MARSH BULLETIN
EISSN 2957-9848

A review on the Importance of insects in the ecosystem

Zainab F. Mansowr

University of Basrah , College of Science, Department of Biology

Abstract

Insects represent one of the largest and most important groups in the phylum Arthroptera and kingdom Animalia. There are several reasons why insects are important to review the provision of ecosystem services (ESs) by insects First, it is globally widespread, and exhibit high species richness, high biodiversity, exceeding that of other arthropods well-studied ecosystem servicing. Here we explain how these organisms are important by mentioning its effective role in the ecosystem.

Key words: Arthropoda, Ecosystem services, Insects.

Introduction

Class Insecta occupy 80% of the kingdom Animalia and considered one of the most biodiverse groups in ecosystem; they are cosmopolitan and exhibit close relationship with other living organisms (Losey and Vaughan, 2006; Noriega et al., 2018).

There is widespread concept that insects play an essential role in ecological and economic services of importance to our planet, so insects are known as ecosystem services (ESs) that are of value to society by supporting either directly or indirectly the quality of human life (Harrington et al., 2010; Brock et al., 2021).

However, the scope and nature of the ecosystem services they provide are not well understood, here we provide a synthesis on how these organisms perform important ecosystem services as role as pollinators in plant reproduction, in improving soil fertility through waste bioconversion, and in natural biocontrol for harmful pest species, and they provide a variety of valuable products for humans such as honey and silk and medical applications such as maggot therapy.

In addition, insects have assumed their place in human cultures as collection items and ornaments and in movies, visual arts and literature and we will focus on their additional services as a sustainable alternative to meat for human consumption (Kumar and Omkar, 2022).

The role of insects in ecosystem

The ecosystem services that insects provide are not only found in the natural environment, but are also found in anthropic landscapes and the semi-natural habitats (Mansowr et al., 2024). These ecosystem services are generally described as the direct or indirect benefits given by the nature to the human society (CDB, 2000; Costanza et al., 2014; IPBES, 2018).

Insects are the abundantly found living organisms on our planet. Nearly, 1 million

species of insects are described so far, and nearly 5 million species still need documentation (Stork, 2018). Insects are the environmental engineers, and the major service providers to our ecosystems (Schowalter et al., 2018). They perform many crucial functions like biological control of agricultural pests, recycling of nutrients, dispersal of fungal spores, disposing wastes products and animal dung, and enhancing agricultural productivity (Nichols et al., 2008; Togni et al., 2019). They are involved in the propagation of plants by promoting pollination and seed dispersal; and help in maintaining the structure of plant community through phytophagy and seed feeding (Braga et al., 2013; Garibaldi et al., 2016; Milotić et al., 2018). Insects provide food for insectivorous birds, mammals, reptiles, and fishes; and maintain the structure of animal community by transmitting diseases in large animals, and predating or parasitizing small animals. Certain insects are greatly beneficial to us, as they either provide the food that we eat or the materials that we use. (Table. 1, Fig. 1).

Table 1 : Ecosystem services provided by different insect orders

Order	Insects	Feeding guild	Ecosystem services
Hymenoptera Coleoptera Mantodea	Wasps ground beetles lady birds Praying mantis	Predators	Biological control of pests
Hymenoptera	Wasps	Parasitoids	Biological control of pests
Hymenoptera Lepidoptera	bees, Butterflies , Moths	Herbivores	Pollination
Hymenoptera	Ants	Carnivores	Scavengers, Seed dispersal, Bioturbation
Isoptera Coleoptera	Termites, Dung beetles, Weevils	Herbivores	Decomposers
Orthoptera Coleoptera Hymenoptera	Locusts, Beetle larvae Wasps	Herbivores	Food For humans
Odonata Ephemeroptera Diptera Hymenoptera Hemiptera	Dragonflies &Damselflies May flies Mosquitos, fly Wasps Aphids	Herbivore& Carnivores	Food for animals
Orthoptera Homopter Hymenoptera Diptera Coleoptera	Locusts, grasshopper ,crickets Bugs , Mealy bugs Wasps House fly Larvae of the May beetle , Blister beetles		medicines and to cure diseases

