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THE INCREASE OF ARTROPODOFAUNA AS AN ACTION OF DEFENSE AGAINST POLLUTION

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EXTENDED ABSTRACT

La biodiversità, intesa come varietà delle forme viventi e degli ambienti, ha subito una forte diminuzione negli ultimi decenni con un sostanziale decremento dal secondo dopoguerra in poi. Tale contrazione è fortemente legata, quindi, allo sviluppo delle attività antropiche.

L'importanza della biodiversità è stata riconosciuta a livello mondiale in quanto da essa dipendono una vasta gamma di funzioni ecologiche definite "servizi ecosistemici"; questi possono essere raggruppati in 4 categorie: approvvigionamento di beni, servizi di regolazione, servizi culturali e servizi di supporto. In quest'ottica si inserisce quindi la tutela e, quando possibile, l'incremento della componente biologica, animale e vegetale, al fine di garantire tutti i servizi ecosistemici tra cui l'assorbimento della CO_2 e degli inquinanti atmosferici, la riduzione delle isole di calore urbane, la riduzione degli afflussi e il miglioramento della qualità delle acque

L'artropodofauna è fortemente soggetta alla pressione delle attività antropiche in quanto sensibili alle sostanze chimiche utilizzate in ambiente agrario ed all'inquinamento ambientale delle aree urbanizzate. Secondo la Lista Rossa delle Specie Minacciate (*Red List of Threatened Species*) della *World Conservation Union (IUCN)*, le specie di Artropodi censite su scala mondiale sono 6472 e circa il 30% di esse risulta minacciata. Un esempio emblematico sono le numerose segnalazioni in diversi paesi degli eventi di mortalità o spopolamento degli alveari, negli ultimi anni questo fenomeno ha assunto dimensioni preoccupanti in quanto le cause sono tuttora sconosciute. Negli Stati Uniti la problematica, cui è stato dato il nome di *CCD (Colony Collapse Disorder)*, viene attribuita ad una interazione fra cause ambientali e parassiti di varia natura. In Italia le prime segnalazione da parte degli apicoltori di morie delle api ed abbandono degli alveari risalgono 1999 nel periodo primaverile-estivo, in occasione della semina dl mais. Successive indagini e sperimentazioni da parte di enti di ricerca e università hanno dimostrato che l'utilizzo di alcuni insetticidi provoca nelle api disorientamento, movimenti lenti e poco coordinati, difficoltà di volo e di ritorno all'alveare. Quindi uno studio sempre più approfondito del fenomeno della moria ha permesso di ipotizzare la multifattorialità individuando tra i fattori di rischio le patologie dell'alveare, i trattamenti fitosanitari, le pratiche apistiche, l'andamento climatico, la diminuzione dei luoghi di bottinamento, lo scarso valore nutrizionale del polline raccolto e la gestione del territorio.

Questo problema, apparentemente irrilevante alla vita umana, in realtà rappresenta una preoccupazione oramai mondiale, infatti molti sono gli insetti ritenuti utili e necessari alla sopravvivenza tra cui i pronubi. Le preoccupazione di una crisi globale di impollinazioni sono reali, il cambiamento climatico, l'espansione di terreni agricoli a spese delle aree naturali, un uso smisurato di pesticidi, mettono a rischio la sopravvivenza degli impollinatori tutti. Quindi se i pronubi muoiono in tutto il mondo e la varietà di specie continua a dimezzarsi con questo ritmo, il sistema di produzione alimentare come noi lo conosciamo va verso la sgretolamento.

La principale causa di perdita delle specie animali è rappresentata dalla distruzione degli habitat con la conseguente scomparsa di aree di rifugio e di alimentazione.

