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COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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MAIN FUNCTIONS AND SERVICES PROVIDED BY INVERTEBRATES RELEVANT TO FOOD AND AGRICULTURE

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I. INTRODUCTION

1. The Commission has, in past sessions, recognised the important roles of invertebrates in relation to food security and sustainable agriculture. This document describes the major functions and services provided by invertebrates in food and agriculture. The main functional groups presented are: pollinators; biological control agents; soil ecosystem engineers and regulators; food providers and providers of non-timber forest goods. Aquatic invertebrates that positively contribute to the fisheries and aquaculture sectors are not considered in this document. Table 1 below lists some of the main invertebrate groups of relevance to food and agriculture, and their key functions and services. The list is illustrative and not exhaustive.

II. POLLINATORS

2. In 2005, the worldwide economic value of the pollination service provided by insect pollinators, mainly bees, for the main crops that feed the world, was evaluated at about USD 208 billion, or 9.5 percent of the total value of the world's agricultural food production.[1] In addition, production values of crops that depend on insect pollination are four times the value of those that do not. Three-quarters of all food crops, primarily vitamin-rich crops like fruits and vegetables, depend on insect pollinators, the vast majority of which are insects such as bees, moths, flies, wasps and beetles. Both introduced and native pollinators are important and native pollinators act as an insurance policy against unexpected losses of introduced pollinators.

3. Pollination services also make important contributions to other aspects of crop production. Improvements in quality of both fruit and fibre crops, such as cotton, are the result of good pollination. Deliberate management of pollination contributes to improved yields and quality in oil crops, including rapeseed oil in Europe or caster oil and croton in Brazil. Pollination in chilli peppers contributes to an increase in the speed of ripening, which enables the entry of peppers to the market at a higher off-season price, and for one additional flush of fruit over the course of a growing season.

4. Pollinators are extensively being used for their services across agricultural production systems, including in low- and medium input production systems, peri-urban horticultural systems and large- scale enterprises. The pollination services of the honey bee species *Apis mellifera* for example, is extensively used in the sunflower seed industry, illustrating the importance of pollinators at a commercial scale. Production increases in a number of crops, which were until recently thought not to need pollination, have been shown to result from management practices that increase populations of pollinators, such as by preserving their habitat in patches of forest near coffee plantations in Indonesia and Costa Rica.

5. For many crops, a broad approach to the management of pollinators, both wild and managed, provides a higher level of service and an insurance policy against climatic changes or disease outbreaks that impact pollinators. A wide-diversity of bee pollinators, even including rare species, are attracted to sustainably managed agro-ecosystems.

III. BIOLOGICAL CONTROL AGENTS

6. Biological control has a long history in both developed and developing countries - and involves the use of living organisms as pest control agents. This approach draws upon a highly diverse component of crop-associated biodiversity, which includes invertebrate predators and parasites that act as natural enemies of pests and weeds.[2]

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[1] http://www.international.inra.fr/research/insect_pollination.

[2] Background Study Paper 38.

7. In 1997, the world-wide economic value of classical biological control was estimated to be US$417 billion a year globally.[3] Classical biological control uses invertebrate predators and parasitoids, so called natural enemies, for the sustainable reduction of pest populations, including other invertebrates and invasive plant species. These invertebrates are usually collected from the invaders' area of origin and introduced into regions of new invasions.

8. Invertebrates are key in Integrated Pest Management (IPM): the conservation, protection and enhancement of selected species which are naturally present in the local agro-ecosystem, and act as a control factor to pest species is the core concept of IPM. Natural enemies can be adversely impacted from agricultural intensification, particularly through the excessive use of pesticides and soil management practices negatively affecting soil biodiversity and organic matter. The conservation of natural enemies is foreseen to have a particularly important role in securing increased and sustainable crop production, in both the developed and developing world, and in avoiding local pest outbreaks. The greatest potential for use of such integrated systems lies in the developing countries.

9. Augmentation and the releases of natural enemies, has developed where self-renewing biological control cannot be achieved, in the public and private sectors. Commercial augmentative products constitute only a limited percentage of the global market in pest control products, but are highly competitive in a growing number of situations.

10. To improve the effectiveness of biological control projects, practitioners increasingly recognize the need for better understanding the ecological conditions related to the agents, the targets and particularly the non-targets. To this end, environmental and risk assessments are conducted, and the application of the ecosystem approach and the use of local knowledge are utilized to understand the potential effectiveness of indigenous populations and identify potential impacts of the introduction and release of an exotic biological control agent into a new environment. It is necessary to first examine the organisms that are already present in the targeted environment and that act as effective biological control agents, before releasing an exotic organism.

IV. SOIL ECOSYSTEM ENGINEERS AND REGULATORS

11. Another category of invertebrates important to the health maintenance and sustainable management of both forest and agro-ecosystems are soil inhabiting invertebrates.[4] This diverse group of invertebrate communities plays significant, but often poorly acknowledged or understood roles in the delivery of ecosystem services. Soil invertebrates perform many roles, including:

- Nutrient cycling, including the degradation and transformation of organic matter facilitated by soil invertebrates such as mites, millipedes, earthworms, ants and termites. Leaf-cutting ants and termites carry out such functions directly, while other types of soil invertebrates have the capacity to activate nutrient cycle related mineralization processes by stimulating microbial activity.
- Climate regulation, extracting carbon dioxide from the atmosphere and storing it in the soil creating valuable reservoirs of carbon pools.
- Regulating the structure and the stability of soils, by for example, distributing organic matter through the activities of earthworms, termites, ants and some other macro fauna in the soil that form channels, pores, aggregates and mounds, and moving particles from

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[3] Costanza et al., 1997. The value of world's ecosystem services and natural capital. Nature 387:253-260.

