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BOOK OF ABSTRACTS

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Averting the Insect Apocalypse

D Goulson

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We are in the midst of the 6th mass extinction event, with extinctions occurring faster than at any time in the last 65 million years. 'Bioabundance' is in decline, with recent studies showing that insects in particular seem to be disappearing fast. For example, recent evidence from Germany found that the biomass of flying insects fell by 76% in the last 26 years. If insect declines continue it will have profound consequences for mankind and for our planet, for insects make up the bulk of life on land, and perform numerous vital roles in ecosystems: they are food for many other organisms, control pests, pollinate, recycle nutrients, and much more. I will explain the main drivers of insect declines, which include habitat loss, intensification of farming practices, pesticides, the spread of disease and climate change. I will also suggest how we should tackle this crisis, first by turning our gardens and urban areas into oases for life, and second by fundamentally changing the way we grow food.

Insect collections amidst the sixth mass extinction

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Historically, biological collections had a prominent role in disclosing the diversity of life across the globe, developing into natural history museums, which became not only the repository of type specimens but also the fundamental basis for any comparative study, the prerequisite of taxonomy. From the second half of the nineteenth and in the twentieth century, taxonomy lost its ground in biological sciences, inevitably leading to repercussions on the role of natural collections, sometimes even questioning their relevance. In the last decades, biodiversity loss hastened at a quick pace as climate change, pollution and rampant habitat destruction affect the whole world. Museums are becoming mausoleums, preserving the remains of lost organisms. Nevertheless, natural history collections are probably more important in these critical times. Large, informative collections serve as a basis to build up extensive databases that can help to shed light on the changes in biomass, abundance, composition of insect communities helping to unambiguously quantify the impact on ecosystems of anthropic activities, becoming the only way to unambiguously assess changes across time. Finally, natural history collections are also fundamental in conservation biology, allowing to locate and protect areas of main concern and of preservation priority.

Overview of insect pollinators in Europe and importance of Red Lists for their conservation

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Several reviews highlight the global decline of insects, including pollinators, thus increasing concern for long-term sustainability in terms of plant biodiversity, food production, nutrition and human well-being. Europe hosts a wide diversity of insects that pollinate wild and cultivated plants. The main groups of insect pollinators include bees, hoverflies, butterflies, beetles and wasps, but a number of insects belonging to other Orders or Families may contribute to plant pollination. Here, we provide an overview of the variety of insect pollinators present across Europe, including species richness, abundance, biology diversity, endemism and current status and trends of their populations.

The International Union for Conservation of Nature (IUCN) European Red List for bees shows that 37% of bee species suffer from declining populations. In addition, 9% of all bees and 26% of bumblebees are classified as threatened, whereas data for 57% of species are deficient and, therefore, cannot be assessed. In some cases, national Red Lists in Europe indicate that up to 40% of bee species are threatened.

The IUCN Red List for butterflies of continental Europe shows that 31% of species have declining populations and 9% of species are classified as threatened. The National Red lists for butterflies indicate that on average 27% of species are considered threatened within the 24 EU countries with existing red lists.

Searching a value for agrobiodiversity, functioning and services

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[2]Development Impact Unit, Alliance of Bioversity International and CIAT

Biological diversity or biodiversity delivers and maintains broader services and benefits on which society and economic activities largely depend: however, even if a human being could not survive without these services, it remains a tricky task and controversial issue to attribute to the biodiversity a comprehensive *value*. Indeed, this *value* should recognize the biodiversity role as the natural provider of several ecosystem services, including direct economic benefits, but it should also cover ethical and aesthetical aspects of the natural resources. Precise economic assessments are particularly complex given knowledge gaps about the biological relationship between biodiversity, the ecosystem functioning, and the generated benefits. Although the difficulties of the task, the attribution of an economic value to biodiversity, or at least to a subset of its services, remain essential for legitimizing its strategic role in the eyes of public and private actors which decisions are taken primarily on economic grounds and may help set a higher priority for its conservation.
This contribution will first summarize the complex relations between biodiversity and ecosystem services since the latter provides a starting point towards identifying and valuing biodiversity benefits by bridging the gap between ecology and economics; secondly, it will illustrate the main theoretical and empirical approaches developed in the literature, with a particular focus, on agricultural biodiversity.

The aim of this contribution is to provide a clear understanding of the economic principles involved, helping entomologists to become more familiar with the economic issues involved in valuing biodiversity and its agro-ecosystems functions.

