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MONOGRAPH

A study case of Assessment of Impact using the invertebrates

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ABSTRACT A study case of Assessment of Impact (A.I.) in regards to the project of achieving diaphragm containment for homogeneous areas T and V of the Gela Refinery is explained. The invertebrates were used to evaluate the environmental quality and also to identify appropriate and effective mitigation measures and for preparing a post-operam monitoring. Some methodological proposals and an index of faunistic habitat value have been proposed.

KEY WORDS Assessment of Impact; Invertebrates; Sicily; Faunistic value index.

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INTRODUCTION

The article 6 of the Directive 92/43 EEC establishes the rules, which govern and regulate the conservation and management of the Nature 2000 network sites, and determines the guidelines to be adopted by the member states for proper relationship between the protection of natural resources and the land use. In particular, the paragraphs 3 and 4 establish procedures governing the approval of plans or projects that insist on SCI or SPA, and not directly related to their management. Essentially, any transformation that interests a Natura 2000 site, as well as areas adjacent thereto must be subjected to a procedure for Assessment of Impact, which excludes negative effects on the site, or, if it recognizes them, proposes corrective measures (mitigation or compensation).

The realization of a diaphragm containment of some areas of the Gela Refinery (Sicily), fell back within the perimeter of the SCI and SPA ITA050001 - Biviere and Macconi of Gela. Therefore, in compliance with the requirements of the aforementioned legislation, the project proposer has decided to proceed to the elaboration of the Assessment of Impact to verify if the project could have the adverse effects on habitats and species in Annexes I and II Directive 92/43 EEC and species of Annex I to Directive 2009/147 EC of the Natura 2000 site.

The project involved the construction of a barrier to excavation with composite diaphragm (self-hardening mud and HDPE sheet) associated to a system of pumping wells of groundwater, already pre-existing for much, built upstream of the diaphragm. For its realization the excavation of a trench, about 1 meter wide, 25 meters on average deep, and about 2.5 kilometers long was foreseen, and so effects on soil fauna, which concerns substantially invertebrates, were expected.

Although invertebrates are little used in environmental impact assessments (Sabella et al., 2015), in this case, for project evaluation their study was necessary, given their importance in determining the composition and structure of the soil fauna. For this reason, at the study of terrestrial Vertebrates it is added that of the invertebrates, with particular attention to the Insects.

MATERIAL AND METHODS

Study area

The study area includes a territory in which it is believed, on the basis of the project data, are possible impacts on wildlife induced by its realization. The area is located in the district of “Piana del Signore”, in the municipality of Gela, within the larger territory of "Piana di Gela". It is bordered to west by the Priolo Channel, to the east by the New Priolo Channel and is between the coast and the south side of the Gela Refinery (Fig. 1).

Sampling and analysis

The species list refers to the study area identified in figure 1. The annotated catalogue of the terrestrial Vertebrates was based on the Nature 2000 site's Standard Data Form, and also on literature references believed to be accurate, on personal observations and/or on the presence of potentially suitable habitat for the species. The annotated catalog of the Arthropods was based on the Natura 2000 site's Standard Data Form, on literature references believed to be accurate, on a faunistic sampling campaign, with a monthly intervals, from June to November, with various techniques (collection on view, mowing, and sifting). For the purposes of an biocoenotic investigation on soil fauna, was also used the method of pit-fall traps, which allowed to sample many species, not detected by other sampling methods.

For each species were reported data on: 1) scientific name, author and year, according to the nomenclature adopted by the check-list of Italian fauna (Minelli et al., 1993-1995) and Ckmap of Italian fauna (Ruffo & Stoch, 2005), considering

