thank professors Juan Lucas Cervera, Marco Bologna, Gonzalo Muñoz, and Marcos Méndez for their invaluable suggestions. I also appreciate the help of Julio Rabadán and Pablo Álvarez to manage, create, and host the citizen science project "Meloidata" on Observation Spain. I would like to express my gratitude to PhD Jazmín Deneb Ortigosa for co-creating and co-directing the citizen science project "Biodiversity of Andalusia" hosted on iNaturalist California Academy of Sciences. Also, to Biodiversidad Virtual team for allowing to use their database. Thanks to PhD student Pablo Escribano for arranging laboratory material for this research. Finally, thanks to all entomologists, naturalists, villagers, citizen scientists and students that kindly and decisively contributed to this work.

Ethical & legal aspects. This study was framed under the legal regulations and laws for the collection and ethical treatment of animals and has been endorsed by Andalusian government.

REFERENCES

Barea-Azcón JM, Ballesteros-Duperón E & Moreno D (2008) Libro Rojo de los Invertebrados de Andalucía. Consejería de Medio Ambiente, Junta de Andalucía, Seville

Bologna MA (1989) *Berberomeloe*, a new west Mediterranean genus of Lyttini for *Meloe majalis* Lineé (Coleoptera, Meloidae). Systematics and bionomics. Italian Journal of Zoology 55 (1–4): 359–366. https://doi.org/10.1080/11250008809386633

Cardoso P, Erwin TL, Borges PAV, New TR (2011) The seven impediments in invertebrate conservation and how to overcome them. Biology Conservation 144: 2647–2655. https://doi.org/10.1016/j.biocon.2011.07.024

Cortés-Fossati F (2018a) Meloidos, 'curitas' y cantaridina: apuntes sobre *Berberomeloe majalis* (Linnaeus, 1758), un

coleóptero peculiar. El Corzo, Sociedad Gaditana de Historia Natural 6: 15–20

Cortés-Fossati F (2018b) Un primer acercamiento al estado de conservación de las poblaciones de *Berberomeloe majalis* (Linnaeus, 1758) (Coleoptera: Meloidae) en la provincia de Cádiz (España). Observaciones de campo y percepciones del mundo rural sobre el estado de la especie. Boletín de la Sociedad Entomológica Aragonesa 62: 327–331

Cortés-Fossati F, Cervera JL (2018) *Berberomeloe majalis* (Linnaeus, 1758), uno de los coleópteros más grandes de Europa presentes en el Campo de Gibraltar. contribución a su etología, distribución y usos tradicionales en la provincia de Cádiz. Almoraima. Revista de Estudios Campogibraltareños 49: 48–54

D'Amen M, Bombi P, Campanaro A, Zapponi L, Bologna MA, Mason F (2013) Protected areas and insect conservation: Questioning the effectiveness of Natura 2000 network for saproxylic beetles in Italy. Animal Conservation 16: 370–378. https://doi.org/10.1111/acv.12016

Della Rocca F, Milanesi P (2020) Combining climate, land use change and dispersal to predict the distribution of endangered species with limited vagility. Journal of Biogeography 47: 1427–1439. https://doi.org/10.1111/jbi.13804

Verdú JR, Numa C, Galante E (2011) Atlas y Libro Rojo de los Invertebrados amenazados de España (Especies Vulnerables). Dirección General de Medio Natural y Política Forestal, Ministerio de Medio Ambiente, Medio rural y Marino, Madrid

García-París M (1998) Revisión sistemática del género *Berberomeloe* Bologna, 1988 (Coleoptera, Meloidae) y diagnosis de un endemismo ibérico olvidado. Graellsia 54: 97–109. https://doi.org/10.3989/graellsia.1998.v54.i0.347

García-París M, Ruíz JL (2008a) *Berberomeloe insignis* (Charpentier, 1818). In: *Libro Rojo de los Invertebrados de Andalucía.* (Barea-Azcón, J.M., Ballesteros-Duperón, E., Moreno, D., Coords.) 4 volumes. Consejería de Medio Ambiente. Junta de Andalucía. Sevilla: 1020–1029

García-París M, Ruíz, JL (2008b) *Mylabris (Micrabris) nevadensis* (Escalera, 1915). Pp. 1045–1051 in: Barea-Azcón JM, Ballesteros-Duperón E & Moreno D (eds) Libro Rojo de los Invertebrados de Andalucía. 4 volumes. Consejería de Medio Ambiente. Junta de Andalucía. Sevilla: 1045–1051