Nello specifico, l'incremento dell'artropodofauna può essere agevolato mediante la progettazione e la gestione di strutture ed elementi naturali quali *bug's hotel*, siepi e filari, in grado di fornire riparo e risorse trofiche alle diverse specie. Le siepi assolvono una serie di funzioni tra cui l'incremento della biodiversità, la difesa delle colture dall'inquinamento, la protezione del suolo dall'erosione, operano da frangivento e costituisce un elemento paesaggistico tipico dell'ambiente agrario. Per quanto riguarda gli aspetti faunistici, le siepi forniscono a numerose specie le risorse necessarie per la sopravvivenza quali aree di rifugio, di riproduzione e risorse trofiche. Inoltre rappresentano un elemento di connessione della rete ecologica in quanto fungono da corridoio ecologico per gli animali che utilizzano siepi e filari per lo spostamento. Gli hotel degli insetti sono dei rifugi artificiali per artropodi, in particolare insetti, con l'obiettivo principale di incrementare la biodiversità animale mediante la creazione di aree di rifugio e di riproduzione. Indipendentemente dal fattore estetico, gli hotel degli insetti devono possedere alcune caratteristiche che li rendano adatti a fornire riparo durante la stagione invernale e siti riproduttivi durante la primavera.

ABSTRACT

This paper illustrates the importance of biodiversity, in particular of the arthropodofauna, as it guarantees a series of ecosystem services needed to improve the quality of life.

The importance of biodiversity has been acknowledged globally since it depends on a wide range of ecological functions defined as "ecosystem services" such as the production of essential goods, the reduction of pollutants, climate regulation and the regulation of waters.

In this context, among environmental improvements is included in the increase in biodiversity and restoring natural processes typical of an equilibrium ecosystem by creating shelter and supply areas. Specifically, the increase in arthropodofauna can be facilitated by the design and management of structures and natural elements such as bug's hotels, hedges and rows, which can provide shelter and trophic resources to the various species.

***Keywords**: biodiversity, ecosystem services, arthropods, hedges, bug's hotel*

INTRODUCTION

Biodiversity, understood as a variety of living forms and environments, has experienced a sharp decline in recent decades with a substantial decrease since the Second World War onwards. This contraction is strongly linked to the development of human activities.

There is no doubt that biodiversity plays a key role in the functionality of various ecosystems, both natural and artificial, the stability and balance of ecological processes depend in fact on the level of biological diversity. A natural ecosystem with a good level of biodiversity has a greater ability to achieve a balance and maintain it over time; otherwise, a simplified artificial ecosystem cannot achieve a stability situation. The alteration of the natural mechanisms of competition and predation causes changes in population dynamics (Benvenuti *et alii*, 2013), loss of biodiversity and ecosystem simplification.

The loss of biodiversity, therefore, does not concern exclusively animal species such as panda, koala and tigers, but involves a wider range of animal and plant living organisms, both wild and domestic.

The decline in biological diversity in all its forms induces a decrease in the ecosystem's resilience to environmental changes that may occur in it and a worsening of ecological conditions and quality of life, physical and mental (Thomson *et alii*, 2005).

It is evident, therefore, how the protection and enhancement of biodiversity intersects with the concept of sustainability and defense of the territory, making clear the need to define proper management of the anthropic environment in order to restore, as far as possible, natural equilibrium (Swaffiled, 2005).

The importance of biodiversity has been acknowledged globally as it depends on a wide range of ecological functions defined as "ecosystem services"; these can be grouped into four categories:

- supply of goods: supply of goods of primary necessity and with a monetary value such as timber, food, medical plants;
- regulation services: vital functions guaranteed by a balanced ecosystem such as pollution abatement, water regimentation, climate regulation, etc;
- cultural services: intangible assets such as landscapes and places of spiritual value that can provide a tourist resource;
- Support Services: Include all the essential functions because an ecosystem is efficient and includes the process of soil formation and plant growth.

In this respect, the protection and, where possible, the increase of the biological component, animal and vegetable, is included in order to guarantee all ecosystem services including CO_2 absorption and atmospheric pollutants, the reduction of the urban warmth, reduced inflows and improved water quality.

