

The use of the entomofauna in the studies of the Environmental Impact Assessment (E.I.A.) and Assessment of Impact (A.I.)

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ABSTRACT

The paper highlights the entomofauna's role as not only as an indicator of the environmental quality, but also as a useful component in the studies of the Environmental Impact Assessment (E.I.A.) and Assessment of Impact (A.I.). Some approaches and tools, with particular emphasis on Sicily, are proposed in regards to the use of the entomofauna in the assessment procedures.

KEY WORDS

Environmental Impact Assessment; Impact Assessment; Entomofauna; tools; Sicily.

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INTRODUCTION

This paper is a brief methodological review, resulting from the experience gained on several impact assessments elaborated in the recent years in Sicily.

In Europe there are three different types of environmental impact assessment: 1) S.E.A. (Strategic Environmental Assessment), based on the Directive 2001/42/EC on the assessment of the effects of certain plans and programs on the environment; 2) E.I.A. (Environmental Impact Assessment) based on the Directive 2014/52/UE, concerning the impacts assessment of public and private projects on the environment. The Directive determines the authorization of certain projects affecting the environment to an assessment by the competent national or regional authority. This assessment must identify the direct and indirect effects of these projects on the following: human, fauna, flora, soil, water, air, climate, landscape, material resources and cultural

heritage, and the interaction between these components; 3) A.I. (Assessment of Impact), regarding the assessment of plans and projects significantly affecting the sites of the Natura 2000 Network.

This evaluation is based on the Directive 92/43/EEC (Habitat Directive), on the conservation of natural habitats and of wild fauna and flora, and on the Directive 2009/147/EC on the conservation of wild birds (ex Directive 79/409 EEC). Particularly, the Assessment of Impact is defined and regulated by the article 6, of the Habitat Directive, that in the third paragraph reads: "*Any plan or project not directly connected with or necessary to manage the site but likely to have a significant effect, individually or in combination with other plans or projects, is subjected to impact assessment on the site respect to the conservation objectives of this site*". Through these guidelines the EU seeks to ensure biodiversity by conserving natural habitats, wild fauna, vegetation and flora in the territory of the Member States.

In the studies of evaluation of environmental impact, the analysis of the biotic component is fundamental to assess the impact generated from plans and projects; therefore it is obvious that the fauna is one of the minimum contents required for the preparation of environmental impact studies, together with vegetation, flora (see Minissale, 2015) and ecosystems.

THE FAUNA IN THE ENVIRONMENTAL IMPACT STUDIES

Before delving into the issues related to the wildlife analysis in the environmental impact studies, the definition of the fauna's concept is necessary. According to La Greca (1995), the fauna is: "A set of species and subspecies of vertebrates and invertebrates, each divided into one or more populations, living in a certain territory not captive or farmed (indigenous species) and included in natural ecosystems, the presence of which in that area is due to historical events (paleogeographic and paleoclimatic), or to evolutionary processes in situ (autochthonous species or subspecies), or to indigenation of exotic species".

The study of wildlife shows numerous and complex problems: a) very large number of animals, especially invertebrates (over 80% of the animals belong to the phylum Arthropoda, inside of which more than 75% belong to the class Hexapoda); b) basic knowledge in general unsatisfactory, even for protected areas; c) difficulty of making a quick faunistic list of a region, even with small extension; d) necessity to adopt different and very specialized sampling methods related to the animals' mobility and the different habitats they occupy; e) difficulty in developing maps for wildlife.

In relation to these issues, two methodologies are used for the study of fauna in the environmental impact studies: 1) Ecosystem approach (review of certain natural habitats of particular interest in relation to the associated fauna component); 2) List of species (for a more detailed discussion of the topic see Sabella & Petralia, 2012). Really, the zoologists must interpret the territory as a mosaic of areas that provide real or potential opportunities (trophic, reproduction, shelter, etc.) for the various wildlife species.

The attention of the zoologists involved in the environmental impact studies, generally, focuses on the

terrestrial vertebrates (especially birds), because it is the best known component of the wildlife and responds to the needs to assess the environmental quality in relation to the targets of the impact studies.