Agroecological practices using biodiversity for the provision of ecosystem services in agriculture

A Wezel

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Agricultural production should provide sufficient food for the world's population while being economically beneficial for farmers, environmentally friendly, and socially acceptable. In addition, the basic food commodities should also be available at affordable prices for low-income people without impairing the quality. The foundations of this agriculture are the different practices farmers apply for crop and livestock production. Here agroecological practices play a crucial role as they try to valorise in the best way possible ecological processes and ecosystem services by integrating them as fundamental elements in the development of agricultural practices in different farming systems. Many agroecological practices already exist around the world, and are applied to different degrees in different regions, under various climatic conditions.

This talk will provide an overview about the large diversity of agroecological practices, and then focus on agroecological practices using biodiversity and diversification of cropping systems with the aim to valorise best ecosystem services. Some examples will be presented, among them diversified rotations, producing natural enemies in the field, using natural habitats for conservation biological control, and relay intercropping and cover crops for weed control or nitrogen fixation. The potential use of these agroecological practices for future agriculture will be also evaluated, but also how they contribute to bringing back more biodiversity in agricultural landscapes in particular functional biodiversity such as natural enemies or pollinators and (re)creating habitats for them.

Building confidence in Beneficials: Conservation biocontrol of insect pests in oilseed rape crops

S Cook

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What are wasps for / what use are wasps? These are among the most frequently asked questions I receive at public events. They refer to *Vespula vulgaris* and I dislike this question because the questioner usually implies that all animals should have some use to humans; and they believe wasps are mean, useless nuisances. However, wasps are part of the 'biodiversity' – the variety of life - on Earth and should be valued (and allowed to exist) for that alone. But furthermore, wasps are carnivores and take aphids and other small insects to feed their brood. In doing so they play a role in reducing aphid pests in the gardens of the people they annoy. This makes them part of the 'functional biodiversity' group, i.e. those organisms that provide an ecosystem service – in this case, pest regulation. Wasps are, in fact, beneficial insects whether you like them or not.

In my talk I will celebrate the beneficial insects that provide ecosystem services in agricultural landscapes with focus on the natural enemies of crop pests that provide pest regulation services (biological control). Using oilseed rape cropping as an example, I will present how use of agronomy and habitat management methods to conserve the natural enemies of crop pests already present in the agri-environment can provide pest regulation services to farmers 'for free'. This is termed conservation biological control (CBC). CBC can help to reduce insecticide use and is central to the design of more sustainable agricultural systems – and involves wasps.

Biological control as an ecosystem service: an Area-Wide Pest Management program in a famous wine-growing area of Tuscany

A Lucchi

University of Pisa

An important Ecosystem service is the biological control of pests. Here I report on a recent cooperative project carried out in Bolgheri, an Italian prestigious area for the production of top-quality wines. The project originated from a partnership between University and growers for the management of *Lobesia botrana* (Lb) and *Planococcus ficus* (Pf). Insecticides adopted against these pests have been showing a limited efficacy, so that vineyard managers asked University for help. The proposed strategies were mating disruption (MD) for Lb and biological control agents (BCAs) for Pf. The program was handled by a technical working group (TWG) composed of University and Wineries personnel. The positive results obtained since the first year in the vineyards treated with MD and BCAs fostered the development of trust and cooperation among all parties. A local campaign was promoted by TWG to communicate, educate and collaborate with decision-makers, with the aim to train growers to recognize, monitor, and promote the non-insecticidal methods, as well as to monitor pest population abundance, through field day activities, lectures and presentations, print articles and posters, a dedicated website and videos uploaded on social media. Growers shared information and related their experiences through peer networks that strengthened the formal educational program. The proposed action plan drastically reduced insect populations and was gradually adopted by several farms in the area. Three years later MD and BCAs have been adopted on about 1,000 ha, with excellent results obtained in the control of Lb and VMB, and almost complete abandon of insecticides.

Rural landscape management at different spatial scales and functional diversity

G Burgio

University of Bologna

The rural landscape management, including the different scales of application, play a fundamental role in the enhancement of functional biodiversity and associated ecosystem services. Common Agricultural Policy that are based on multifunctional agriculture have sanctioned, *de facto,* a series of ecological principles that sustain the scientific philosophy of biological control and the adoption of sustainable pest management models. This intervention deals with the habitat management methods, with particular reference to the management of ecological infrastructures. Agri-environmental interventions are reviewed focusing on functional diversity enhancement and conservation, with examples within the scenario of pest management and conservation biological control. The aspects related to the practical applications of habitat management are critically discussed, by an analysis of advantages and the need to prevent potential disservices.

