

UPDATING THE TAXONOMY AND DISTRIBUTION OF THE  
EUROPEAN *OSMODERMA*, AND STRATEGIES  
FOR THEIR CONSERVATION  
(Coleoptera, Scarabaeidae, Cetoniinae)

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INTRODUCTION

Hermit beetles are a group of flower chafers (Scarabaeidae: subfamily Cetoniinae: tribe Trichiini) of the genus *Osmoderma* LePeletier de Saint-Fargeau & Serville, 1828. They are large scarab beetles (more than 30 mm long) that live in old hollow trees. This genus includes a dozen of species widespread throughout the Palaearctic and the Nearctic Regions (see below for a world checklist of the genus). The geographic distribution and the ecological traits of the European species, jointed together under the name *Osmoderma eremita* sensu lato, have been recently summarized by Ranius & Nillson (1997), Schaffrath (2003a, 2003b), Ranius (2000, 2001), Ranius & Hedin (2001, 2004), and Ranius et al. (2005). These studies, supported by many other surveys conducted at local level, evidenced a strong decline suffered by this taxonomic group throughout its distribution range, and reported the extinction from some countries due to habitat loss and intensive forest management. For this reason, *Osmoderma eremita* s.l. was

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listed as priority species in Annex IV of the EU's Habitat Directive (Luce 1995, 1996, 2001; Galante & Verdú 2000; Audisio et al. 2003; Ranius et al. 2005).

As discussed in a series of recent contributions (Sparacio 1994, 2000; Tauzin 1994a, b, 1996, 2000, 2002; Krell 1997; Gusakov 2002; Audisio et al. 2003; Dutto 2003; Ranius et al. 2004, 2005), under the name *O. eremita* are probably included at least two or more distinct species or semi-species, whose taxonomic rank has been matter for strongly controversial interpretations. In fact, some studies (Nüssler 1986; Sparacio 1994, 2000; Tauzin 1994b, 2006; Gusakov 2002; Audisio et al. 2003; Ranius et al. 2004) suggested a morphological distinction of at least two up to five substantially allopatric semi-species, whose actual taxonomic position is difficult to ascertain:

*O. eremita* Scopoli, 1763 widespread in W Europe, eastwards to Germany and W Slovenia; *O. cristinae* Sparacio, 1994 confined to Sicily; *O. italicum* Sparacio, 2000 occurring in S Italy; *O. lassallei* Baraud & Tauzin, 1991 distributed in Greece and European Turkey; *O. coriarius* De Geer, 1774 *sensu* Gusakov (2002) from E Europe (this taxon hereafter treated under the combination *O. barnabita* Motschulsky, 1845; see below the Commented World Checklist).

However, until very recently, *O. eremita* s.l. was provisionally treated as one species with clear geographic morphological variation and three recognized distinct subspecies (*O. eremita eremita*, *O. eremita lassallei*, and *O. eremita cristinae* (Krell 1997, 2004; Shokhin & Bozadjiev 2003).

The aim of this paper is mainly to update the available information towards a reasonable and objectively supported taxonomic arrangement for the whole complex, mainly based on results of a companion molecular paper (Audisio et al. in press), and on recently checked distributional data. We also provide below a complete summary of both previous and current taxonomic and nomenclatorial interpretations, starting from the present-day official arrangement of the complex (*O. eremita eremita*, *O. eremita lassallei*, and *O. eremita cristinae*: Krell 2004), along with the rationale for the newly introduced taxonomic proposals, partly as a consequence of the molecular results of the above mentioned companion paper. Finally, we discuss how genetic and distributional data available so far could contribute in evaluating more correct strategies for the conservation of these rare and endangered species at European level. Hermit beetles,

in fact, represent, especially in lowlands, one of the most important “flagship-species” and “umbrella-species” for the protection of the local saproxylic communities (Ranius 2002a, 2002b, 2002c; Audisio et al. 2003).

#### AVAILABLE MOLECULAR DATA

The results of our companion molecular paper (Audisio et al. in press) suggest that the distance and parsimony analyses well support two clusters grouping *O. barnabita* and *O. lassallei* on one side, and *O. eremita*, *O. italicum* and *O. cristinae* on the other side. The average level of genetic divergence between the two identified groups is equal to 0.090 (scored values of the genetic distances ( $D_{T\&N}$ ) among all sampled individuals and taxa computed using the Tamura & Nei (1993) algorithm). The genetic divergence within each cluster is enough to discriminate the majority of the included taxa and to confirm their specific status, with the exception of *O. italicum*, whose divergence with *O. eremita* is equal to 0.035. Mean value scored among taxa within the assemblage clustering *O. barnabita* and *O. lassallei* is equal to 0.054. These figures are comparable with values recently scored in other scarab beetles (Coleoptera, Scarabaeidae) for taxa currently interpreted as related but separated species (Villalba et al. 2002; Micó et al. 2003; Cabrero-Sañudo & Zardoya 2004; Tassi et al. 2004), or well distinct sub-species (Carisio et al. 2004). On the other hand, values scored within the group clustering *O. eremita*, *O. italicum* and *O. cristinae* range from 0.035 to 0.047. The lower bound value outlines a more strict degree of genetic relatedness between *O. eremita* and *O. italicum*, suggesting a possible interpretation of the latter as a subspecies or only significant geographic form of the widespread *O. eremita* s.s. On the contrary, the higher values of genetic divergence between *O. cristinae* and both *O. eremita* or *O. italicum*, seem to better support a specific status for the Sicilian group of populations, in congruence with its isolated geographic range (fig. 1).

#### ZOOGEOGRAPHY AND DISTRIBUTION

The main taxonomic and zoogeographic conclusions of our companion molecular paper (Audisio et al., in press) are summarised as follows.