THE USE OF ENTOMOFAUNA: APPROACHES AND TOOLS

The insects are generally poorly used in the environmental impact studies. This component, instead, on account of its species richness (more than 1 million of taxa known heretofore), of its ubiquitous occurrence and very different diet (predators, phytophagous, saprophagous, parasites, pollinators, etc.) and of its diverse and articulated ecological requirements is suited for the environmental impact studies (Rosenberg et al., 1986). The study of entomofauna, in many cases, provides more detailed information on the fine structure and functioning of the ecosystems and/or allows to study in more detail the habitats or the microhabitats of particular naturalistic value (dunes and back-shore, springs, ripicolous environments, soil, caves, rotting stumps, hollow of old trees, etc.), which are sometimes very important in the environmental impact studies, and also in the territorial planning and in the nature conservation policy (Gobbi, 2000).

In relation to the high species number and to the great diversity of the environments in which they occur, the study of insects presents all the problems outlined above in a more accentuated way, so much so that, at first glance, it would seem almost impossible to use the insects in the assessment procedures. For these reasons guidelines for the use of insects in impact evaluation are, generally, lacking, with exception regarding the freshwater ecosystems (Adham et al., 2009; Walters, 2011; Barman, 2014) and the agro ecosystems (see for example Caoduro et al., 2014).

To do this you have, first, to give up the idea of establishing a more or less full list of insect species of a territory, even if small. In any case, this idea is unworkable for all faunistic studies. But ignoring entomofauna cannot solve this problem. In the last years, however, many tools have become available for use the insects in the environmental management and also in the impact assessment studies. For a review of the various sampling methodologies of entomofauna used in environmental monitoring and a case study see Burgio et al. (2013).

It is clear that for assessment studies can be used only a small fraction of all insect species that occur in the study area and should be considered those with conservation problems (IUCN status, inclusion in international conventions or European directive annexes) and/or scientific value (endemic, stenocious, at the areal limit, etc.).

Below are briefly treated the main tools usable for the evaluation of the environmental quality based on the presence of insects species.

They, substantially, consist of the European, national and regional red list drafted according to IUCN criteria, of the annexes of different international convention and European directive, of the checklists (sometimes georeferenced), and of the Standard Data Form and the Management Plan of the Natura 2000 site.

SPECIES INCLUDED IN THE ANNEXES OF DIRECTIVE 43/92 EEC

Insects species of Annex II to Directive 43/92 EEC present in Sicily

The taxa listed in Annex II are named as “Community interest species whose conservation requires the designation of special areas of conser-

vation” (with an asterisk priority species are indicated). All these species are very important for Assessment of Impact because it is mandatory to take them into account and considering the possible negative effects induced by the territory's transformation linked to realize a project. Only if you can exclude negative effects on these species, or in the presence of negative impacts proposing effective mitigation measures, it is possible to give a positive evaluation of the environmental compatibility of the project.

The insect species included in the Annex II to Directive 43/92 EEC present in Sicily are show in Table 1, and briefly commentated on below, emphasizing the most important threat factors to consider for their conservation.

Coenagrion mercuriale (Charpentier, 1840)

The larvae live in streams, usually on limestone substrates. Sicilian populations (Fig. 1) are very localized. The species is rare in Italy and must be considered vulnerable. The major threats are: river straightening, water harnessing, swamps and soil drainage, water table lowering through irrigation, field destruction or conversion into other agricultural practices, water pollution (IUCN, 2014).

ODONATA	Coenagrionidae	<i>Coenagrion mercuriale</i> (o) - in Italy <i>C. mercuriale castellani</i> Roberts, 1948
	Cordulegasteridae	<i>Cordulegaster trinacriae</i>
ORTHOPTERA	Gryllidae	<i>Brachytrupes megacephalus</i>
		<i>Myrmecophilus baronii</i> - only Pantelleria island
COLEOPTERA	Lucanidae	<i>Lucanus cervus</i> (?) (o)
	Geotrupidae	<i>Bolbelasmus unicornis</i> - in Sicily <i>B. romanorum</i>
	Cetoniidae	* <i>Osmoderma eremita</i> - in Sicily <i>O. cristinae</i>
	Cerambycidae	<i>Cerambyx cerdo</i>
		* <i>Rosalia alpina</i>
LEPIDOPTERA	Arctiidae	* <i>Callimorpha quadripunctaria</i> (now <i>Euplagia</i>) (o)
	Satyridae	<i>Melanargia arge</i>