García-París, M, Ruíz, JL (2011) *Berberomeloe insignis* (Charpentier, 1818). Pp. 285–294 in: Verdú JR, Numa C & Galante E. (eds) Atlas y Libro Rojo de los Invertebrados amenazados de España (Especies Vulnerables). Vol I. Dirección General de Medio Natural y Política Forestal, Ministerio de Medio Ambiente, Medio rural y Marino. Madrid

García-París M., Ruiz JL, Percino-Daniel N, Buckley D (2016) Nombres comunes de las cantáridas y aceiteras (Coleoptera: Meloidae) de España: "las circunstancias obligan". Boletín de la Sociedad Entomológica Aragonesa 58: 245–252

Lomolino MV (2004) Conservation Biogeography. Pp. 293–296 in: Lomolino MV & Heaney LR (eds) Frontiers of Biogeography: new directions in the geography of nature. Sinauer Associates, Inc. Sunderland, Massachussets

Percino-Daniel N, Buckley D, García-París M (2013) Pharmacological properties of blister beetles (Coleoptera: Meloidae) promoted their integration into the cultural heritage of native rural Spain as inferred by vernacular names diversity, traditions, and mitochondrial DNA. Journal of Ethnopharmacology 147 (3): 570–583. https://doi.org/10.1016/j.jep.2013.03.037

Ruiz JL, García-París M, París M (2003). Los representantes ibéricos de la tribu Lytini (Coleoptera, Meloidae). Graellsia 59 (2): 69–90. https://doi.org/10.3989/graellsia.2003.v59.i2-3.236

Ruíz JL, García-París M (2008a) *Meloe (Eurymeloe) nanus* Lucas 1849. Pp. 1030–1037 in: Barea-Azcón JM, Ballesteros-Duperón E & Moreno D (eds) Libro Rojo de los Invertebrados de Andalucía. 4 volumes. Consejería de Medio Ambiente. Junta de Andalucía. Sevilla

Ruíz JL, García-París M (2008b) *Meloe (Taphromeloe) foveolatus* Guérin de Méneville 1842. Pp. 1038–1043 in: Barea-Azcón JM, Ballesteros-Duperón E & Moreno D (eds) Libro Rojo de los Invertebrados de Andalucía. 4 volumes. Consejería de Medio Ambiente. Junta de Andalucía. Sevilla: 1038–1043

QGIS Development Team (2020) QGIS geographic information system. Open Geospatial Source Foundation. Online at qgis.osgeo.org [last accessed 4 Mar. 2022]

Sánchez-Vialas A, García-París M, Ruíz JL, Recuero E (2020) Patterns of morphological diversification in *Berberomeloe* blister beetles (Coleoptera: Meloidae) reveal an unexpected taxonomic diversity concordant with mtDNA phylogenetic structure. Zoological Journal of the Linnean Society 189: 1249–1312. https://doi.org/10.1093/zoolinnean/zlz164

APPENDIX I

(*electronic supplement, available at www.zoologicalbulletin.de*)

Table S1. Location dataset composed by data from field work (F), citizen science programs (CS) and Literature (L: authors, year). Dates indicated in intervals pertaining to the field campaings represent a sustained work in the period between January and August of those years.

Table S2. List of specimens studied in the field in which the color of the banding was noted. The observations are divided between two classes, Orange (O) which is represented on the map with orange dots and Red (Red) represented on the map with red dots. Only those individuals from the sampling campaigns were included in the study as the colors could not be standardized from photographs provided by third parties.

Fig. S2. Mapping of specimens studied on field divided by colouration in the post-tergal banded pattern. The observations are divided between with orange dots (populations with orange bands and black dots (populations with red bands) represented on the map with red dots. Only those individuals from the sampling campaigns and Cortés-Fossati, 2018 were included in the study as the colors could not be standardized from photographs provided by third parties. According to citizen science data, which have not been taken into account in the plot because it cannot be corroborated – since despite having testimonies and photos the colors have not been normalized with a scale – the red individuals would be confined to the northern part of the province and the southern part of the same Strait Zone), leaving the central strip of the province dominated by populations of orange coloration, thus being probably the most widespread coloration.