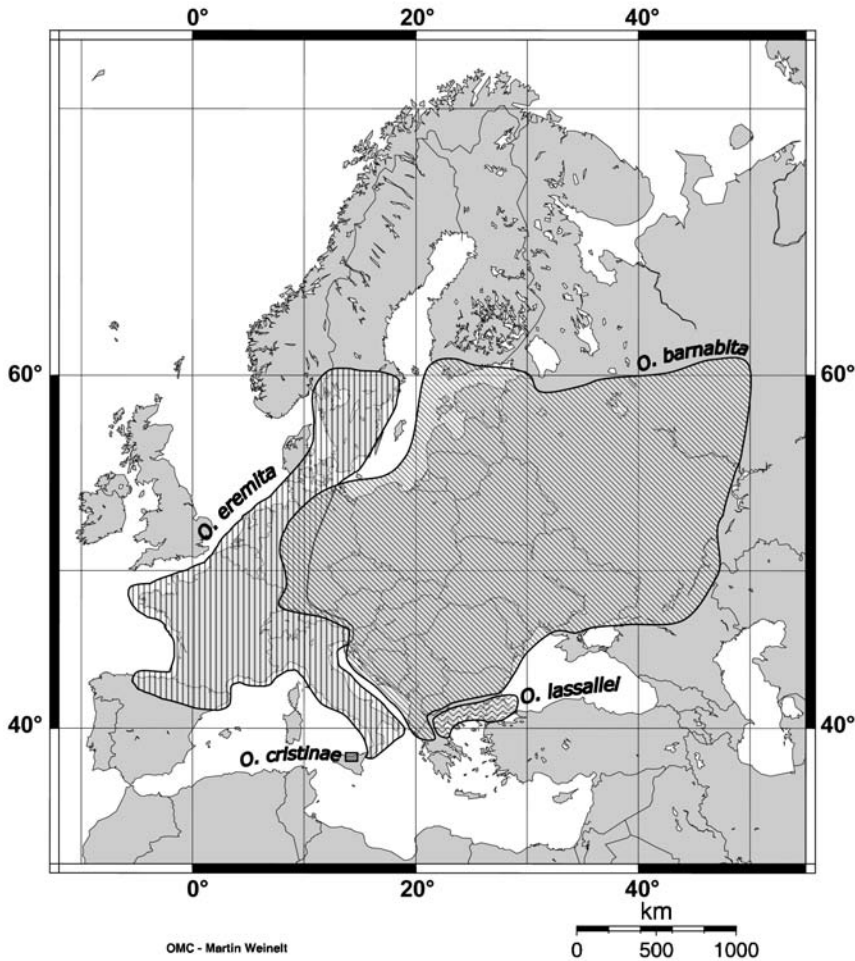


Fig. 1 – Geographical ranges of the *Osmoderma eremita* complex in Europe.

The *Osmoderma eremita* complex includes in Europe at least two distinct clades. The first one (*O. eremita* s.l.), comprises taxa distributed in western Europe (fig. 1: northern Spain, France, Belgium, the Netherlands, Denmark, southern Sweden, southern Norway, Italy, Switzerland, western Austria, western Slovenia, most of western and northern Germany). The second clade (*O. barnabita* s.l.), includes taxa distributed in central and eastern Europe (fig. 1: most of Germany, eastern Austria, Slovenia, Czech Republic, Poland, Hungary, Rumania, Bulgaria, Ukraine, Belarus, Latvia, Lithuania,

Estonia, southern Finland, European Russia, Slovakia, Croatia, Bosnia and Herzegovina, Albania, Serbia, Montenegro, Macedonia, Greece, European Turkey) (Sparacio 2000; Gusakov 2002; Ranius et al. 2005; Tauzin 2006; M. Dutto & P. Audisio unpublished data).

Within the *O. eremita* s.l. clade, the taxonomic rank to be attributed to *O. italicum* and to *O. cristinae* is still questionable, both taxa probably being at the border line between recently separated allopatric species and semispecies. For the reasons discussed above, we prefer here provisionally to treat at least *O. cristinae* as separated species (fig. 1). As to *O. italicum*, despite the rather significant genetic divergence of the single examined specimen (OI1.1), we choose here to tentatively consider it only as a possible ESU (Evolutionary Significant Unit in the sense recently proposed by Ryder 1986, and by Moritz 1994, 1995), closely related to the widespread *O. eremita* s.s. Additional genetic data on Italian hermit beetles ("*O. italicum*" and *O. eremita* s.s.) and a more detailed information on their geographical distribution in southern Italy are needed, chiefly in the areas between southern Latium, Molise and Campania.

Within the *O. barnabita* s.l. clade, the taxonomic rank to be attributed to *O. lassallei* seems to be less questionable, due to the evidence of nearly parapatric occurrence of both *O. barnabita* s.s. and *O. lassallei* in NW and NE Greece, respectively (fig. 1), with a relatively high degree of genetic differentiation.

As widely discussed by Audisio et al. (in press), under a first assumption of a mtDNA mutation rate of only 1.2% per million years, the divergence time estimated between *Osmoderma barnabita* s.l. (= *O. barnabita* + *O. lassallei*) and *O. eremita* s.l. (= *O. eremita* + *O. cristinae* + *O. italicum*) is more than 6 million years, and around 3-4 m.y. among taxa included in each clade. Under the second assumption of a mtDNA mutation rate of 2% per million years, the divergence time estimated between *Osmoderma barnabita* s.l. (= *O. barnabita* + *O. lassallei*) and *O. eremita* s.l. (= *O. eremita* + *O. cristinae* + *O. italicum*) is more than 4-5 million years (Pliocene), and around 2 m.y. (Pleistocene) among taxa included in each clade. Therefore, in both cases the suggested evolutionary scenario implies that the divergence of *Osmoderma* populations (following the geographic isolation of mesophilous woodlands) likely predated most of the late Pleistocene glaciations. However, the climatic cooling probably confined *Osmoderma* populations for several times to some scattered ref-

uge areas of the Balkan and Italian peninsulas, and Sicily, causing further fragmentation of their genetic pools into more or less isolated groups. In this way the ancestral European *Osmoderma* may have been scattered in isolated southern refugia for many thousands of years during the Ice Ages and then expanded northwards following climate amelioration (Taberlet et al. 1998; Hewitt 1999; Vogel et al. 1999).

The rarity of most hermit beetle taxa and the associated legal limitations in collecting specimens are a serious and obvious drawback for taxonomic research on this genus. In fact, genetic data on hermit beetles should be increased both in terms of sampled specimens and examined populations, in order to assess the specific or subspecific rank of all the taxa assigned to *Osmoderma*. The divergence levels between European species, assessed by our researches, should be calibrated with data gathered from closely related but neatly distinct taxa (e.g., species of the related genus *Gnorimus* LePeletier de Saint-Fargeau & Serville, 1828, or less closely related *Osmoderma* species from the Caucasus, the Palaearctic Far East or the Nearctic Region; see Check List).