THE BIODIVERSITY OF THE ARTHROPODOFAUNA

The arthropodofauna is highly susceptible to the pressure of human activity because it is sensitive to the chemicals used in the agrarian environment and the environmental pollution of the urban areas.

According to the Red List of Threatened Species of the World Conservation Union (IUCN), in the world are estimated 6472 species of Arthropods and around 30% of them are threatened.

An emblematic example is the numerous reports in several countries of the mortality or depopulation events of hives, in recent years this phenomenon has taken worrying dimensions as the causes are still unknown.

In the United States the problem, which has been named Colony Collapse Disorder (CCD), is attributed to an interaction between environmental causes and parasites of various kinds (Mutinelli & Grenade, 2007). The possible causes of the CCD have been identified among many factors such as Varroa infestation, new or emerging pathologies such as *Nosema ceranae* (Higes *et alii*, 2006) or the Israeli acute bee paralysis virus (IAPV) (Cox-Foster *et alii*, 2007), poisoning by pesticides, environmental stress factors, including lack or low nutritional value of pollen and nectar of some crops and drought.

In Italy the first reports by beekeepers on deaths of bees and abandonment of hives date back to spring-summer 1999, during the planting of corn. Subsequent surveys and experiments by research organizations and universities have shown that the use of some insecticides (Imidacloprid) causes in bees disorientation, slow and uncoordinated movements, difficulty in flying and returning to the beehive (Bortolotti *et alii*, 2003; Medrzycki *et alii*, 2003). Following the emergence of a network of information gathering from Italian beekeepers, more and more frequent mortality phenomena have been recorded, with increasing territorial spread and in different periods of the year. Therefore, an in-depth study of

the phenomenon of the deaths of bees allowed us to hypothesize the multifactoriality by identifying among the risk factors the hay pathologies, the phytosanitary treatments, the apical practices, the climate change, the decrease of the places of inoculation, the poor Nutritional value of pollen collected and land management (Bortolotti *et alii*, 2009).

It is thus evident that arthropodofauna is heavily influenced by human activity and directly affects pollution and environmental variations.

This problem, seemingly irrelevant to human life, actually represents a worldwide concern, in fact, many insects are considered useful and necessary for survival, including pronubi.

Pollinators are important insects by transporting pollen from one flower to another by participating in fruit formation. There are so many insects that carry out this task, among all we enumerate the bees. Common pronouns have their own characteristics:

- a body covered with bristles: they need to cling to the pollen between the bristles;
- a suction or lapping-sucking mouthpiece: an adaptation to the diet based on sugary liquid (nectar).

The apoidei, in particular, exhibit more obvious specializations such as tibia of the rear paws dilatated with an external concave said basket needed to deposit the pollen. Among the *Hymenoptera*, the main pronubi are the apoidei, vespids and formicides, followed by moths, dipters and beetles.

There is a high level of specialization between pollinators and plants, with a very close ecological relationship, benefiting reciprocally, this is defined as mutual relationship.

Pollinators generally play a crucial role in agriculture. The relationship between pollinators and plants is studied from an ecological point of view as a biological indicator in environmental monitoring (Porrini *et alii*, 1998).

Another use of pronubi is the ability to carry microorganisms (fungi, bacteria, viruses) that are fundamental to combat any threats to cultivated plants.

Flowering plants and pollinator insects are a clear example of coevolution that is a simultaneous evolution of different species that is realized by the parallel affirmation of both. The flowers are mostly pollinated by insects, and these in turn receive the nectar from the flowers as a reward, so the insect-flowering association is specific for species. In fact, a certain group of insect species can pollinate the flower of a plant species, and some species of insects visit a certain group of plant species.

Therefore, in addition to strong emanations of perfumes and coloured petals, according to a recent study, the basis of the attraction of insects and flowers would be express in terms of a real electric attraction. Research suggests that the flowers are able to signal the nectar available inside them by modulating a field of forces generated in space by the presence of electric charges. In fact, the flowers have a weak negative electrical charge, on the contrary, pollinator insects have a positive charge.