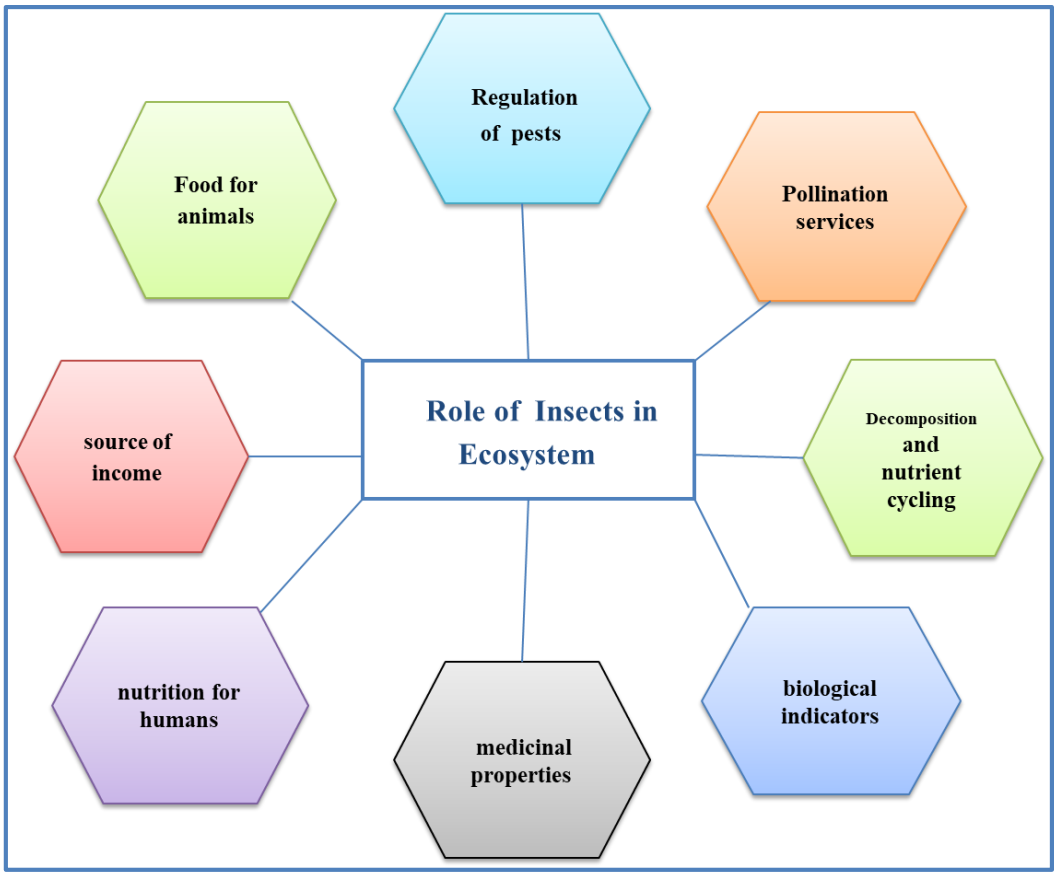

Fig .1 : **The role of insects in ecosystem**

1- Regulation of agricultural arthropod pests

Insects play important role as regulators of insect populations in natural ecosystems, they are also likely to be important as bio-control agents. For example, at least 30000 species of aculeate wasps are known to hunt a wide range of arthropods as predators or parasites (Goulet and Huber, 1993; Grissell, 2010),

Unlike chemical pesticides, biological control is based on pre-existing predator–prey relationships, meaning that pest resistance is unlikely. Insects provided by biological control has an estimated value of 417 billion (USD) per year (Costanza et al., 2014). In North America alone, the value of natural control provided by insects was estimated at 4.5 billion (USD) annually (Losey and Vaughan, 2006). Most successful examples of) biological control using invertebrates have involved parasitoid wasps (Greathead and Greathead, 1992; Carvalho, 2006)

2- Pollination services

Over 75% of human-cultivated crops worldwide depend directly on insect pollination (Klein et al., 2007). About 88% of angiosperm plants are pollinated by insects (Ollerton et al., 2011), the pollination services provided by insects are estimated to be worth over 250 billion (USD)/year worldwide (IPBES, 2016). The Hymenoptera are often considered a “beneficial” order because of the importance of pollination, for which many species are adapted, especially the bees and most species of wasps.