Given the taxonomical and zoogeographical scenario here reported, and summarised in fig. 1, we strongly support the need to enhance the efforts of the European entomologists, in order to quickly achieve more detailed data on the actual geographic distribution and genetic variation of *Osmoderma* spp. in Europe, with special reference to those countries where two or more species are actually (or potentially) present. As showed in fig. 1, the focal points of these researches should be represented by the following areas:

Germany, eastern Switzerland, western Austria, and Slovenia, where *Osmoderma eremita* s.s. and *O. barnabita* s.s. are locally parapatric or even sympatric (see also Tauzin 1994b, Sparacio 2000, Gusakov 2002, Dutto 2003, and unpublished data; fig. 1);

central-southern Italy, where *O. eremita* s.s. and "*O. italicum*" could be in contact;

northern Greece, Albania, Macedonia, southern Serbia, southern Bulgaria, and European Turkey, where the actual detailed distribution of *O. barnabita* s.s. and *O. lassallei* should be more accurately analysed.

**Osmoderma** LePeletier de Saint-Fargeau & Serville, 1828

*Gymmodi* Kirby, 1827: 157

*Osmoderma* LePeletier de Saint-Fargeau & Serville, 1828: 702

*Gymmodus* Kirby, 1837: 139

*Osmoedermum* Burmeister & Schaum, 1840: 364

NOTE: We maintain here the traditional generic name *Osmoderma* instead of the recently re-introduced name *Gymmodus* Kirby, 1827 (Ádám 1994, 2003; Gusakov 2002), according to a submitted proposal to the ICZN (Krell et al. 2006) to place the former one on the Official List of Generic Names in Zoology and to suppress the generic name *Gymmodus* for the purposes of the Principle of Priority but not for those of the Principle of Homonymy (Krell et al. 2006; Barclay 2007; International Commission of Zoological Nomenclature, 2007; Audisio et al. in press).

TYPE SPECIES: *Scarabaeus eremita* Scopoli, 1763 (subsequent designation by MacLeay 1838, p. 16).

THE *OSMODERMA EREMITA* GROUP

Western Europe (fig. 1)

**Osmoderma eremita** (Scopoli, 1763)

*Scarabaeus variabilis* Linné, 1758: 352 (nec *Scarabaeus variabilis* Linné, 1758: 353)

*Scarabaeus eremita* Scopoli, 1763: 7 (\*)

*Scarabaeus coriarius* De Geer, 1774: 300

*Trichius eremita* Fabricius, 1775: 45

*Cetonia eremitica* Knoch, 1801: 107

? *Osmoderma sociale* Horn, 1871:338

*Osmoderma eremita* var. *Semirufum* Pic, 1915: 363

*Osmoderma eremitum*: Tauzin, 1994b: 224

*Osmoderma eremita eremita*: Krell, 1997: 226

*Osmoderma italica* Sparacio, 2000: 232 (\*\*)

*Osmoderma italicum*: Audisio et al., 2003: 58 (\*\*); Pignaturo & Vicidomini, 2007

*Gymmodus eremita*: Gusakov, 2002: 12

NOTES: (\*) the neotype of *Osmoderma eremita* (Scopoli, 1763) was recently redesignated by Dutto (2003, 2005) on a male specimen from Slovenia, Kranj; in fact, the first neotype designation by Tauzin (1994b: 228) on a male specimen from Italy, Florence, was manifestly invalid (Massa 1995; Audisio et al. 2003; Dutto 2003).

(\*\*) The interpretation of *Osmoderma italicum* from southern Italy as potentially distinct species, semispecies or at least Evolutionary Significant Unit (ESU: Moritz 1994) is to be still considered highly questionable, pending for more detailed distributional and molecular data on this extremely rare taxon.

**Osmoderma cristinae** Sparacio, 1994                      Northern Sicily (fig. 1)

*Osmoderma cristinae* Sparacio, 1994: 306; Brustel, 2004: 204  
*Osmoderma eremita meridionale* Tausin, 1994b: 228; Massa, 1995: 307  
*Osmoderma eremita cristinae*: Krell, 1997: 226  
*Gymnodus cristinae*: Gusakov, 2002: 12

**Osmoderma barnabita** Motschulsky, 1845  
E Europe, W Russia (fig. 1)

*Osmoderma barnabita* Motschulsky, 1845: 58 (nec *O. barnabita* sensu Motschulsky, 1860: 134, nec auct.); Tausin, 2006: 40.  
*Osmoderma lassallei septentrionale* Tausin, 1994b: 223  
*Gymnodus eremita*: Ádám, 1994: 10  
*Osmoderma eremita lassallei*: Krell, 1997: 226, partim  
*Gymnodus coriarius*: Gusakov, 2002: 16, nec ? (De Geer, 1774): 300

NOTE: the lectotype of *Osmoderma barnabita* Motschulsky, 1845 was recently designated by Gusakov (2002: 16) on a female specimen from Central Russia, certainly conspecific with the central-eastern European populations of the *Osmoderma eremita* complex previously attributed to *O. eremita* (Ádám 1994), *O. lassallei septentrionale* (Tausin 1994b), *O. eremita* ssp. *lassallei* (Krell 1997, partim) or to *O. lassallei* s.l. (Sparacio 2000, partim). The use of a junior synonym of *O. eremita*, *Scarabaeus coriarius* De Geer (1774), recently exhumed by Gusakov (2002) as valid name for *Osmoderma barnabita*, is to be considered as strongly inadvisable, due to the problems of uncertain specific attribution of the so far not available type specimen of this taxon. Gusakov (2002: 25) refers that ‘As a name for the “eastern” form [of *O. eremita* s.l.] I am suggesting *Scarabaeus coriarius* De Geer, 1774 - as new combination *G. coriarius* (De Geer, 1774). I had no an opportunity to study type specimens of *G. coriarius* and in the primary description there are not mentioned characters important for resolving “western” and “eastern” forms. But I consider it unlikely, that the Swedish



naturalist De Geer had material from distributional area of the “eastern” form’.