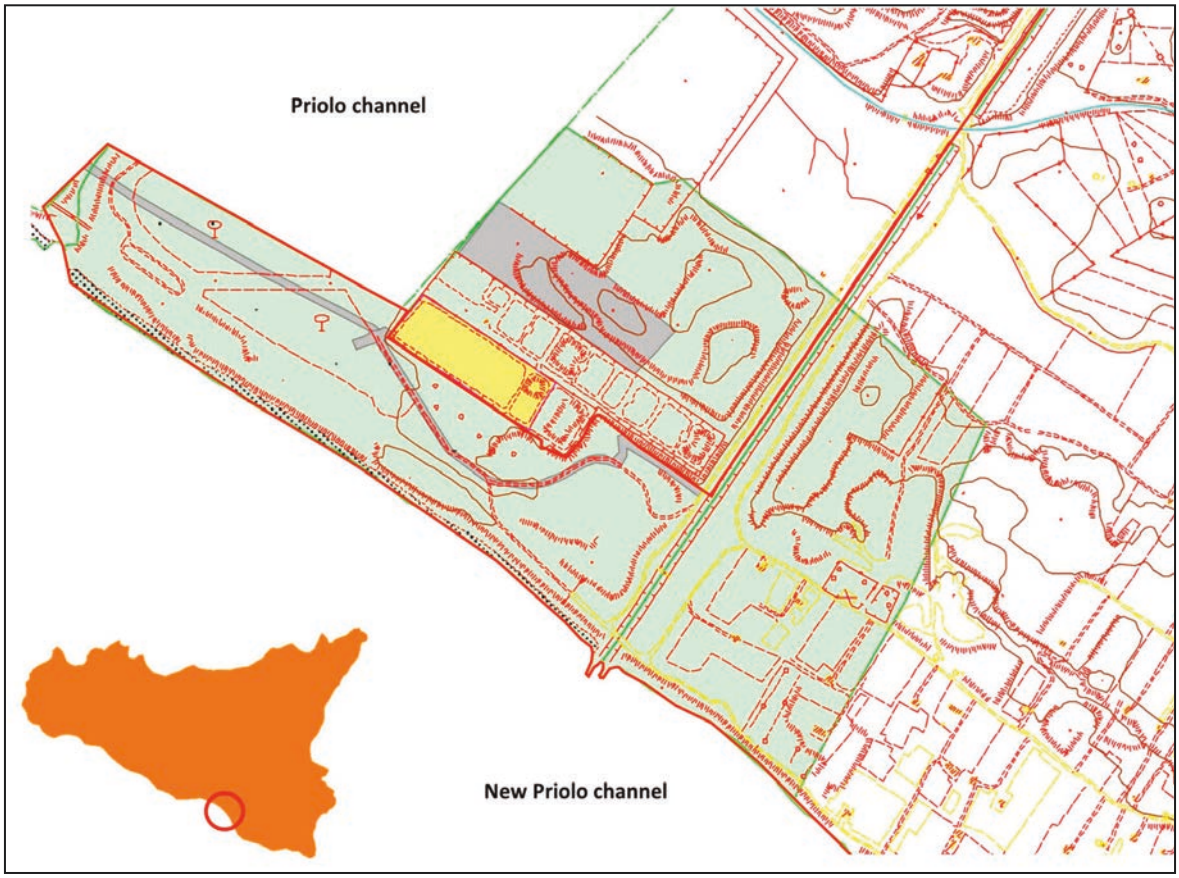

Figure 1. Study area. Red line: perimeter of the Natura 2000 site; in green: study area; in yellow: remediation area of basin A zone 2 of Gela Refinery, Sicily; in gray: affected area in the project of the diaphragm containment for homogeneous areas T and V of the Gela Refinery.

the subsequent changes in the nomenclature of the recent literature; 2) the chorologic category, according to Vigna Taglianti et al. (1992, 1999), while for birds according to Brichetti (1997); 3) the habitats potentially utilized by the species in the area; 4) if known, the phenology of the species; 5) the trend of European and Italian populations.

Particular attention was given to measures of protection and conservation of which the species is the subject, indicating its presence in the following annexes:

- II (strictly protected species of fauna) and III (protected fauna species) of the Berne Convention, law 5 August 1981 n. 503, on the Conservation of European Wildlife and Natural Habitats in Europe;
- I (endangered migratory species) and II (migratory species to be the subject of agreements) of the Bonn Convention, law 25 January 1983 n. 42, on the Conservation of migratory species of wild animals;
- A (species threatened with extinction which are or may be an action of the trade) and B (species not necessarily threatened with extinction at the present time, but that may become so unless trade is not subject to regulation close) of the Washington Convention, law 19 December 1975 n. 874, on international trade in animal and plant species threatened with extinction (CITES) and subsequent amendments and additions;
- II (animal and plant species of Community interest whose conservation requires the designation of special areas of conservation), IV (animal and plant species of Community interest in need of strict protection) and V (animal and plant species of Community interest whose taking in the wild and exploitation may be subject to management measures) of EEC Directive 92/43, D.P.R. 8 September 1997 n. 357, on the conservation of natural habitats and of wild fauna and flora in Europe.

As for the birds, for each species was specified inclusion in the Annexes (I, II/A, II/B, III/A and III/C of the Directive EC 2009/147 and the conservation status according the Species of European Conservation Concern of Birdlife International, 2004 (SPEC1, SPEC2, SPEC3, Non-SPEC^{E} and Non-SPEC).

For Mammals and Birds species, their possible protection established by the law 11 February 1992, n. 157 (rules for the protection of homeotherme wildlife and for hunting) and their inclusion in article 2, which provides for such species specific protective measures, was also considered.