3- Decomposition and nutrient cycling

The role of insects in decomposition and nutrient cycling is almost entirely unstudied. Wasps primarily predate live prey. Social have been reported engaging in necrophagy (the eating of dead or decaying animals); carcasses are a source of amino acids, lipids, protein, carbohydrates, vitamins and minerals, although the quality of these resources depend on the taxon and stage of decomposition (Roubinet et al., 2017).

Ants play a vital role in removing dead arthropods from the environment and they play an important role in the redistribution of nutrients in nature. This is an essential ecosystem process and a key energetic link between higher trophic levels, decomposers and primary producers. (Brock et al., 2021).

4- Insects as biological indicators

Biological indicators are taxa that reflect the state of an environment, the effect of environmental change on a habitat or ecosystem, or the diversity of a subset of taxa within an area (Duelli and Obrist, 2003). Due to their important ESs, ubiquity and abundance, insects make excellent biological indicators (McGeoch, 1998). Theoretically, the predatory and parasitic insects should be particularly useful in indicating the health of an ecosystem: by ranking highly in food webs, their presence in a habitat indicates the presence of an abundant and divers community of prey arthropods (Gayubo et al., 2005).

A best example of this Social insects like termites, ants, bees and wasps are frequently used as bioindicators, wasps are considered as biological indicators of habitat quality, biodiversity, and pollution resulting from human activities.

Insects make us aware about the status of the habitat they inhabit. While various termite species are used as bioindicators for assessing the habitat quality (Alves et al., 2011), different ant species are used for analyzing habitat restoration, heavy metal contamination and land management practices (Skaldina et al., 2018). Honeybees are used as the bioindicators of environmental pollution (Celli & Maccagnani, 2003) . Wasps are employed to check the status of habitat conservation (de Souza et al., 2010) , ants and wasps which are considered as biological indicators of habitat quality, biodiversity, and pollution resulting from human activities .

Unlike vertebrate keystone predators, sampling insects populations and measuring their abundance is relatively cheap and easy (Gayubo et al., 2005).

5- Medicinal properties

The venom of bee and wasps is a complex mixture of toxins, allergens, enzymes, and amines (de Graaf et al., 2009), it is unsurprising that venoms contain many biologically active molecules which are of significant pharmacological interest.

Of recent interest is the potential of wasp venom in the treatment of cancer (Heinen and Gorini da Veiga, 2011). This venom has antimicrobial properties. Anoplin, a peptide isolated from the venom of *Anoplius samariensis* (Pompilidae), and Eumenitin, isolated from the venom of *Eumenes rubronotatus* (Vespidae), show strong inhibitory activity against both Gram-positive and Gram negative bacteria (Konno et al., 2001, 2006).

Both the folk and traditional insect medicines (entomotherapy and entomoprophylaxis) are widely used around the world (Schabel, 2010). Many communities in Africa consume insects having medicinal properties, as these insects act as appetizers, enhance sexual desires and cure asthma and heart diseases (Musundire, 2014).

Finally, from a biomedical perspective, there is a growing research field exploiting the biochemical components of social wasp venom for antimicrobial properties and use in the treatment of cancer and other diseases.

6- Insects as nutrition for humans

Insects deliver a host of ecological services that are fundamental to the survival of humankind, and they are commonly consumed

as a food source in many regions of the world (Brock et al., 2021).

It is estimated that insects form part of the traditional diets of at least 2 billion people. More than 2000 species have reportedly been used as food (Huis et al., 2013).

Insects is heavily influenced by cultural and religious practices. The global increase in demand for meat and the limited land area available prompt the search for alternative protein sources. Also the sustainability of meat production has been questioned. Edible insects can be used as an alternative source of protein in human food (Huis et al., 2013).