In fact, De Geer was in contact especially with entomologists from France, Germany, Denmark, and obviously Sweden, all countries being well within the range of the “western form” of *O. eremita*. Then, *Scarabaeus coriarius* De Geer, 1774, described from an unknown European locality (De Geer, 1774: 300; he literally reported “C’est un grand Scarabé des plus rares, et que je n’ai point trouvé à Leufsta [= Lovstabruk, near Üppsala], l’ayant eu d’un de mes amis, et je doute même qu’on le rencontre en Suede”), according to our opinion should much more likely be a synonym of *O. eremita* than of *O. barnabita*. We choose then to consider *O. coriarium* a likely junior synonym of *O. eremita*, resurrecting *Osmoderma barnabita* Motschulsky, 1845 (**resurrected name**), as being the valid and certainly applicable specific epithet for the “oriental form” of *O. eremita* s.l.

**Osmoderma lassallei** Baraud & Tausin, 1991

NE Greece, European Turkey (fig. 1)

*Osmoderma lassallei* Baraud & Tausin, 1991: 159 et auct., partim; Brustel, 2004: 204

*Osmoderma lassallei lassallei*: Tausin, 1994b: 223

*Osmoderma eremita lassallei*: Krell, 1997: 226, partim

*Gymnodus coriarius lassallei*: Gusakov, 2002: 12

**Osmoderma davidis** Fairmaire, 1887      Russian Far East, NE China

*Osmoderma Davidis* Fairmaire, 1887: 221

*Osmoderma barnabita*: Motschulsky, 1860: 134, et auct., partim, nec Motschulsky, 1845: 58

*Osmoderma barnabita*: Tausin, 1994a: 202

*Osmoderma davidis* (sic !): Tausin, 1994a: 202

*Gymnodus davidis*: Gusakov, 2002: 35

*Gymnodus davidis* forma *amurensis* Gusakov, 2002: 39

**Osmoderma opicum** Lewis, 1887

Japan (Honshu Island)

*Osmoderma opica* Lewis, 1887: 47

*Osmoderma opicum*: Tausin, 1994b: 217

*Gymnodus opicus*: Gusakov, 2002: 42.

**Osmoderma caeleste** (Gusakov, 2002)

Russian Far East, N Korea, NE China

*Osmoderma barnabutum* var. *castaneum* Tausin, 1994: 204; Tausin, 2006: 39

*Gymnodus caelestis* Gusakov, 2002: 39

*Osmoderma barnabita* auct., partim, nec Motschulsky, 1845: 58

*Osmoderma sikhotense* Boucher, 2002: 426; Boucher et al., 2003: 401; Tausin, 2006: 43.

NOTE: the official publication date (26.viii.2002) of the Gusakov's monograph where *Gymnodus caelestis* was described (Gusakov 2002) precedes the description of *Osmoderma sikhotense* Boucher, 2002 (published at the end of 2002), despite some doubts still remain on the name having actual priority (Tausin 2006). The first published name of this taxon appeared under the combination *Osmoderma barnabutum* var. *castaneum* Tausin, 1994. But, according to the ICZN, an infrasubspecific name published after 1960 and expressly considered a "variety" in its original description, cannot be made available from its original publication by any subsequent action (such as "elevation in rank": Art. 45.5), as correctly discussed by Tausin (2006).

**Osmoderma scabrum** (Palisot de Beauvois, 1807)

NE North America

*Trichius scaber* Palisot de Beauvois, 1807: 58

*Osmoderma scaber*: Gory & Percheron, 1833: 47

*Trichius (Gymnodus) foveatus* Kirby, 1837: 140

*Trichius (Gymnodus) rugosus* Kirby, 1837: 140

*Osmoderma scabrum* var. *beauvoisii* Bainbridge, 1841: 481

*Osmoderma scabrum*: Burmeister & Schaum, 1840: 384; Bedel, 1906: 254; Tausin, 1994a: 198

*Osmoderma scabra rugosa*: Casey, 1915: 373

*Osmoderma scabra gracilipes* Casey, 1915: 374

*Osmoderma caviceps* Casey, 1915: 374

*Osmoderma caviceps lacustrina* Casey, 1915: 374

*Osmoderma scabrum Caseyi* Shenkling, 1922: 9

*Osmoderma scabra*: Howden, 1968: 8

*Gymnodus scaber*: Gusakov, 2002: 13

THE *OSMODERMA BREVIPENNE* GROUP

***Osmoderma brevipenne* Pic, 1904**

Asiatic Turkey

*Osmoderma brevipennis* Pic, 1904: 74

*Osmoderma brevipenne*: Bedel, 1906: 30; Tausin, 1994a: 208

*Gymnodus brevipennis*: Gusakov, 2002: 13

***Osmoderma richteri* Medvedev, 1953**

Georgian Caucasus

*Osmoderma richteri* Medvedev, 1953: 297; 1960: 385; Tausin, 1994a: 212

*Gymnodus richteri*: Gusakov, 2002: 32

THE *OSMODERMA EREMICOLA* GROUP

***Osmoderma eremicola* (Knoch, 1801)**

NE North America

*Cetonia eremicola* Knoch, 1801: 105

*Osmoderma eremicola*: Gory & Percheron, 1833: 47; Howden, 1968: 9; Tausin, 1994a: 198

*Trichius (Gymmodus) drakii* Kirby, 1837: 155

*Gymnodus eremicola*: Gusakov, 2002: 13

***Osmoderma subplanatum* Casey, 1915**

Central North America

*Osmoderma eremicola subplanata* Casey, 1915: 376; Hoffmann, 1939: 521; Tausin, 1994a: 205

*Osmoderma montana* Wickham, 1920: 233; Hoffmann, 1939: 521

*Osmoderma subplanata*: Howden, 1968: 11; Smith, 2003: 73

*Gymnodus eremicola subplanatus*: Gusakov, 2002: 13

NOTE: we examined some specimens and agree with R.H. Howden (1968) and Smith (2003) in considering this taxon as a valid species and not a subspecies of *O. eremicola* as proposed by Gusakov (2002), or even a simple synonym as proposed by Hoffmann (1939) and Tausin (1994a). However it seems that the problem of the taxonomic arrangement of the pair *O. eremicola* and *O. subplanatum* is partly analogous to that observed for some species pairs within the *O. eremita* complex, and it is likely that only molecular analyses could soon provide more insights on the whole matter.