Insect biodiversity recovery. Let's act!

L E M Vet

Netherlands Institute of Ecology and Wageningen University

This confusing Corona crisis makes us even more aware of the underlying problem: the destructive habits of *Homo sapiens*, the most invasive species on Earth! More rapid than ever we globally lose natural habitat and well-functioning ecosystems that we, as humans, are part of and dependent on! Not only insects but biodiversity as a whole are declining due to multiple human-induced stress factors: habitat loss and fragmentation, pollution, invasive species and climate change. But how can we reverse the trend? Well, first of all, let's be positive, everybody knows the saying 'never waste a good crisis' so this Corona misery may hopefully initiate a promising reset of our economic system and values. We need to turn our destructive economy into one of symbiosis between ecology and economy. Working WITH nature instead of AGAINST it. I plea for learning from nature's 3.8 billion years of experience to guide the transition. With a focus on a system approach and building resilience. Examples that insects can benefit from are nature-inclusive agriculture in a wider landscape approach, increasing landscape heterogeneity and creating novel habitats in public spaces. Biodiversity recovery asks for more than scientific knowledge. As scientists we have to work together with the wider public, farmers, land managers, decision makers. In the Netherlands we have started this positive movement and we are progressing internationally. I will plea that leadership, communication and especially positive advocacy will be vital to reach our goals of sustainability and biodiversity recovery.

Classical and fortuitous biological control, when the exotic is useful

L Tavella

University of Torino

Globalization, international trade and environmental changes have facilitated the movement and the subsequent establishment of exotic organisms, including insects. Usually, we associate the term “exotic” with invasive harmful pests, neglecting beneficials. Classic biological control exploits the exotic beneficials to contain the pests accidentally introduced into our area. The aim is to restore the natural balance in the ecosystem, which the new invasive insects not accompanied by their natural enemy complex altered. Classical biological control has been applied worldwide for over a century, starting from the case of *Rodolia cardinalis* against *Icerya purchase* to the case of *Torymus sinensis* against *Dryocosmus kuriphilus*, and includes very successful cases but also unsuccessful ones due to multiple factors. Sometimes, however, the exotic beneficials can spontaneously follow their prey or host in the invasion pathways, and establish in the new areas, giving rise to a fortuitous biological control, which is sometimes unknown in the native area. The record of adventive populations of the exotic egg parasitoids of *Halyomorpha halys* in both North America and Europe falls in this context. Therefore, a large-scale multiplication and release programme of *Trissolcus japonicus* is implemented in Italy to help and speed up its natural colonization. Here, we report some recent cases of classical and fortuitous biological control in Italy, and analyse the associated benefits and risks.

Food webs in augmentative and conservation biocontrol

L Zappalà

University of Catania

Arthropod biodiversity is one of the most important components of agroecosystem resilience against invaders. Indeed, among the various factors that can influence the spread and the invasion speed of exotic pests invading new territories, the efficiency of the complex of indigenous natural enemies can play a key role. One strategy to improve their ecological services is enhancing habitat diversity through the provision of semi-natural vegetation within or near agricultural fields. An alternative and potentially complementary avenue for enhancing biological control is the release of mass-reared natural enemies in large numbers to obtain an immediate control of pests. In fact, augmentative releases of natural enemies have proven to be an environmentally and economically sound alternative to chemical pest control in a wide range of crop systems. Traditionally, the most investigated aspects in evaluating the efficacy of these beneficials are the basic biological traits and their ecological services in controlling the pest. However, new complex multitrophic interactions among natural enemies, pests and plants take place and the resulting food webs may have an impact on the efficacy of biocontrol. Examples will be given of the role of food webs in the biological control of key pests in fruit and vegetable crops.

How does chemical ecology contribute to improving conservation biological control?