Globally, the most commonly consumed insects are beetles (Coleoptera) (31%), (Lepidoptera) (18%), bees, wasps and ants (Hymenoptera) (14%). Following these are grasshoppers, locusts and crickets (Orthoptera) (13%), cicadas, leafhoppers, plant hoppers, scale insects and true bugs (Hemiptera) (10 %), termites (Isoptera) (3%), dragonflies (Odonata) (3%), flies (Diptera) (2%) and other orders (5 %) (Huis et al., 2013).

Nutrition

It is difficult to generalise the nutritional value of insects, because it varies with species, gender, developmental stage, diet and environment factors (temperature, humidity and photoperiod) and even with the analytical methods used (Finke and Oonincx, 2014). Many species are rich in protein and fat, essential fatty acids as well as vitamins and minerals (Bukkens, 1997; Rumpold and Schlüter, 2013).

Protein

The protein content on a dry-matter basis of insects about (7-91) % and many species contain approximately 60 % protein (Finke and Oonincx, 2014) . The digestibility of protein from insects is highly variable, partly because a part of the AA in cuticular protein is bound to chitin, a polysaccharide and component of the exoskeleton of insects (Rumpold and Schlüter, 2013).

The species from the order Orthoptera (grasshoppers, crickets and locusts) are rich in proteins and represent a valuable alternative protein source (Yi et al., 2013).

Wasps account for 4.8% of the insect species consumed: there is more than 109 wasp species reported as being eaten across more than 20 countries. This is likely to be an underestimate since many wasps sold for human consumption can only be identified to genus level and data are only known for a small number of countries (Chen et al., 2009; Ying et al., 2010).

Wasp larvae have an exceptional dry protein mass (46 - 81) %, typically contain around 70% of required amino acids and have an extremely low fat content (Ramos-Elorduy, 1997).

Typically, wasps are eaten in their larval or pupal stages and thus mainly social species are utilised, since the nests of solitary species are rarely large enough to merit the efforts of collection (Ruddle, 1973).

During the autumn harvest in Japan, wasp nests typically sell for USD 100 per kg and demand is often so high that markets must be supplemented by the importation of further nests from China, New Zealand, and the Republic of Korea (Nonaka, 2010). Wasps are a popular street food in East Asia, Africa, and South America (Ramos-Elorduy, 2009).

In rural China, wasps are the most common edible insects for sale; more than 18 species have been recorded at market (Chen et al., 2009). Furthermore, in tropical climates, the perennial colony cycles of wasps mean they are reliable food source which can be collected year-round (Acuña et al., 2011).

Fat content

After protein, fat represents the second largest portion of the nutrient composition of edible insects, ranging from 13 % for Orthoptera (grasshoppers, crickets, locusts) to 33 % for Coleoptera (Rumpold and Schlüter, 2013) .

The larvae of the African palm weevil are considered a delicacy in Nigeria. The lipid

content of this larva 67 % on a dry weight is higher than the amount found in most conventional protein foods such as beef, chicken, egg and milk (Ekpo and Onigbinde, 2005).

Micronutrients

Most species of insects contain little calcium because insects, like other invertebrates do not have a mineralised skeleton (Finke and Oonincx, 2014). Several insect species, such as crickets, palm weevils, termites and caterpillars were shown to be rich in content of zinc and iron. This is interesting as the proportion of the world population at risk for zinc deficiency is more than 17 % for zinc (De Foliart, 1992) and 25 % for iron deficiency (Mc Lean et al., 2009) .

In a study in Kenya, crickets and termites proved to have a high iron and zinc content, assuming a bio-availability of 10 %, 10 g crickets would cover 114 % of the recommended nutrient intake for iron for adult males and 53 % for adult females; these figures for zinc are 36 and 51 % (Christensen et al., 2006) .

In the democratic republic of Congo, the benefits were investigated of a cereal made with caterpillars and used as a micronutrient-rich supplement to complementary feedings in infants aged between 6 and 18 months (Bauserman et al., 2015) , infants aged 6–12 months were provided with 30 g caterpillar cereal daily and infants aged 12–18 months with 45 g (100 g containing 1840·96 kJ (440 kcal), 23 g protein, 21 g fat, 40 g carbohydrate, and 12·7 mg Fe and 12·7 mg Zn), infants in the cereal group had higher Hb concentration and fewer were anaemic, compared with the usual diet .