In order to set up and develop successful conservation strategies, it is advisable to combine the diagnostic morphological characters listed and figured by Tausin (1994b), Sparacio (2000) and Gusakov (2002) with short diagnostic nucleotide sequences, allowing to discriminate among the five taxa here discussed, especially to identify individuals inhabiting the areas of parapatry and sympatry among them. We have in progress a study aimed to summarize morphological and molecular characters to distinguish the different European taxa of the *Osmoderma eremita* species-complex, in order to provide useful data for planning conservation efforts. In fact, the taxonomic changes caused by the splitting of some widespread species into a higher number of them, each with a smaller distribution range, compel conservation biologists to a new assessment of threat level for all the taxonomic group (Ryder 1986). An urgent re-evaluation of threat categories is required for each taxonomic unit derived from any splitting decision, either because of the reduced size of its geographic range or the consequent reduction of its population consistency (Mace & Lande 1991; AA.VV. 1994). Each derived taxonomic unit should be carefully examined in order to apply the major criteria for assessing the risk of extinction, such as (1) Extent of Occurrence, (2) Area of Occupancy, (3) Population Consistency (Mace & Lande 1991). For the same reason, the process of setting priorities for conservation action should also be rebuilt after the evaluation of the different factors which affect the risk of extinction for each taxonomic unit.

In the case of *Osmoderma* species and/or semispecies, as defined by the present paper, the small size of geographic range (extent of occurrence) for *O. cristinae* and *O. lassallei* let us to consider them as the most threatened taxa of the complex. Probably, they should also be placed among the most threatened animal species of southern Europe, considering their restricted area of occupancy (mainly that of *O. cristinae*), associated with a potentially fatal combination of limited population size, reduced habitat availability, bird predation, fires, and frequently unsuitable local techniques of forest management. The population size of these two taxa should be accurately estimated and monitored, at least in the Sites of Community Importance established according to the EU Habitat Directive.

It must be also considered that the taxa recently separated at specific level from the former "*Osmoderma eremita*" risk now to have no legal protection in the next few years, as recently discussed by Brustel (2004). In fact, if considered as being a distinct species, their legal protection should be formally no longer active under the "umbrella" of the binomial combination "*Osmoderma eremita*" regulated by the EU Habitat Directive, 1992. Happily, the new coming Italian Coleoptera Red List (Various Authors in progress) should soon provide the necessary legal protection at least to *O. cristinae* in Sicily.

Our studies show that there is clear evidence of genetically divergent European species and semi-species within the *Osmoderma eremita* complex. It is rather high the risk that at least part of this genetic diversity could be eroded in the next future, and these preliminary data may be key to the conservation of the hermit beetles in Europe. The whole problem should be considered as an international concern, to be managed with different criteria in each single area.

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#### SUMMARY

Results of a molecular analysis on the European hermit beetles (the *Osmoderma eremita* species-complex), recently published in a companion paper, are shortly discussed and commented. These results indicate a clear-cut distinction between two clades. The first one includes the W-European *O. eremita* Scopoli, 1763, and the two Italian endemic taxa *O. italicum* Sparacio, 2000 and *O. cristinae* Sparacio, 1994, from southern peninsular Italy and Sicily, respectively. The second one includes the widespread E-European *O. barnabita* Motschulsky, 1845 (**nom. resurr.**), and the southern Balcanic *O. lassallei* Baraud & Tausin, 1991 from Greece and European Turkey. Within the two clades, molecular data well support a specific rank for *O. lassallei* and *O. barnabita* on one side, and of *O. eremita* and *O. cristinae* on the other side, while the taxo-

onomic position of *O. italicum*, more closely related with *O. eremita*, is still uncertain, waiting for analysis of additional specimens of this very rare taxon. Current geographical distribution, interspecific genetic diversification, and relatively low levels of intraspecific genetic divergence in *O. eremita* sensu stricto, are hypothesized to be the result of multiple speciation events (mainly occurred in refugial forest areas of the Italian and Balkan peninsulas and Sicily before and during the Pleistocene glacial peaks), followed by fast post-glacial northward and westward expansion of some species. The need of further genetic data on the rare and threatened hermit beetle species and the importance of more detailed information on their distribution ranges are emphasized and discussed, in order to plan conservation strategies in the near future. An updated worldwide checklist of the species of the genus *Osmoderma* is finally presented.

## REFERENCES

- AA.VV., 1994. The IUCN Red List of Threatened species: 1994 Categories and Criteria. [http://www.iucnredlist.org/info/categories\\_criteria1994](http://www.iucnredlist.org/info/categories_criteria1994).
- ÁDÁM, L. 1994. A check-list of the Hungarian Scarabaeoidea with the description of ten new taxa (Coleoptera). *Folia Entomologica Hungarica*, 55, 5-17.
- ÁDÁM, L. 2003. Faunisztikai adatok a Kárpát-medencéből (Coleoptera: Scarabaeoidea). *Folia Historico Naturalia Musei Matraensis*, 27, 101-136.
- AUDISIO, P., A. BALLERIO, G.C. CARPANETO, G. ANTONINI, E. MANCINI, G. COLETTI, E. PIATTELLA, & A. DE BIASE. 2003. *Osmoderma eremita* s.l. in Europa meridionale: stato delle conoscenze e problemi di conservazione (Coleoptera, Cetoniidae). Proceedings of the International Symposium "Dead wood: a key to biodiversity", Mantova, May 29-31, 2003, *Sherwood*, 95, suppl. 2. (ed. by F. Mason, G. Nardi & M. Tisato), pp. 57-60.
- AUDISIO, P., H. BRUSTEL, G.M. CARPANETO, G. COLETTI, E. MANCINI, M. TRIZZINO & A. DE BIASE. In press. Data on molecular taxonomy and genetic diversification of the European Hermit beetles, a species-complex of endangered insects (Coleoptera: Scarabaeidae, Cetoniinae, genus *Osmoderma*). *Journal of Zoological Systematics and Evolutionary Research*.
- BAINBRIDGE, W. 1841. Observations on *Osmoderma* and some new species of Cetonidae. *Annals and Magazine of Natural History*, 6, 481-483.
- BARAUD, J. & P. TAUZIN. 1991. Une nouvelle espèce Européenne du genre *Osmoderma* Serville (Coleoptera Cetonidae Trichiinae). *Lambillionea*, 91 (3), 159-166.
- BARCLAY, M.V.L. 2007. Comment on the proposed conservation of the generic names *Gnorimus* Le Peletier de Saint-Fargeau & Serville, 1828 and *Osmoderma* Le Peletier de Saint-Fargeau & Serville, 1828 (Insecta, Coleoptera). (Case 3349; BZN 63: 177-183). *Bulletin of Zoological Nomenclature*, 64 (2): 122.
- BEDÉL, L. 1906. Révision du genre *Osmoderma* Gory et Percheron. *L'Abeille*, 30, 253-258.
- BOUCHER, S. 2002. Un nouvel *Osmoderma* endémique des monts Sikhote-Aline (Coleoptera, Cetonidae). *Bulletin de la Société entomologique de France*, 107 (4), 425-427.
- BOUCHER, S., O. MONTREUIL & A. LE RESTIF. 2003. Découverte de la femelle et nouvelles localisations d'*Osmoderma sikhotense* Boucher (Coleoptera, Cetoniidae). *Bulletin de la Société entomologique de France*, 108 (4), 401-403.
- BRUSTEL, H. 2004. Contribution à la connaissance d'*Osmoderma* spp. dans le sud de l'Europe (Coleoptera, Cetoniidae). *Le Coléoptériste*, 7 (3), 203-205.
- BURMEISTER, H. & H. SCHAUM. 1840. Kritische Revision der Lamellicornia melitophila (Trichiidae). In: Germar E.F., *Zeitschrift für die Entomologie*, 2, 353-420. Leipzig.