The species conservation status, inferred by the website IUCN 2014 and by the various national (Prola & Prola, 1990; Cerfolli et al., 2002; Rondinini et al., 2013; Audisio et al., 2014; Riservato et al., 2014) and regional (AA.VV., 2008) red lists, based on IUCN criteria (IUCN, 2012), was also indicated.

Species of Annex II to Directive 43/92 EEC = 1.5 + 0.50 if prioritary

Species of Annexes to international convention, or to national or regional laws = 1

Species included in national red lists based on IUCN criteria

- CR = 1
- EN = 0.80
- VU = 0.60
- NT = 0.40
- LC = 0.20

Species of biogeographical interest

- Sicilian endemic species = 1+ 0.20 if present only in southern Sicily
- Sicilian endemic subspecies = 0.50 + 0.20 if present only in southern Sicily
- Species with restricted distribution = 0.50
- Species at the northern end of their distribution = 0.70
- Species which in Italy are present only in Sicily = 0.50 (1.00 if in Europe are present only in Sicily)
- Species at the southern end of their distribution = 0.50

Species relevant for ecological aspects

- Stenotops or stenoecious = 0.70
- Susceptible to human disturbance = 0.70
- Localized = 0.50
- Restricted populations = 0.50

Table 1. Criteria used for the faunistic value attribution to the invertebrats species.

A faunistic value (see for example Massa & Canale, 2008) to each species is assigned, for invertebrates it was based on the criteria showed in Table 1. If a species fell within in more than categories, the values were summed. Within the study area, based on the vegetation and the land use

Habitat	Acronym
Shoreline and sandy shore	**BAR**
Aquatic environment and riparian zone	**ACQ**
Sand dune	**DUN**
Juniperus maritimus scrub	**MAG**
Retama raetam scrub	**MAR**
Tamarix groupings	**TAM**
Back dune open environment	**APR**
Saccarum monophytic groupings	**SAC**
Eucalyptus rostrata reforestation	**EUC**
Acacia saligna reforestation	**ACA**
Pinus pinea reforestation	**PIN**

Table 2. Habitat types within the study area and used acronyms.

maps, the following 11 natural and seminatural habitat types have been identified (Table 2):

In order to compare the faunistic values of the habitats aforementioned, considering the specific biodiversity level in each habitat, and the faunistic value of each species, an index of the faunistic value of the habitat, $I(h)$, calculated with the formula showed in Fig. 2.

$$I(h)=\frac{\sum_{j\in h} v'(j)}{\sum_{j\in S} v'(j)}\times 100 \quad \text{with} \quad v'(j)=\frac{v(j)}{nh(j)}+0.01$$

$I(h)$ = Index of habitat faunistic value
j = species
h = habitat
$v(j)$ = faunistic value of species
$nh(j)$ = number of habitats in which the species is present
S = species of all habitat

Figure 2. Formula used to calculate the faunistic value of the habitat.

Each species contributes to the ecosystems functioning, becoming part of the trophic networks, and using, at various levels, the habitat resources, so none of them can take a null faunistic value. Therefore, it was considered appropriate to assign a minimum value of 0.01 to each taxon. This value has been estimated as half of the minimum value of $\frac{v(j)}{nh(j)}$ found.

RESULTS

A total of 273 animal taxa were counted, of which 198 were Arthropods, and 186 Insects.

The study of the invertebrate fauna of a geographical area, although of limited size, requires very long times and the use of many specialists of different taxonomic groups, in consideration of its great richness and of its articulation, which allows it to occupy most part of habitats, and in any case, can not be exhaustive (Sabella et al., 2015). Just remember that the check-list of Italian fauna (Minelli et al., 1993-1995) cites for Sicily over 12,000 terrestrial taxa, with the Order of the Coleoptera which includes about 4,400 species and subspecies.

The study of the invertebrate fauna, therefore, was aimed to examine only some of the fauna components considered important to establish the environmental quality and to identify the potential impacts related to modifications of the environment. So, some groups were considered relevant to the study of the fauna of the soil, and of the subaerial environments. In particular, were considered, among the Chelicerata, Araneidae, and among the Mandibulata, Crustacea (terrestrials amphipods and isopods) and Insecta (Odonata, Orthoptera, Blattoidea, Heteroptera, Coleoptera, Lepidoptera and Hymenoptera Formicidae). Among these 96 species were Coleoptera, 14 Lepidoptera, and 22 Hymenoptera Formicidae.