7-Food for animals

Insects can also be used as feedstock for pets, livestock and fish. The candidate insect species are the Black soldier fly *Hermetia illuscens* (Diptera: Stratiomyidae), the common housefly *Musca domestica* (Diptera: Muscidae) and to a lesser extent mealworm, locusts/grasshoppers/ crickets and silkworms. The advantage of the fly species and the mealworms is that they can be reared on organic side streams, interesting because one-third of the produce in the food and agriculture industry is wasted (FAO, 2011) . Low value organic products can in this way be transformed into high value protein products (van Huis, 2020).

Maggots are important sources of animal proteins for poultry: they have a dry matter of 30 percent of their total wet larval mass, 54 percent of which is crude protein, Maggots can be offered fresh (Cerritos, 2009).

In Nigeria and Cameroon, for example, maggot production could provide an excellent source of animal protein for local poultry farms (Ekoue and Hadzi, 2000 ; Téguia et al., 2002). In South Korea, Hwangbo et al. (2009) explored the contribution of maggots to the meat quality and growth performance of broiler chickens and found that feeding diets containing 10–15% maggots can improve the carcass quality and growth performance of broiler chickens. In Nigeria, Awoniyi et al. (2004) evaluated the replacement of fishmeal with maggot meal and found that diets in which 25 % of fishmeal was replaced with maggot meal were most efficient in terms of average weekly weight gain and protein efficiency rate.

8- Insects as a source of income

The harvesting and marketing of edible insects can improve livelihoods, in particular of women. Examples are: harvesting the Mopane caterpillar Imbrasia belina (Lepidoptera: Saturniidae) in Southern Africa is an 85 million USD business (Ghazoul, 2006; Styles, 1994). Another example, the marketing of the Edible stinkbug Encosternum delegorguei (Hemiptera: Tessaratomidae) in sub-Saharan African countries mainly benefits women in impoverished rural communities (Dzerefos and Witkowski, 2015), edible pupae of a saturniid wild silkworm, is commercially reared for sericulture in Madagascar,

contribute to poverty alleviation (Randrianandrasana and Berenbaum , 2015)

The larvae of the African palm weevil *Rhynchophorus phoenicis* (Coleoptera: Curculionidae) are popular food throughout the humid tropics. In the Congo Basin and Cameroon, they are consumed by the majority of the inhabitants ,their exploitation and trade by forest dependent communities is an important source of income (Muafor et al., 2015).

In Thailand, insect farming is expanding rapidly and offers significant income and livelihood opportunities for tens of thousands of Thai people engaged in insect farming, processing, transport and marketing (Durst and Hanboonsong, 2015) .About 20000 domestic cricket farms in Thailand produce an average of 7500 metric tonnes of insects annually for home consumption and for the market(Hanboonsong et al., 2013) . To improve the health status of people in a province of Cambodia, the cricket *Teleogryllus testaceus* (Orthoptera: Gryllidae) is mass produced as a sustainable, cost-effective and high-quality alternative source of protein to traditional livestock. (Caparros et al., 2016).

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مراجعة حول أهمية الحشرات في النظام البيئي

زينب فاضل منصور
قسم علوم الحياة- كلية العلوم- جامعة البصرة

المستخلص

تمثل الحشرات واحدة من أكبر وأهم المجموعات في شعبة مفصليات الأجنحة ومملكة الحيوانات. هناك عدة أسباب تجعل الحشرات مهمة لمراجعة توفير خدمات النظام البيئي (ESs) من قبل الحشرات. أولاً، إنها منتشرة عالميًا، وتُظهر ثراءً كبيرًا في الأنواع، وتنوعًا بيولوجيًا عاليًا، يتجاوز خدمات النظام البيئي للمفصليات الأخرى المدروسة جيدًا. هنا نشرح كيف أن هذه الكائنات الحية مهمة من خلال ذكر دورها الفعال في النظام البيئي.