- CABRERO-SANUDO, F.-J. & R. ZARDOYA. 2004. Phylogenetic relationship of Iberian Aphodiini (Coleoptera: Scarabaeidae) based on morphological and molecular data. *Molecular Phylogenetics and Evolution*, 31, 1084-1100.
- CARISIO, L., P. CERVELLA, C. PALESTRINI, M. DEL PERO & A. ROLANDO. 2004. Biogeographical patterns of genetic differentiation in dung beetles of the genus *Trypocopris* (Coleoptera, Geotrupidae) inferred from mtDNA and AFLP analyses. *Journal of Biogeography*, 31, 1149-1162.
- CASEY, T.L. 1915. A review of the American species of Rutelinae, Dynastinae and Cetoniinae. *Memoirs of the Coleoptera*, 6, 1-394.
- DE GEER, C. 1774. *Memoires pour servir a L'Histoire des Insectes*. Stockholm.
- DUTTO, M. 2003. Sulla presenza di *Osmoderma eremita* (Scopoli, 1763) in Slovenia e nell'estremo nord-est dell'Italia e designazione del neotipo (Coleoptera, Scarabaeoidea, Cetoniidae). *Naturalista siciliano*, IV series, 27 (3-4), 233-236.
- DUTTO, M. 2005. Precisazioni Geografiche sul Neotipo di *Osmoderma eremita* (Scopoli, 1763) (Coleoptera, Scarabaeoidea, Cetoniidae). *Lambillionea*, CV, 3, 392.
- FABRICIUS, J.C. 1775. *Systema entomologiae*. Lipsiae.
- FAIRMAIRE, L. 1877. Notes sur les Coléoptères des environs de Pékin. *Revue d'Entomologie*, 6, 312-335.
- GALANTE, E. & J.R. VERDÚ. 2000. Los artrópodos de la "Directiva Hábitat" en España. Organismo Autónomo de Parques Nacionales, Madrid.
- GORY, M.H. & M.A. PERCHERON. 1833. *Monographie des Cetoines*. Baillière, Paris and London.
- GUSAKOV, A.A. 2002. Scarabaeid beetles of the subfamily Trichiinae (Coleoptera, Scarabaeidae) in the Fauna of Russia. Species of the genus *Gymmodus* Kirby, 1827. 55 pp. Eidos, Kaluga. [In Russian].
- HEWITT, G.M. 1999. Post-glacial re-colonization of European biota. *Biological Journal of the Linnean Society*, 68, 87-112.
- HOFFMANN, C.H. 1939. The biology and taxonomy of the nearctic species of *Osmoderma* (Coleoptera, Scarabaeidae). *Annals of the Entomological Society of America*, 32, 510-525.
- HORN, G.H. 1871. Description of new Coleoptera of the United States, with notes on known species. *Transactions of the American Entomological Society*, 3, 325-344.
- HOWDEN, H.F. 1968. A review of the Trichiinae of North and Central America (Coleoptera: Scarabaeidae). *Memoirs of the Entomological Society of Canada*, 54, 1-77.
- INTERNATIONAL COMMISSION OF ZOOLOGICAL NOMENCLATURE, 2007. OPINION 2186 (Case 3349). *Gnorimus* Le Peletier de Saint-Fargeau & Serville, 1828, and *Osmoderma* Le Peletier de Saint-Fargeau & Serville, 1828 (Insecta, Coleoptera, Scarabaeidae): conserved. *Bulletin of Zoological Nomenclature* 64(4), 265-266.
- KIRBY, W. 1827. A description of some new genera and species of petalocerous Coleoptera. *Zoological Journal*, 3, 145-158.
- KIRBY, W. 1837. *Insects. Coleoptera*. In: Richardson, *Fauna Boreali-Americana; or the zoology of the northern parts of British America*. Norwich.
- KNOCH, A.W. 1801. *Neue Beitrage zur Insektenkunde*, vol. 1, Leipzig.
- KRELL, F.-T. 1997. Zur Taxonomie, Chorologie und Eidonomie einiger westpaläarktischer Lamellicornia (Coleoptera). *Entomologische Nachrichten und Berichte*, 40 (4), 217-229.
- KRELL, F.-T. 2004. Coleoptera Cetoniidae. In: AA.VV., *Fauna Europaea Project Data Bank*, Amsterdam. [WEB edition, <http://www.faunaeur.org>]
- KRELL, F.-T., A. BALLERIO, A.B.T. SMITH, & P. AUDISIO. 2006. Case 3349. *Gnorimus* Le Peletier de Saint-Fargeau & Serville, 1828, and *Osmoderma* Le Peletier de Saint-Fargeau & Serville, 1828 (Insecta, Coleoptera): proposed conservation of the generic names. *Bulletin of the Zoological Nomenclature*, 63 (3), 177-183.