Among collected Insects taxa, three (*Orthetrum trinacria* (Selys, 1841), *Ochrilidia sicula* Salfi, 1931 and *Carabus faminii faminii* Dejean, 1826) have already been proposed for inclusion in Annex II to Directive 92/43 EEC, while two (*Calomera littoralis nemoralis* (Olivier, 1790), and *Eurynebria complanata* (Linnaeus, 1767) are included in annex A of regional law 6 April 2000 n. 56 of Tuscany

	Total	BAR	ACQ	DUN	MAG	MAR	TAM	APR	SAC	EUC	ACA	PIN
N of species	273	34	83	121	105	109	98	135	54	72	57	64
Faunistic value (VF)	89.75	9.017	13.623	14.510	7.540	10.115	7.682	12.959	2.811	4.723	3.281	3.490
N of species with VF = 0.001	169	17	45	75	62	64	57	88	29	40	33	38
N of species with VF > 0.001	104	17	38	46	43	45	41	47	25	32	24	26
N of species exclusives of habitat	39	5	16	1	0	2	4	11	0	0	0	1
I(h)		9.44	14.59	15.87	8.67	11.31	8.74	14.44	3.38	5.49	3.89	4.17

Table 3. Distribution per habitat of species number, faunistic value, and faunistic value index. BAR = Shoreline and sandy shore; ACQ = Aquatic environment and riparian zone; DUN = Sand dune; MAG = *Juniperus maritimus* scrub; MAR = *Retama raetam* scrub; TAM = *Tamarix* groupings; APR = Back dune open environment; SAC = *Saccarum monophytic* groupings; EUC = *Eucalyptus rostrata* reforestation; ACA = *Acacia saligna* reforestation; PIN = *Pinus pinea* reforestation. VF = Faunistic value. *I(h)* = Habitat faunistic value index.

Region (Ballerio, 2004). *Dociostaurus minutus* La Greca, 1962 is endemic to southern Sicily, while five species (*Ochrilidia sicula*, *Isomira paupercula* (Baudi, 1883), *Notoxus siculus* La Ferte-Senectere, 1849, *Temnothorax laestrygon* (Santschi, 1931), and *Temnothorax lagrecai* (Baroni Urbani, 1964), and six subspecies (*Euchorthippus albolineatus siculus* Ramme, 1927, *Erodius siculus siculus* Solier, 1834, *Tasgius falcifer aliquoi* (Bordoni, 1976), *Tasgius globulifer evitendus* (Tottenham, 1945), *Tasgius pedator siculus* (Aubé, 1842), and *Pimelia rugulosa sublaevigata* Solier, 1836) are endemic to Sicily.

Twelve taxa show a distribution restricted to the Mediterranean basin. Among these, one species, *Pimelia grossa* Fabricius, 1792, has a Sardinian-Sicilian-Maghrebian geonemy, four species, *Ocneridia nigropunctata* (Lucas, 1849), *Platycranus putoni* Reuter, 1879, *Broscus politus* (Dejean, 1828), and *Carabus faminii faminii*, show a Sicilian-Maghrebian geonemy, while *Cylindera trisignata siciliensis* (W. Horn, 1891) has a Sicilian-Tunisian distribution, and *Temnothorax kraussei* (Emery, 1916) shows a Sicilian-Sardinian-Corsican geonemy. Also, two taxa, *Brachygluta aubei* (Tournier, 1867) and *Plagiolepis schmitzi* Forel, 1895 in Italy are known only to Sicily, while two other, *Orthetrum trinacria* and *Hypocacculus elongatulus* (Rosenhauer, 1856) are known only to Sicily and Sardinia.

Twenty four species could be considered stenotopes and/or stenoecious, sometimes with a strict and exclusive binding to a particular type of habitat. They often show populations of a few specimens and they are very localized and very sensitive to the antropic disturbance (e.g. *Orthetrum trinacria*, *Pterolepis annulata* (Fieber, 1853), *Ochrilidia sicula*, *Masoreus aegyptiacus* Dejean, 1828, and *Myrmica sabuleti* Meinert, 1861). Therefore, the insect fauna shows remarkable faunistic emergencies, which are related essentially to the dune and back-dunes ecosystems and to the open environments.

In Table 3 are shown, for each habitat, its species number, its faunistic value, and its faunistic value index, while figure 3 shows, in decreasing order, the *I*(*h*) values of each habitat.