During this experiment it was found that even bombs are able to detect the presence of electric fields different from similar flowers or with different shapes, and finally, from the "electrical conditions" where a flower is found, they are even able to understand if the flower has already been visited by tall insects or not.

In Australia, numerous studies claim that other insects, such as flies and some beetles, contribute to the pollination of crops and may offset the decline of the global population of bees. This research also confirms that these insects could be important also for crops that do not raise the interest of bees, such as trout fruits. From the analyses carried out, it also points out that "non-bees" react differently to the habitat structure. While bees refer to hives and other structures that may be affected by environmental changes, while "non-bees" live usually near planes, grass or bushes (Clarke *et alii*, 2015).

The concerns of a global pollination crisis are real, climate change, the expansion of farmland at natural expense, pesticide use, endangered the survival of all pollinators. Therefore, if the pollinators die all over the world and the variety of species continues to halve at this rate, the food production system as we know it goes to crumbling. Concluding, we need to survive biodiversity and it is unthinkable to replace nature services with few kinds of artificial pollinators.

INTERVENTIONS TO INCREASE THE ARTHROPODOFAUNA

The main cause of loss of animal species is habitat development, with the consequent disappearance of shelter and feeding areas. There are many environmental improvement measures aimed at increasing biodiversity and restoring natural processes typical of a balanced ecosystem by creating shelter and supply areas. Environmental improvements, intended as measures to recreate degraded or degraded environmental conditions, are incorporated into a wider strategy for environmental conservation and natural re-emergence (Genghini, 1994). The restoration of natural and semi-natural environments in urban and urban environments must be made taking into account also the positive effects they can bring to the surrounding areas and, more generally, to environmental quality.

Specifically, the increase in arthropodofauna can be facilitated by designing and managing structures and natural elements such as bug's hotels, hedges and rows, which can provide shelter and trophic resources to the various species.

HEDGES

Hedges and rows are natural elements that have always characterized the agrarian landscape, but that they have been slow to use until their complete destruction, this has caused a banalization and homogenization of the environments resulting in loss of biodiversity.

Fig. 1 - Example of hedges in C.da Lacone-Rende-Calabria (Italy)

The hedges perform a number of functions, such as increasing biodiversity, protecting crops from pollution, protecting soil from erosion, operating as windbreaks and constituting a landscape-typical element of the agrarian environment.

In recent years, the role of hedges and rows has been re-evaluated since they are of great natural and ecological importance in relation to both plant and animal components (Fig. 1).

From a floristic point of view, they represent a resource as they concentrate on a limited space a high specific diversity linked to the presence of different environmental conditions (humidity, depth of soil, sunshine).

As far as faunistic aspects are concerned, hedges provide numerous species (arthropods, reptiles, amphibians, birds, mammals) the resources needed for survival such as shelter, breeding areas and trophies. They also represent a connection element of the ecological network as they act as ecological corridors for animals that use hedges and rows to move.

The greater functionality of hedges has been detected in those of greater size and plant diversity, and with the presence of three layers simultaneously (Reif & Schmutz, 2011):

- herbaceous: consisting of temporary pioneer species and small trees with rapid growth and fill function. It includes plants such as elder, sorb, etc.;
- shrubs: it includes large and small shrubs that form the intermediate layer. It is characterized by species that tolerate the shadow like roses, violet, hawthorn, etc.;
- arboreal: consisting of tall trees, represents the structure of the plant. It is characterized by species that tolerate light and half shade, with height and relatively high life expectancy. It includes trees such as oak, ash, linden, maple, etc.

The planting of hedges and rows, both in the agrarian and periurban fields, in order to increase biodiversity, especially the arthropodofauna, must be designed by evaluating a number of factors including:

- number and characteristics of the plant species used: different species should be planted with different flowering, dimensional and bearing ages. It is also necessary to evaluate plant species that produce berries and fruits, trophic resources for many animals, in different seasons;
- positioning of the hedge in relation to the spatial situation: it is important to reconstruct the linkage between the habitats present in the area and to dislodge hedges as connecting lines between the ecological elements present;
- Crops in the area of interest: especially for arthropods, it is of great importance also to evaluate the type of cultivated fields in the area around the possible site of the hedge plant. You can create hedges and rows aimed at increasing de-termed arthropods useful to limit the use of pesticides and planning an integrated fight (Tab. 1).