- LEPELETIER, A.L.M. & A. SERVILLE. 1825-1828. In: Encyclopédie méthodique, 10 (2), 345-832.
- LEWIS, G. 1887. Note on a new species of *Osmoderma* and a *Trichius* from Japan. Wiener Entomologische Zeitung, 6 (2), 49.
- LINNÉ, C. 1758. Systema Naturae per Regna tria Naturae, secundum Classes, Ordines, Genera, Species, cum Characteribus, Differentiis, Synonymis, Locis. Tomus I, Editio X, reformata. Holmiae, 824 pp. [pp. 352-353].
- LUCE, J.-M. 1995. Écologie des cétoïnes (Insecta: Coleoptera) microcavernicoles de la forêt de Fontainebleau. Niches écologiques, relations interspécifiques et conditions de conservation des populations. Thesis, Muséum National d'Histoire Naturelle, Paris [In French].
- LUCE, J.-M. 1996. *Osmoderma eremita* (Scopoli, 1763). In: Background information on invertebrates of the Habitats Directive and the Bern Convention. Part I: Crustacea, Coleoptera and Lepidoptera (ed. by P.J. van Helsdingen, L. Willemse & M.C.D. Speight), pp. 64-69. Council of Europe, Strasbourg.
- LUCE, J.-M. 2001. La Cétoïne protégée *Osmoderma eremita* (Scopoli, 1763) peut elle être un outil de gestion de la biodiversité? In: Inventaire et Cartographie des invertebrés comme contribution à la gestion des milieu naturels français. Actes du séminaire tenu à Besançon les 8, 9 et 10 Juillet 1999 (ed. by J.C. Robert, R. Guilbot, J.L. Dommanget & H. Maurin), vol. 46, 332 pp. Patrimoines naturels, M.N.H.N., Paris.
- MACE, G. M. & R. LANDE, R. 1991. Assessing extinction threats: toward a re-evaluation of IUCN threatened species categories. Conservation Biology, 5 (2), 148-157.
- MASSA, B. 1995. *Osmoderma eremitum meridionale* Tausen, 1994 sinonimo di *Osmoderma cristinae* Sparacio, 1994 (Insecta Coleoptera Cetoniidae). Naturalista siciliano, IV series, 19, 307-308.
- MEDVEDEV, S.I. 1953. A new species of *Osmoderma* Serville (Coleoptera Scarabaeidae) from Georgia. Entomologiceskoe Obozrenie (Moska), 32, 297-299, figs 1 and 2. [In Russian]
- MEDVEDEV, S.I. 1960. Scarabaeidae. Subfam. Euchirinae, Dynastinae, Glaphyrinae, Trichiinae. In: Coleoptera, vol.10 (4), 398 pp. (Fauna of USSR, New series, N 74).
- MICÓ, E., O. PIAU, E. GALANTE & J.P. LUMARET. 2003. Taxonomy of Iberian *Hoplia* (Col., Scarabaeoidea, Hopliinae) based on mtDNA analysis. Molecular Phylogenetics and Evolution, 26, 348-353.
- MORITZ, C. 1994. Defining evolutionarily significant units for conservation. Trends in Ecology and Evolution, 9, 373-375.
- MORITZ, C. 1995. Uses of molecular phylogenies for conservation. Philosophical Transactions of Royal Society of London B349, 113-118.
- MOTSCHULSKY, V. de 1845. Remarques sur la collection de Coléoptères russes de Victor de Motschulsky. Bulletin de la Société impériale des naturalistes de Moscou, 18, 1-127.
- MOTSCHULSKY, V. de 1860. Coléoptères de la Sibérie Orientale et en particulier des rives de l'Amour. In: Schrenck L., Dr. L. v. Schrenck's Reisen und Forschungen im Amur-Land. Band II, 258 pp. Académie Impériale des Sciences, St. Péters-bourg.
- NÜSSLER, H. 1986. Eine von *Osmoderma eremita* (Scop.) abweichende Weibchen-Form aus Südwestbulgarien (Insecta, Coleoptera, Scarabaeidae). Faunistische Abhandlungen Staatliches Museum für Tierkunde, Dresden, 13, 113-117.
- PALISOT DE BEAUVOIS, A.M.F.J. 1807 (1805-1821) Insectes recueillis en Afrique et en Amérique. Paris.
- PIC, M. 1904. Coléoptères nouveaux de la Turquie d'Asie. L'Échange, 14, 74.
- PIC, M. 1915. Notes diverses - Descriptions et diagnoses. L'Échange, 33, 363.
- PIGNATURO, C. & S. VICIDOMINI. 2007. *Osmoderma italicum* Sparacio (Coleoptera): ri-