Table 1. Insects species of Annex II to Directive 43/92 EEC present in Sicily. All species listed in Annex II are present also in Annex IV excluding those followed by symbol (o). The symbol * highlights the priorities species, while the symbol (?) indicates the uncertain presence of the species in Sicily.

Cordulegaster trinacriae Waterston, 1976

The larvae live in clean streams with sandy bottom, shaded by tree vegetation. The species is threatened by chemical and physical water pollution, by water extraction for human use and by removal of riparian vegetation. Desiccation due to climate change is a further threat for this species (IUCN, 2014).

Brachytrupes megacephalus (Lefevre, 1827)

Large cricket that lives in dune and back-dune environments, showing strong burrowing habits. It builds a long one-meter burrow using a spectacular technique of excavation. The species (Fig. 2) is threatened by habitat changes due to agricultural practices and touristic exploitation of beach (see Petralia et al., 2015).

Myrmecophilus baronii Baccetti, 1966

Endemic species to Pantelleria Island. It is a mirmecophilous Grillidae generally enfeoffed with the ants of the genus *Lasius* Fabricius, 1804.

Lucanus cervus cervus (Linnaeus, 1758)

The presence of this taxon in Sicily is to be confirmed. It lives in forests of oak and chestnut, sometimes, on the trunks and branches of willows and mulberries. The female lays the eggs at the foot of the trees; the larvae feed on humus and then penetrate into the trunk, but generally they dig their tunnels in the stumps remaining in ground and their development requires up to 5 years. The species is threatened by the coppicing of the forests and cleanliness of the undergrowth. The taxon not yet assessed for the IUCN Red List. In Sicily is certainly presents *L. tetraodon sicilianus* Planet, 1899, showing similar ecological requirements but is not listed in any Annex to the Habitats Directive.

Bolbelasmus romanorum Arnone et Massa, 2010

Bolbelasmus unicornis (Schrank, 1789) is included in Annex II of the Habitats Directive and also *B. romanorum*, endemic to Sicily, should be inserted into Annex II. *B. romanorum* is relatively rare and localized species. Its biology is still poorly known. It can be occasionally observed wandering on the

ground or under stones and during crepuscular flight. The taxon not yet assessed for the IUCN Red List.

****Osmoderma cristinae*** Sparacio, 1994

The genus *Osmoderma* Le Peletier de Saint-Fargeau et Serville, 1828 includes species very sensitive to environmental changes and everywhere in rarefaction. *O. eremita* (Scopoli, 1763) is included in Annex II of the Habitats Directive as priority species. Even *O. cristinae* (Fig. 3), endemic to northwestern Sicily, and *O. italicum* Sparacio, 2000, endemic to Central and Southern Italy, with a biology entirely comparable with that of *O. eremita*, should be inserted into Annex II and regarded as priority species. *O. cristinae* is a silvicolous species. The larvae develop in old rotting trunks of oaks or maples. The main overall threat is likely to be degradation or loss of habitat quality, involving structural changes in the tree populations arising from changing land use - affecting age structures and trees density. Exploitation from forestry is often a key immediate issue, but equally damaging can be long-term changes towards canopy closure and loss of old trees as a result of non or minimum intervention management systems which all too often exclude grazing by large herbivores. Fragmentation and increasing isolation of beetle populations are also key factors. The restricted area of occupancy combines limited population size with reduced habitat availability, bird predation, fires, and frequently unsuitable local techniques of forest management (Audisio et al., 2007).

Cerambyx cerdo cerdo (Linnaeus, 1758)

Silvicolous species. The adult feeds on leaves, fruit and lymph and actively flies in the twilight hours. After mating, which occurs between June and August, the female lays her eggs in the cracks of the bark of big oak trees. The saproxylic larva begins to dig tunnels in the cortical layers and then penetrates into the wood and its development requires 3-4 years. It is a species threatened by coppicing of oak trees and by the removal of old decaying plants.