In the presence of hedges and rows, it is also necessary to plan a series of maintenance plans in order to increase their ecological functionality and to enhance their fauna (Gambier, 2009). It is necessary to:

- make pruning between January and February in order to avoid disturbance in the breeding months;
- avoid excessive pruning;
- do not keep the shape of the hedge too sharp, leaving several protruding branches usable by the birdworm as postage;
- avoid the use of pesticides in the herbaceous band around the hedge;
- maintenance of necromass (dead wood) to stimulate the presence of saproxilophageal insects.

HOTEL INSECTS (BUG'S HOTEL)

Insect's hotels are arthropod artificial shelters, in particular insects, with the primary goal of increasing animal biodiversity by creating haven and breeding areas. Widespread in Europe, they are used in public and private areas and are built with natural materials. Some popular examples are Bug's hotels set up in some London public parks (Bunhill Fields, West Smithfield Postman's Park, St Dustan's in the East and Cleary Garden) designed by several architects in a competition.

Regardless of the aesthetic factor, insect's hotels must have some characteristics that make them suitable for shelter during the winter season and reproductive sites during the spring. Each host and guest will have a specific reception structure, but in general, the hotel of insects must be placed in a dry, wind-sheltered, direct sunlight (exposed south or west). Then it is possible to define the target using certain structures more or less suitable for the target arthropod species:

- solitary bees: they require cable corridors with a blind base of 4 to 12 cm diameter and 12 to 20 cm long. For this purpose, it is possible to use bamboo roots, graminaceous stems and specially trimmed trunks (Fig. 2);

Plant species	Positive effect	Bibliographical reference
Alaterno *(Rhamnus alaterno)*	It hosts various psille and can thus become a "tank" of anthocorids	FAUVEL *et alii*, 1981
Alloro *(Laurus nobilis)*	It hosts psilla *Trioza alacris*, in whose galleys shelters in the winter antocoride *Anthocoris nemoralis*	FAUVEL *et alii*, 1981
Biancospino *(Crataegus monogyna)*	It is a shelter for ladybugs in the fall	NICOLI *et alii*,1995 IF7-8/95, pp 58-64
Carpino bianco *(Carpinus betulus)*	It hosts different phytoseids that can migrate to the vineyard where they control tetranichid mites	DUSO *et alii*, 1993
Edera *(Edera helix)*	Hosts syphids, coccinellides and parasitosis of luteophagous herbivores	FAUVEL *et alii*, 1981
Gelso nero *(Morus nigra)*	It is a shelter for ladybugs in the fall	NICOLI *et alii*, 1995
Ginestra dei carbonai *(Sarothamnus scoparius)*	It hosts various psille and can thus become a "tank" of anthocorids	FAUVEL *et alii*, 1981
Nocciolo *(Corylus avellana)*	It hosts different phytoseids (*Ambliseius aberans*) that can migrate to the vineyard where they control tetranichid mites	DUSO *et alii*, 1993
Noce nazionale *(Juglans regia)*	It hosts different phytoseids that can migrate to the vineyard where they control tetranichid mites	DUSO *et alii*, 1993
Ontano nero *(Alnus glutinosa)*	It hosts various psille and can thus become a "tank" of anthocorids	FAUVEL *et alii*, 1981
Ortica *(Urtica dioica)*	It hosts fitoseide *Typhlodromus pyri*, that can migrate to the vineyard where they control tetranichid mites	DUSO *et alii*, 1993
Prugnolo *(Prunus spinosa)*	It is a shelter for ladybugs in the fall. It hosts hymenopter *Anagrus atomus*, parasite of vine buzzers	NICOLI *et alii*, 1995 FAUVEL *et alii*, 1981
Rovo *(Rubus ulmifolius)*	It hosts different phytoseids that can migrate to the vineyard where they control tetranichid mites	CERUTTI *et alii*,1989 DUSO *et alii*, 1993
Salici *(Salix spp.)*	There are populations of aphids very early in the spring on which grow predators that migrate on cultivated plants	FAUVEL *et alii*, 1981
Sambuco *(Sambucus nigra)*	There are populations of aphids very early in the spring on which grow predators that migrate on cultivated plants	FAUVEL *et alii*, 1981
Siliquastro *(Cercis siliquastrum)*	It hosts various psille and can thus become a "tank" of anthocorids	FAUVEL *et alii*, 1981
Querce *(Quercus spp.)*	There are parasites of the moth of grapes	SERVADEI *et alii*, 1972
Fonte: ALDINI A. & QUAINI T. (2001) - *Schede tecniche frutticoltura biologica*		