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Conservation biological control (CBC) aims to preserve and improve natural enemy efficacy in crop habitats through modification of the biotic environment, *e.g.* by providing flowering plants (companion plants) as food resources. In this work, we look at the chemical ecology of floral resources as a tool to improve conservation biocontrol. In order to feed on companion plants, foraging parasitoids need to find suitable flowers and it is known that floral scent is used for orientation. Thus, ideal companion plants for conservation biocontrol, in addition to improve natural enemy survival and fecundity, should possess highly attractive floral volatiles to ensure they are frequently visited. Such correspondence is indeed possible and studies have shown that highly rewarding plants can also emit floral volatiles which are attractive for parasitoids. Recent discoveries have shown that nectar-inhabiting microbes (bacteria/ yeasts) can act as “hidden players” by modifying the nectar chemistry and/or by producing microbial volatiles (mVOCs) mediating parasitoid attraction to floral resources. However, these compounds can be perceived and used as information by a variety of organisms, such as neighboring plants, herbivores, members of the third trophic level, and members of the fourth trophic level such as obligate hyperparasitoids. These top-carnivore insects are often overlooked, despite the fact hyperparasitoids are common components of natural and agricultural trophic webs and therefore they should be incorporated in chemical ecology approaches targeting conservation biocontrol.

Double double toil and trouble: the countryside is dismal for bees and pollination

R J Paxton

Martin Luther University Halle-Wittenberg, Germany

There is considerable concern for the plight of bees because of perceived declines of honey bees and range restrictions of many wild bee species. The causes of these declines are widely acknowledged to be a combination of habitat degradation/destruction, loss of floral/nesting resources, and exotic pest/pathogens. Less is known about knock-on consequences of bee declines for the ecosystem service of pollination. Toward this end, my group and I have championed methods to quantify pollination by insects, including the use of potted plants that act as 'pollinometers', and employed them to quantify pollination service provision across habitats. On the one side, our measures of bee density and diversity through field sampling and observations of flower visitors correlate well with plant pollination success, suggesting that the monitoring of bees is a suitable, quantitative proxy for the ecosystem service pollination. On the other side, our 'pollinometer' assays suggest that provision of the ecosystem service of pollination is low in the countryside but high in the city, where bees also fare well. Urban sites are not, though, a panacea for all insects; advocating urban sprawl will not reverse ongoing insect declines. Action needs to be undertaken in the countryside, where most of our pollinator-dependent crops are grown, to improve the lot of bees.

The need for a holistic study of the impact of biotic and abiotic stress factors on the conservation of pollinators

F Nazzi

University of Udine

Wild and domesticated bees provide a vital pollination service to the benefit of both natural and cultivated plants. Several stress factors can influence the survival of individual bees and the sustainability of the colonies of social species, thus indirectly affecting pollination. In particular, parasites and pathogens, some of which are shared by different species, represent a common cause of colony collapse in social species and can impair the survival of solitary bees. Xenobiotic substances that are used for crop protection, besides directly killing bees, can exert a number of sublethal effects both on wild and domesticated bees and can interact with parasites to aggravate their respective effect.

Furthermore, the lack of sufficient food resources of adequate quality, related to landscape degradation, can multiply the negative effects of other stressors. How the changing climate will shape this network of interactions is a matter that is still under scrutiny. All the above-mentioned factors have been studied in detail but their possible combined effect, which is what really matters under field conditions, has not been properly understood and this has profound implications for the management.

A sensible approach to preserve the essential contribute of bees to biodiversity and crop production must rely upon a holistic view of bees within the framework of interactions they entertain with the other ecosystem's components.

Biopesticides: a perspective on their sublethal effects on bees and other pollinators

F Cappa & R Cervo

University of Firenze

In the last few decades, biopesticides have been gaining increased attention and interest to develop environmentally friendly and safe approaches and tactics for pest management and to reduce the severe impact of synthetic biocides. Unfortunately, when it comes to non-target insects, such as pollinators, only the acute or chronic effects on survival after these treatments are generally tested. This approach is failing to assess all the potential adverse side-effects on more complex biological and behavioral traits that such biopesticides could have on pollinators. Although international boards have highlighted the need to include also behavioral traits, such as foraging, when assessing risks of plant protection products on bees, no substantial concerns have been raised about the risks associated with sublethal exposure to these agents in terms of individual behavioral alterations and loss of colony integrity and efficiency for social species. Given the dramatic decline of insect pollinators and the increasing demand for a sustainable agriculture, it appears compelling that the so far neglected side-effects on bees and other pollinators should be more thoroughly assessed before allegedly safe biopesticides can be used in the field. Here, we will provide a brief review of the most recent work investigating sublethal behavioral effects of biopesticides on pollinators, focusing on the studies carried out by our and other research groups.