****Rosalia alpina*** (Linnaeus, 1758)

The species (Fig. 4) lives preferentially in mature forests with a predominance of beech, especially

those characterized by very rainy or oceanic climate. Adults are active during the day on logs felled or inflorescences of Umbrelliferae. After mating, eggs are laid in the wood; the larval development takes 3 years, and it is preferably done in dead or decayed wood of beech exposed to the sun. The larva can develop also on alder, ash, hawthorn, linden and maple or conifers. The species is threatened by excessive cleaning the forest area; perhaps even by air pollution and by the general contraction of beech forests, especially mature ones.

****Euplagia quadripunctaria*** (Poda, 1761)

The only European species of this genus. It can be found in the cool forests and, in the Mediterranean region, most often in narrow valleys bounded by mountains with steep slopes with perennial streams and continuous woodlands, characterized by a microclimate cooler and wetter than the surround-

ing areas. Adults have primarily nocturnal habits and spending the day in the dense vegetation. The larvae emerge after 8-15 days after spawning and feed on various plants for a short time (like several Rosaceae, and other species such as black locust and eastern plane tree, vines and mulberry trees, honeysuckle) then they go into hibernation. After the 5th molt, the caterpillar spins a slight cocoon in the litter. The pupal stage lasts about 1 month; the imago emerges between June and August, most often in July, according to the altitude and the seasons.

Melanargia arge (Sulzer, 1776)

The species is distributed in peninsular Italy and northern Sicily. Its habitat is represented by arid steppes with scattered bushes and isolates trees with outcropping rocks. Most of the sites are located in the valleys sheltered from the wind or in hilly areas inland. The fires favored by shepherds and the



Figure 1. *Coenagrion mercuriale castellani*, Sicily, Palermo, stazione Montemaggiore Belsito, 30.IV.2010. Figure 2. *Brachytrupes megacephalus*, Sicily, Trapani, Capo Feto, 1.V.2011. Figure 3. *Osmoderma cristinae*, Sicily, Madonie Mountains, Gibilmanna, 2.VII.2014. Figure 4. *Rosalia alpina*, Nebrodi Mountains, Biviere di Cesarò, 6.VII.2014 (Photos by C. Muscarella).

ORTHOPTERA	TETTIGONIIDAE	<i>Saga pedo</i>
LEPIDOPTERA	PAPILIONIDAE	<i>Papilio alexanor</i>
		<i>Parnassius apollo</i>
		<i>Parnassius mnemosyne</i>
		<i>Zerynthia polyxena</i>
	SPHINGIDAE	<i>Proserpinus proserpina</i>

Table 2. Insects species of Annex IV to Directive 43/92 EEC not listed in Annex II, present in Sicily.

overgrazing can have serious negative effects on this species along with other habitat alterations. This species is not believed to face major threats at the European level.

Insects species of Annex IV to Directive 43/92 EEC not listed in Annex II, present in Sicily

The taxa listed in Annex IV are named as “Community interest species in need of strict protection”.

Most of the species listed in Annex II are also mentioned in Annex IV, so in Table 2 are shown only the insects species present in Sicily and listed in Annex IV, but not in Annex II. They are briefly commented on below, emphasizing the most important threat factors to consider for their conservation.

***Saga pedo* (Pallas, 1771)**

Species distributed from central-southern and southeastern Europe to central Asia and north-western China. In Italy it is present in a few areas of the Alps and Apennines, Sardinia and Sicily. *Saga pedo* colonizes areas with more or less open herbaceous vegetation or shrubs. It can be observed on the ground or on bushes, where moves rather slowly. Predator species, feeding mainly on other Orthoptera (grasshoppers and locusts) that captures thanks to the long and strong forelegs armed with spines. Never common in areas where it is present, is threatened by habitat degradation.