Tab. 1 - Plant species used for biological control of harmful insects

- lacewings, ladybirds, earwigs: they prefer houses with straw and sheltered from the weather. You can use overturned terracotta vases and stuffed with straw with a protected entrance from wood or brick pieces (Fig. 3);
- butterflies: it is necessary to prepare sheltered cavities, enclosed by a wooden door with vertical slots that can facilitate the insect entry without damaging its wings. Inside the accommodation, vertical dry vegetable stems must be arranged in order to provide butterfly support points.

In order to make the bug's hotel more attractive, it is appropriate to create areas with nectar plants nearby, which can provide nutrition to the various species of insects. Especially in urban areas, it is possible to implant species such as cosmos, sweet pea, nasturtium, zinnia, calendula, dandelion, and aromatic plants in general (thyme, lavender, sage, rosemary).

In addition, especially for the moths, can be planted species

Fig. 2 - Accommodation for solitary bees

Fig. 3 - Example of houses with straw

also suitable for juvenile forms (caterpillars) such as wild fennel and leguminous plants.

CONCLUSION

Concerns about a global pollination crisis are real, climate change, farmland expansion at natural expense, pesticide use, endangered the survival of all pollinators. So, if the pollinators die all over the world the food production system and many of the primary necessities as we know it goes to crumbling.

In addition, the wide range of ecosystem services provided by a high biodiversity, interest a number of sectors including pollution abatement, water regimation, and climate regulation.

Concluding, we need biodiversity to survive and it is not conceivable to replace services provided by nature with a few species of artificial pollinators.

REFERENCES

Benvenuti S., Bretzel F., Di Gregorio R., Piotti B. & Romani D. (2013) - S*pecie erbacee spontanee mediterranee per la riqualificazione di ambienti antropici. Stato dell'arte, criticità e possibilità d'impiego,* Manuali e Linee guida ISPRA 86/2013.

Bortolotti L., Montanari R., Marcelino J., Medrzycki P., Maini S. & Porrini C. (2003) - *Effects of sublethal imidacloprid doses on honey bees' (Apis mellifera L.) homing rate and foraging activity.* Proceedings 8th International Symposium "Hazards of Pesticides to Bees", 4-6 September 2002, Bologna, Italy. Bulletin of Insectology, **56** (1): 63-67.

Bortolotti L., Porrini C., Utinelli F., Pochi D., Marinelli E., Balconi C., Nazzi F., Lodesani M. & Sabatini A.G. (2009) - *Salute delle api: analisi dei fattori di rischio. Il progetto Apenet.* Apoidea, **6**: 3-22.

Cerutti F., Delucchi V., Baumgärtner J. & Rubli D. (1989) - *Ricerche sull'ecosistema "vigneto" nel Ticino: II. La colonizzazione dei vigneti da parte della cicalina Empoasca vitis Goethe (Hom., Cicadellidae, Typhlocybinae) e del suo parassitoide Anagrus atomus Haliday (Hym., Mymaridae), e importanza della flora circostante.* Mitt Schweiz Entomol Ges, **62**: 253-267.