The ecological role of the honey bee

P Fontana

Fondazione Edmund Mach

Apis mellifera Linnaes, 1758, is often referred to as the domestic bee but, despite being bred for several thousand years, this insect has not undergone any domestication process as Charles Darwin had already shown in his writings. The ecological role of this species is however controversial so that often the honey bee is placed in contrast with the other Apoidea or even defined as an alien insect. If this can be true outside the original range of this species, Apis mellifera is the main pollinator in large pate of Europe, Africa, the Middle East and in some areas of Central Asia. The ability to pollinate most of the Magnoliophitae but above all the size of the Apis mellifera companies, make it possible for a single colony of this bee to pollinate several billion flowers in a year of at least 30 km2. The dramatic disappearance of the unmanaged colonies of Apis mellifera, which occurred in Europe in the last 40 years, after the advent of the mite *Varroa destruictor*, have put in crisis not only beekeeping but certainly also many ecological balances. In this sense, however, certain data are lacking, because unfortunately, as regards the pollinators of natural habitats, *Apis mellifera* has always been poorly considered. The situation in recent years is changing and the world of research is giving new impetus to these studies.

Bioinspired pest control technologies: A new frontier in biological control

A M R Gatehouse

Newcastle University, School of Natural and Environmental Sciences, Newcastle upon Tyne, UK

A paradigm shift in current practices is required to increase primary agricultural productivity to feed an additional 2.3 billion people by 2050. To achieve this goal improvements to the control of insect pests will require the development of strategies and molecules that are efficacious, but at the same time have minimal impact on insect biodiversity, and in particular ecosystem service providers. Biological control has been used for centuries, but its success has been varied. One notable success is that of formulations of a bacterial pathogen of insects, *Bacillus thuringiensis* (Bt). This led to the successful commercialisation of Biotech crops expressing δ-endotoxins from *B. thuringiensis* for control of phytophagous insects in the mid 1990s. The advent of new technologies has enabled the development of a new repertoire of "bioinspired" pest control technologies. Insect antagonists provide a novel source of protein-based insecticidal molecules that can be delivered as biopesticides, including those that target the CNS or disrupt the immune response of the pest insect. The use of RNA interference (RNAi) also provides an attractive "bioinspired" approach to crop protection, as the technology is highly specific leading to gene silencing in a sequence-specific manner. The presentation will provide an over view of the potential of these emerging technologies for effective control of crop insect pests and some of the challenges that they may pose. It will also consider their biosafety and the different approaches required to mitigate the potential for pest populations to evolve resistance, thus increasing their durability.

Augusto Vigna Taglianti (1943-2019)

M A Bologna[1], P Audisio[2], M Biondi[3], M Zapparoli[4]

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[4]University of Tuscia

Augusto Vigna Taglianti (Borgo San Dalmazzo June 25th 1943–Roma June 7th 2019), Professor of Entomology, spent his entire academic career (1966-2013) at the Sapienza University of Rome. He was a Full Member of the Italian National Academy of Entomology and of the National Academy of Sciences, and played a leading role among the Italian amateur entomologists and naturalists, constantly participating in the social activities of the wildlife lovers. He was member of several naturalistic associations, became President of the Italian Entomological Society, the Roman Association of Entomology, and the Scientific Committee for the Fauna of Italy. Professor Vigna was also the Editor-in-chief of some Italian entomological scientific journals.
A. Vigna Taglianti was an active organizer of scientific expeditions aimed at improving our knowledge of insect diversity. He published 415 scientific articles in the fields of systematics, biogeography and ecology of Coleoptera Carabidae (mostly), Dermaptera, Crustacea Amphipoda, and Mammalia. Furthermore, and many articles of broader interest, such as those on generalized models of animal distribution. His deep knowledge of Italian biodiversity also led him to an important activity in the field of natural resources conservation and management. His notable contribution in museology included the Direction of the Museum of Zoology at the Sapienza University. Augusto was also a promoter of the Occitan culture and history, which he had an intense bond with since he was a boy.

Myths and reality of biodiversity protection: the fate of professional and amateur entomologists

A Ballerio

Società Entomologica Italiana

The major threats to terrestrial invertebrate diversity are clearly connected with chemical and light pollution, land management and climate change and require therefore comprehensive and far-reaching measures to face the aforesaid problems. Conversely the actions taken by governments, other public authorities and private environmental organizations in order to cope with those problems often centre on single species "conservation" or even single individuals protection. This results in unjustified restrictions to any activity involving the enjoyment of the natural world by people, including professional and amateur entomologists. This presentation tries to explain the causes of such an approach and the impact that it has on entomological research. The potential impact of other laws on biodiversity research (such as the Nagoya protocol) will be discussed too.