[4] It has been estimated that the value of ecosystem services provided each year by the soil biota worldwide may exceed USD 1.5 trillion (Pimentel, D., C. Wilson, C. McCullum, R. Huang, P. Dwen, J. Flack, Q. Tran, T. Saltman, and B. Cliff, 1997. Economic and environmental benefits of biodiversity, *Bioscience* 47: 747-757).

one horizon to another, enhancing soil aeration, water infiltration and retention, reducing runoff or flooding and soil erosion, and improving water resource quality and quantity as well as landscape hydrology.

- Acting as biological control agents for soil pests such as plant-parasitic nematodes, and in some cases, they can also be soil infesting pests themselves, a good example of which would be the *Adoryphorus couloni* (Burmeister) beetle, whose larvae feed on organic material in improved pastures.

12. A comprehensive analysis of soil invertebrate activities has shown that invertebrates can be linked to the delivery of specific ecosystem services by soils. Scientists are exploring the development of biological indicators, using soil invertebrate species, for example, to study soil quality and set soil degradation thresholds. Ecosystem services indicators would help farmers to improve land-use and resource-use decision-making by enabling better understanding of possible trade-offs as well as win-win situations. The provision of support to farmers for enhancing ecosystem services that provide societal benefits can improve the ecological management of their production systems, and thereby, for example, result in improved conditions for soil inhabiting invertebrates.

V. PROVIDERS OF GOODS INCLUDING FOOD AND NON-TIMBER FOREST PRODUCTS

13. In Africa, Asia and Latin America, insects contribute to human nutrition. Hundreds of species, including grasshoppers, caterpillars, beetle grubs, winged termites and ants are used for food. They provide a valuable source of protein, and are included as a planned part of diets throughout the year, or when they are seasonally available.

14. Sericulture - the rearing of silkworms for the production of raw silk - is an age-old cottage industry which originated in China, and rapidly expanded across continents. Sericulture is a high-value activity in some countries, but also the main source of income to many poor and landless farmers in other countries, and important in particular to women.

TABLE 1: MAIN SERVICES OF INVERTEBRATES IN RELATION TO FOOD AND AGRICULTURE[5]

Functional groups	**Services**	**Invertebrates (examples)**	**Examples**
Pollinators	Pollination (regulatory) Genetic resources (provisioning)	**BEES** - Alfalfa leafcutter bee (*Megachile rotundata)* - *Apis Cerana* **WASPS** Fig wasp *Blastophaga psenes* **FLIES** Hover fly *Eristalis tenax*	 Pollinates legume forage crops Pollinator in vegetable seed production Pollinate flowers within the female figs Feeds on nectar and pollen to develop its eggs; pollinator of mangoes, chilli peppers and many other crops
Biological control agents	Disease regulation (regulatory) Invasive species management (regulatory)	**Above ground** **PREDATORS** Polyphagous coccinellid mealybug *Cryptolaemus montrouzier* Mulsant **LADYBIRDS** Beetle *Hyperaspis Pantherina* Fürsch **PARASITOID INSECTS** Parasitic wasps of the families *Bethyliidae* and *Eulophidae* Coccineal Ragwort Flea Beetle (*Longitarsus jacobaeae*) and defoliating Cinnabar Moth (*Tyria jacobaeae*) Stem-Boring Weevil, *Mecinus janthinus*	 Feeds on mealy bugs in all stages Feeds on the Coccidae *Orthezia insignis* Browne Release eggs in their insect host, the coffee berry borer, which is then used to feed the larvae Dramatic reduction of Optunia Dramatic reduction of tansy ragwort (*Senecio jacobaeae*) Reduction in Dalmatian toadflax (severely damages the flowering and reproduction of

[5] The Millennium Ecosystem Assessment defines ecosystem services as "...the benefits people obtain from ecosystems. These include provisioning, regulating, and cultural services that directly affect people and supporting services needed to maintain the other services." Parts of this table have been adapted from the "Millennium Ecosystem Assessment. Ecosystems and Human Well-Being. A Framework For Assessment, 2003".

		<u>Below ground</u> Earthworm *Millsonia anomala* spp.	toadflax. Adult weevils feed externally on the foliage and the larvae feed within the plant) The earthworm enables rice plants parasitized by the nematode Heterodera sacchari spp. to keep on growing. The process behind this phenomenon is still unknown
Soil ecosystem engineers / soil and water regulators	Nutrient cycling (supporting) Soil formation (supporting) Water regulation (provisioning)	**MACRO-FAUNA** Annelida (segmented worms) **MICRO-FAUNA** Nematoda (eelworms) **MESO-FAUNA** Acari (mites) Gamasina/Oribatida **ROOT FEEDERS** Coleoptera (beetles) *Adoryphorus couloni* (Burmeister) Termites, earthworms, ants, mites, millipedes	Assimilate small amounts of inorganic elements from mineral soils Soil nematodes feed on the bacteria and fungi which decompose organic matter Are predators of other soil fauna (saprofagous, micofagous, detritofagous) Its larvae feed on organic matter in soils Their burrowing, feeding and distributive activities can be utilised to break up crusted soils and build soil health, structure and porosity thereby counteract land degradation and runoff
Providers of goods	Direct use values – food, silk, etc. (provisioning)	Grasshoppers, caterpillars, beetle grubs, winged termites Silkworms	As part of human diets, they provide a direct and valuable source of protein Are reared for the production of raw silk, a high value activity in some countries