Clarke D., Whitney H., Sutton G. & Erobert D. (2015) - Death detection and learning of floral electric field by Bumble bees science DOI: 10, 1126/ Science 1230883;

Cox-Foster D.L., Conlan S., Holmes E.C., Palacios G., Evans J.D., Moran N.A., Quan P.-L., Briese T., Hornig M., Geiser D.M., Martinson V., Van Engelsdorp D., Kalkstein A.L., Drysdale A., Hui J., Zhai J., Cui L., Hutchison S.K., Simons J.F., Egholm M., Pettis J.S. & Lipkin W.I. (2007a) - *A metagenomic survey of microbes in honey bee colony collapse disorder.* Science, **318** (5848): 283-287.

Duso C. & Pasqualetto C. (1993) - *Factors affecting the potential of phytoseiid mites (Acari: Phytoseiidae) as biocontrol agents in north-Italian vineyards.* Experim. appl. Acarol., **17** (4): 241-258

Fauvel G., Atger P., Cotton D. & Faivre D'Arcier F. (1981) - *Etude de l'evolution des insectes auxiliaires et de leurs relations avec le psylle du poirier (Psylla pyri L.) et l'acarien rouge (Panonychus ulmi Koch) dans deux vergers du Sud-Est de la France en 1979.* Agronomie, EDP Sciences, 1 (9): 813-820.

Gambier B. (2009) - *Siepi campestri - La natura in giardino Ideare un progetto - scegliere e comporre le specie,* Collana: SOS Del Giardiniere, De Vecchi.

Genghini M. (1994) - *I miglioramenti ambientali a fini faunistici.* Istituto Nazionale per la Fauna Selvatica, Documenti Tecnici, n.16, Bologna;

Higes M., Martin R. & Meana A. (2006) - *Nosema ceranae, a new microsporidian parasite in honeybees in Europe.* Journal of Invertebrate Pathology, **92**: 93-95.

Medrzycki P., Montanari R., Bortolotti L., Sabatini A. G., Maini S., Porrini C. (2003) – *Effects of imidacloprid administered in sub-lethal doses on honey bees' (Apis mellifera L.) behaviour. Laboratory tests.* Proceedings 8th International Symposium "Hazards of Pesticides to Bees", 4-6 September 2002, Bologna, Italy. Bulletin of Insectology, **56** (1): 59-62.

Mutinelli F. & Granato A. (2007) - *La sindrome del collasso della colonia (Colony Collapse Disorder) negli USA. Un aggiornamento sulla situazione attuale.* Apoidea, 4: 175-185.

Nicoli G., Limonta L., Cavazzuti C. & Pozzati M. (1995) - *Il ruolo delle siepi nell'ecologia del campo coltivato. I. Prime indagini sui Coccinellidi predatori di afidi*. Informatore Fitopatologico, **45** (7-8): 58-64.

Porrini C. Radaghieri P., Romagnoli F. & Versari S. (1998) - *I pronubi selvatici come indicatori della biocomplessità ambientale.* Atti XVIII Congr. Naz. It. Ent. Maratea 21-26 Giugno 1998 204 pp.

Reif A. & Schmutz T. (2011) - *Impianto e manutenzione delle siepi in Europa*. Institut pour le développement forestier.

Servadei A., Zangheri S. & Masutti L. (1972) - *Entomologia generale ed applicata.*

Swaffield S. (2005) - *Shaping an urban landscape strategy to promote biodiversity*. In: Dawson M.I. (Ed.). *Greening the city: bringing biodiversity into the uban environment.* Royal New Zealand Istitute of Horticulture, Lincoln University, 310 pp.

Thompson K., Askew A.P., Grime J.P., Dunnett N.P. & Willis A.J. (2005) - *Biodiversity, ecosystem function and plant traits in mature and immature plant communities.* Functional Ecology, **19**: 355-358.

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