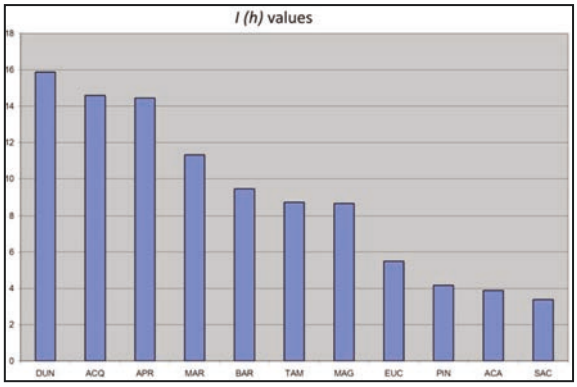

Figure 3. Histogram of *I*(*h*) values of the different habitats in the study area. DUN = Sand dune; ACQ = Aquatic environment and riparian zone; APR = Back dune open environment; MAR = *Retama raetam* scrub; BAR = Shoreline and sandy shore; TAM = *Tamarix* groupings; MAG = *Juniperus maritimus* scrub; EUC = *Eucalyptus rostrata* reforestation; PIN = *Pinus pinea* reforestation; ACA = *Acacia saligna* reforestation; SAC = *Saccarum monophytic* groupings.

The richest habitat in species has been the back dunes open environment (APR), followed by the sand dune (DUN), and by the scrub habitats (MAR and MAG). The reforestations (EUC, ACA, and PIN) are relatively poor in species, while the shoreline and sandy shore (BAR) is the habitat with the least number of taxa.

The faunistic value of each habitat is equivalent to the sum of the faunistic values (VF) of the species present in its interior. The highest faunistic value is found in the sand dune (DUN), followed by the aquatic environment and riparian zone (ACQ), by the back dune open environment (APR), by the *Retama raetam* scrub (MAR), and by the shoreline and sandy shore (BAR). These habitats take a particular value precisely in relation to the invertebrates fauna component, while the species of terrestrial Vertebrates not would have highlighted the importance of these habitat from the wildlife point of view.

The lowest values are found, instead, in the *Saccarum monophytic* groupings (SAC) and in the reforestations (EUC, ACA, and PIN).

The *I*(*h*) values have been subdivided into 4 classes:

- Class 1 Habitat of low faunistic value for *I*(*h*) values ranging between 0.01 and 4.
- Class 2 Habitat of medium faunistic value for *I*(*h*) values ranging between 4.01and 8.
- Class 3 Habitat of high faunistic value for *I*(*h*) values ranging between 8.01 and 12.
- Class 4 Habitat of very high faunistic value for *I*(*h*) values ranging between 12.01 and 16.

Relying on these classes, a map of the faunistic value of the study area was processed (Fig. 4); for some useful methods to the identification of the areas of faunistic interest see also Giunti et al. (2008), Sabella et al. (2009), Petralia (2010), Ingegnoli (2011), Petralia (2012).

Figure 4. Map of the faunistic value of the study area (Gela Refinery, Sicily).

The analysis of this map showed as the most part of the realization of the containment diaphragm concerned the areas of low or medium faunistic interest. On this base, the identification of the project potential impacts, and the propositions of an optimal allocation of building sites and of the safeguard of the neighboring habitats with high naturalistic value were also possible.

Were also proposed appropriate and effective mitigation measures, based on criteria, not aesthetic, but scientific and naturalistic. Specifically, renaturation actions with the restoration and the extension of the habitats of particular naturalistic interest, as back dune open environments and *Retama raetam* scrubs in place of reforestations, have been provided.

CONCLUSIONS

The level of knowledge about the ecological responses of species and communities to environmental changes not still allows an accurate and precise quantification of their effects.

The study of the invertebrate fauna, in relation to its great species richness and the various and articulated ecological requirements of the latter, allows a more detailed assessment of the environmental quality and a more accurate prediction of the changes that may occur in the structure and in the dynamics of the zoocoenosis in response to perturbations induced by the realization of a project. So this study, together with that of the Vertebrates, enables better the identification of the areas of faunistic interest and the evaluation of their value. Then it is possible a more accurate assessment of potential impacts of the project on wildlife and the proposal for suitable and effective mitigation measures and the post-operam monitoring the actual effectiveness of these latter.

The study highlighted that, in unsuitable environmental conditions to the stay of the vertebrates community, in relation to their high levels of anthropic disturbance and/or to the limited extension of the territory, the study of invertebrates communities for the environmental quality assessment from the faunistic point of view can be very useful. In fact, confined habitats can retain good levels of animal biodiversity and represent a refuge for many rare species of invertebrates, and so they have a relevant importance for the wildlife conservation. Unfortunately, in impact assessment studies, the invertebrates are often completely neglected and the evaluations are based solely on the vertebrate species. When "*umbrella species* " or habitats of community interest are lacking, the communities of invertebrates are, therefore, at risk.

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