***Papilio alexanor* Esper, 1800**

This butterfly is mostly found on warm and dry

calcareous slopes with flower-rich vegetation and low-growing bushes. It prefers slopes that are steep and rocky and it is especially active during the hottest hours of the day. Different foodplants are known, all of them umbellifers. Although this species shows a decline in a part of its European range, it is not believed to face major threats at the European scale.

***Parnassius apollo* (Linnaeus, 1758)**

Species widely distributed in the mountains of Western Europe and Southern and Fennoscandia, although it is extinct in some areas such as central Germany, Czechoslovakia and Denmark and it is absent in Britain. In Sicily, the species is at the southern limit of its distribution range and is extremely localized, it is in fact known only from a few stations on the Madonie Mountains and according to some authors belongs to a subspecies *P. apollo siciliae* Oberthür, 1899 (Fig. 5). *Parnassius apollo* is linked to stony and mountainous areas poor of vegetation. It shows a preference for calcareous soils and for some plants such as *Cardus* spp., *Cirsium* spp., *Origanum* spp., *Centaurea* spp., *Scabiosa* spp. and *Knauzia* spp.

***Parnassius mnemosyne* (Linnaeus, 1758)**

In Central Europe the species (Fig. 6) lives in hill and mountain areas up to 1,500 m of altitude, in Northern Europe in plain areas. In Italy he attends the clearings and the edges of deciduous forest (beech, turkey oak). Adults are attracted to many vegetal species, with a preference for red, purple and blue flowers as *Centaurea* spp., *Knauzia* spp., *Geranium* spp. and *Lychnis* spp. The two main

causes of its decline are the reforestation and the changes in traditional agricultural practices, which have caused the disappearance of many meadow areas.

Zerynthia polyxena (Denis et Schiffermüller, 1775)

The only Italian species of this genus. It attends the plain near wetlands, the hilly and mountainous areas with arid terrain or rocky areas up to 900 m. It has a single annual generation, usually adults appear in April-May, but in Sicily may be active already at the end of February. The caterpillars feed on various species of *Aristolochia* L. The disappearance of this species, observed throughout Europe, is due to the reforestation and the habitat destruction. Locally may be threatened by excessive collection.

Proserpinus proserpina (Pallas, 1772)

The only European species of the genus. It lives from the sea level up to 1,500 m in different biotopes such as valleys, forest edges, clearings and banks of the streams, in rich sites of *Epilobium angustifolium* L. Adults are primarily nocturnal and prefer nectar-rich flowers, such as the common oregano, several species of fireweed, wild pink and honeysuckle. The species has disappeared from many localities in recent times, but the causes are not known. Some populations seem to disappear for a few years and reappear suddenly, for no apparent reason.

SPECIES INCLUDED IN THE RED LIST BASED ON IUCN CRITERIA

One other very useful tool is represented of the Red Lists based on IUCN criteria (IUCN, 2012). On the site <http://www.iucnredlist.org/> can be check the Red List of Threatened Species, which are mentioned all insect species considered threatened at the global level. For each of them, informations on taxonomy, assessment, geographic range, population, habitat and ecology, and major threats are provided. However, there are European red lists among which are to mention those of saproxylic Coleoptera (Nieto & Alexander, 2010), of butterfly (Van Swaay et al., 2010), and of dragonflies (Kalkman et al., 2010). Also to be mentioned some national red lists such as those on Italian invertebrates (Cerfolli et al.,



Figure 5. *Parnassius apollo*, Sicily, Madonie Mountains, Pizzo Carbonara, 15.VII.2006. Figure 6. *Parnassius mnemosyne*, Sicily, Madonie Mountains, Piano Battaglietta, 12.VI.2012 (Photos by C. Muscarella).

2002), on butterflies (Prola & Prola, 1990) and the recent red lists of Italian saproxylic Coleoptera (Audisio et al., 2014) and Italian dragonflies (Riservato et al., 2014). For Sicily, currently, there are not regional red lists of insects, the only work, that concerns only Coleoptera and Lepidoptera, is a list of species present within the Regional Parks, in which, for each species, informations on assessment, geographic distribution, and habitat are provided (Sabella & Sparacio, 2004).