- trovato nei pressi del locus typicus dopo circa un secolo (Campania). XXI Congresso Nazionale Italiano di Entomologia, Campobasso, 11-16 Giugno 2007. Abstract.
- RANIUS, T. 2000. Minimum viable metapopulation size of a beetle, *Osmoderma eremita*, living in tree hollows. *Animal Conservation*, 3, 37–43.
- RANIUS, T. 2001. Constancy and asynchrony of populations of a beetle, *Osmoderma eremita*, living in tree hollows. *Oecologia*, 126, 208–215.
- RANIUS, T. 2002a. *Osmoderma eremita* as an indicator of species richness of beetles in tree hollows. *Biodiversity and Conservation*, 11, 931-941.
- RANIUS, T. 2002b. Population ecology and conservation of beetles and pseudoscorpions living in hollow oaks in Sweden. *Animal Biodiversity and Conservation*, 25 (1), 53-68.
- RANIUS, T. 2002c. Influence of stand size and quality of tree hollows on saproxylic beetles in Sweden. *Biological Conservation*, 103, 85-91.
- RANIUS, T. & J. HEDIN. 2001. The dispersal rate of a beetle, *Osmoderma eremita*, living in tree hollows. *Oecologia*, 126, 363–370.
- RANIUS, T. & J. HEDIN. 2004. The occupancy pattern of a saproxylic beetle, *Osmoderma eremita*, in a fragmented landscape predicted from a RAMAS metapopulation model. In: *Species conservation and management: case studies* (ed. by H.R. Akcakaya, M. Burgman, O. Kindvall, C.C. Ward, P. Sjögren-Gulve, J.S. Hatfield & M.A. McCarthy). Oxford University Press, New York.
- RANIUS, T. & S.G. NILSSON. 1997. Habitat of *Osmoderma eremita* Scop. (Coleoptera: Scarabaeidae), a beetle living in hollow trees. *Journal of Insect Conservation*, 1, 193-204.
- RANIUS, T., L.O. AGUADO, K. ANTONSSON, P. AUDISIO, A. BALLERIO, G.M. CARPANETO, K. CHOBOT, B. GJURASIN, O. HANSEN, H. HUIJBREGTS, F. LAKATOS, O. MARTIN, Z. NECULISEANU, N.B. NIKITSKY, W. PAILL, A. PIRNAT, V. RIZUN, A. RUCĂNESCU, J. STEGNER, I. SUDA, P. SZWAŁKO, V. TAMUTIS, D. TELNOV, V. TSINKEVICH, V. VERSTEIRT, V. VIGNON, M. VÖGELI & P. ZACH. 2005. *Osmoderma eremita* (Coleoptera, Scarabaeidae, Cetoniinae) in Europe. *Animal Biodiversity and Conservation*, 28 (1), 1–44.
- RYDER, O.A. 1986. Species conservation and dilemma of subspecies. *Trends in Ecology and Evolution*, 1, 9-10.
- SCHAFFRATH, U. 2003a. Zur Lebensweise, Verbreitung und Gefährdung von *Osmoderma eremita* (Teile 1). *Philippia*, 10 (3), 157-248.
- SCHAFFRATH, U. 2003b. Zur Lebensweise, Verbreitung und Gefährdung von *Osmoderma eremita* (Teile 2). *Philippia*, 10 (4), 249-336.
- SCHENKING, S. 1922. Scarabaeidae: Trichiinae, Valginae. In: *Coleopterorum Catalogus* (ed. by W. Junk), 75, 1-39.
- SCOPOLI, J. 1763. *Entomologia Carniolica*. 420 pp. Vindobonae (Wien).
- SHOKHIN, I.V. & V.Y. BOZADJIEV. 2003. Lamellicorn beetles (Coleoptera: Scarabaeoidea) of Rostov region. Electronic journal "Investigated in Russia", 6, 468-488. [In Russian].
- SMITH, A.B.T. 2003. Checklist of the Scarabaeoidea of the Nearctic Realm including Canada, the continental United States, and the northern Mexican states of Baja California, Baja California Sur, Chihuahua, Coahuila de Zaragoza, Durango, Nuevo Leon, Sinaloa, Sonora, Tamaulipas, and Zacatecas. Version 3, released 25 September 2003, 74 pp. [<http://www-museum.unl.edu/research/entomology/Nearctic-scarabs3.doc>]
- SPARACIO, I. 1994. *Osmoderma cristinae* n. sp. di Sicilia (Insecta Coleoptera: Cetoniidae). *Naturalista siciliano*, IV series, 17 (3-4), 305-310.
- SPARACIO, I. 2000. Osservazioni sulle *Osmoderma* Le Peletier et Audinet-Serville europee con descrizione di una nuova specie dell'Italia meridionale (Coleoptera Cetoniidae). *Naturalista siciliano*, IV series, 24 (3-4), 225-239.

- TABERLET, P., L. FUMAGALLI, A.-G. WUST-SAUCY, & J.-F. COSSON. 1998. Comparative phylogeography and postglacial colonization routes in Europe. *Molecular Ecology*, 7, 453-464.
- TAMURA, K. & M. NEI. 1993. Estimation of the number of nucleotide substitutions in the control region of mitochondrial DNA in humans and chimpanzees. *Molecular Biology and Evolution*, 10, 512-526.
- TASSI, F., H.-P. ABERLENC, J.-Y. RASPLUS, G. CURLETTI, M. DUTTO, G. GENSON & G. LEMPÉRIÈRE. 2004. *Eupotosia mirifica*, la grande Cétoine bleue, joyau menacé du patrimoine naturel européen. Propositions pour la protection de l'espèce et de ses biotopes. (Coleoptera, Cetoniidae, Cetoniinae). *Lambillionea*, 104 (Suppl.), 1-33.
- TAUZIN, P. 1994a. Le genre *Osmoderma* Le Peletier et Audinet-Serville 1828 (Coleopt., Cetoniidae, Trichiinae, Osmodermatini). *Systématique, biologie et distribution (Première partie)*. *L'Entomologiste*, 50 (3), 195-214.
- TAUZIN, P. 1994b. Le genre *Osmoderma* Le Peletier et Audinet-Serville 1828 (Coleopt., Cetoniidae, Trichiinae, Osmodermatini). *Systématique, biologie et distribution (Deuxième partie)*. *L'Entomologiste*, 50 (4), 217-242.
- TAUZIN, P. 1996. Complément à la note sur le genre *Osmoderma* (Coléoptères, Cetoniidae, Trichiinae). *L'Entomologiste*, 52 (3), 105-106.
- TAUZIN, P. 2000. Localités connues de *Osmoderma eremitum* Scopoli en France. *Le Coléoptériste*, 39, 133-136.
- TAUZIN, P. 2002. *Osmoderma eremitum*: compléments sur sa distribution en France et nouvelle information sur la taxonomie du genre (Coleoptera, Cetoniidae, Trichiinae, Osmodermatini). *L'Entomologiste*, 58 (3-4), 145-151.
- TAUZIN, P. 2006. Nouveau statut pour la variété *castaneum* de *Osmoderma barnabita* Motschoulsky, 1845 (Coleoptera, Scarabaeoidea, Cetoniidae, Trichiinae, Osmodermatini). *Cetoniimania*, 1-2, 39-49.
- VILLALBA, S., J.M. LOBO, F. MARTÍN-PIERA & R. ZARDOYA. 2002. Phylogenetic relationships of Iberian dung beetles (Coleoptera: Scarabaeinae): insights on the evolution of nesting behavior. *Journal of Molecular Evolution*, 55, 116-126.
- VOGEL, J.C., F.J. RUMSEY, J.J. SCHNELLER, J.A. BARRETT & M. GIBBY. 1999. Where are the glacial refugia in Europe? Evidence from pteridophytes. *Biological Journal of the Linnean Society*, 66, 23-37.
- WICKHAM, H. F. 1920. New species of *Perthalykra* and *Osmoderma* (Col.). *Proceedings of the Entomological Society of Washington*, 22, 232-234.