SPECIES LISTED IN THE ENTOMOLEX

A very useful tool, drawn up under the auspices of the Italian Entomological Society, is represented

by Entomolex (Ballerio, 2004). It is a review that aims to provide an overview of all the rules concerning the conservation of the Italian insects. For each mentioned species is considered its inclusion in the annexes of international conventions (Conventions of Washington and Bern), of EU legislation (Directive 43/92 EEC), and of national and regional (Regions Friuli Venezia-Giulia, Liguria, Lombardy, Piedmont, Tuscany, and Veneto and the autonomous provinces of Trento and Bolzano) laws.

CKMAP OF ITALIAN FAUNA, FAUNA D'ITALIA AND REGIONAL CATALOGUE

The CKmap project (Ruffo & Stoch, 2005) and its database have made available information on the punctual distribution in Italy of approximately 10,000 terrestrial and freshwater species selected from the checklist because protected, threatened, with scientific or biogeographical interest, or bioindicators. The project represents an important tool for a correct and scientific management of the biodiversity and the natural habitats, as from Checklist of the Italian fauna (Minelli et al., 1993-1995), that comprises about 55,000 species. In the CKmap, for each species, geo-referenced data of the Italian localities, of the distribution, of the ecology, and its value as a bioindicator are provided. The analysis of so large sample of species has allowed to identify the most important areas in terms of the number of species, of the concentration of endemic species, of the species with restricted distribution and/or of particular biogeographical interest. All that permit to draw a picture of the overall distribution of animal biodiversity in Italy with a level of accuracy and detail unthinkable a few years ago.

The CKmap can provide, therefore, detailed information on many species of Sicilian entomofauna, and must be integrated with the many monographs of the series "Fauna d'Italia" dedicated to insects, some regional checklist (see for example Pilato et al., 2007 for Iblean region) and many regional faunistic catalogs concerning various taxonomic groups such as Ephemeroptera (Belfiore et al., 1991), Plecoptera (Fochetti & Nicolai, 1987; Ravizza & Gerecke, 1991), Neuroptera (Pantaleoni, 1986), Coleoptera Cerambycidae (Sama & Schurmann, 1980), Coleoptera Staphylinidae (Sabella & Zanetti, 1991), Coleoptera Pselaphidae

(Sabella, 1998), Coleoptera Tenebrionidae (Aliquò & Soldati, 2010; Aliquò & Soldati, 2014), etc. Of course many other citations of Sicilian insect species are dispersed in numerous scientific publications, it would be better to know, but the use of the tools suggested previously can be deemed sufficient to estimate the environmental quality of an area and assess the impact of the implementation of a project.

STANDARD DATA FORM AND MANAGEMENT PLAN OF NATURA 2000 SITES

At each site Natura 2000 is associated a standard data form, available, for Italian sites, on the official website of the Ministry of Environment and Protection of Land and Sea (<http://www.minambiente.it/pagina/schede-e-cartografie>). The standard data form, which is still required in an Annex when processing a report of Impact Assessment, listing all habitats and species of Community interest whose conservation requires the designation of special areas of conservation (for the invertebrates see the section 3.2.f.) and also all other important species (see the section 3.3), because listed in the national red list (motivation A), endemics (motivation B); included in the international conventions (motivation C) or for other reasons (motivation D).

In regards to the sicilian Region, on the official website of the Regional Ministry of Land and Environment (http://www.artasicilia.eu/old_site/web/natura2000/index.html) most of the Management Plans of the sicilian Natura 2000 sites are available and downloadable in pdf format. In these plans can be find detailed information on the animal species including their distribution in the site habitats and their ecological requirements.

BRIEF CONCLUSIVE CONSIDERATIONS

This paper attempts to emphasize the importance of the insect fauna study in environmental impact assessment and more generally in the territory planning and nature conservation.

The numerous problems related to the study of the entomofauna should not discourage, because by a reasonable approach, it can get to a list of species that, far from being exhaustive, may represent a

good basis for the assessment, in terms of fauna, of the environmental quality and thus to assess any impacts. In another article in this volume, a study case, in which were used the approach and tools previously treated, is proposed (Sabella et al., 2015).

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