CHAPTER

3

THE ECONOMIC IMPORTANCE OF BENEFICIAL INSECTS: VALUING NATURE'S HIDDEN WORKFORCE

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Abstract
Insects are often perceived through the narrow lens of pests, yet this perspective overlooks the profound economic contributions of their beneficial counterparts. This chapter provides a comprehensive economic analysis of the ecosystem services provided by beneficial insects. These services are foundational to global food security, sustainable agriculture, and ecological health. We synthesize current research to quantify the economic value of three primary services: (1) Pollination, the indispensable service for crop production; (2) Biological Control, the natural regulation of pests by predatory and parasitic insects; and (3) Decomposition and Nutrient Cycling, the critical waste-recycling services provided by detritivores. Furthermore, we explore the established and emerging markets for direct insect products, including apiculture (honey, wax), sericulture (silk), and the burgeoning industry of insects as food and animal feed (entomophagy). By attaching monetary values amounting to hundreds of billions of dollars annually to these often-invisible services, we highlight the severe economic risks posed by insect population declines. This chapter argues for the urgent integration of insect conservation into economic policies and agricultural practices, reframing beneficial insects as indispensable natural capital.
***Keywords:** Ecosystem Services, Economic Entomology, Pollination, Biological Control*

Introduction

The narrative surrounding insects in human society is overwhelmingly negative, dominated by their roles as vectors of disease, destroyers of crops, and general domestic nuisances. This perspective, while understandable, is dangerously incomplete. It obscures a fundamental truth: human civilization is supported by an unseen, untiring, and largely uncompensated workforce of beneficial insects (Losey & Vaughan, 2006). The vast majority of insect species are either neutral or profoundly beneficial to human interests, providing ecosystem services so essential that their replacement, if even possible, would be astronomically expensive (Costanza et al., 1997). The failure to recognize, value, and protect this natural capital represents one of the most significant and unaddressed risks to global food security and economic stability (Daily & Matson, 2008). The economic contributions of insects can be broadly categorized into direct products and indirect services. Direct products, such as honey, silk, and wax, have been integrated into human economies for millennia and represent significant global markets (Rattan, 2012; Sharma et al., 2013). However, the value of these markets is dwarfed by the economic contribution of indirect services. These "ecosystem services" are the benefits that nature provides to people, and insects are key providers. These services include the pollination of crops, the natural suppression of pests, the decomposition of waste, and the maintenance of soil fertility. When these services are disrupted, the economic consequences are immediate and severe, manifesting as increased production costs, reduced crop yields, and greater reliance on costly, environmentally damaging inputs like synthetic pesticides and fertilizers (Naranjo et al., 2015).

This chapter aims to synthesize the economic importance of beneficial insects by examining the monetary value of their key contributions. We will first explore the indispensable role of pollinators, who are responsible for a significant fraction of global crop production (Klein et al., 2007). We will then analyze the value of biological control, where predatory and parasitic insects act as nature's pest managers, providing billions of dollars in free pest suppression (Symondson et al., 2002). Following this, we investigate the often-overlooked but critical role of insect decomposers in nutrient cycling and waste removal (Nichols et al., 2008). Finally, we will examine both the traditional and emerging markets for insects as direct products, from sericulture to the rapidly growing field of entomophagy (van Huis et al., 2013). By placing a quantifiable economic value on these services, this chapter underscores the urgent need for policies that protect beneficial insects as one of our most valuable and vulnerable economic assets.

Pollination Services

Pollination is perhaps the most well-known and economically significant service provided by insects. It is the process of transferring pollen, which enables fertilization and the production of seeds and fruits in flowering plants. While some crops are wind-pollinated (like cereals) or self-pollinating, an estimated 75% of the world's leading food crops, and over 85% of all flowering plants, depend at least in part on animal pollinators (Klein et al., 2007). Insects, particularly bees, are the dominant actors in this process, but flies, butterflies, moths, wasps, and beetles also play crucial roles. This service is not merely beneficial; it is a fundamental pillar of human nutrition, responsible for the production of the fruits, vegetables, nuts, and seeds that provide essential micronutrients (Eilers et al., 2011). The economic valuation of this single service is staggering. A landmark study by Gallai et al. (2009) estimated the total global economic value of insect pollination for crops at €153 billion (approximately $217 billion at the time). This figure represents the value of crop production that is directly attributable to insect pollinators. For some crops, the dependency is absolute; almonds, for example, are 100% reliant on insect pollination, primarily by managed honeybees, creating an entire industry dedicated to "renting" hives (Breeze et al., 2021). For other crops like apples, blueberries, and coffee, pollinators significantly increase both the yield and the quality of the produce. Without these pollinators, global agricultural output would plummet, and food prices would skyrocket, disproportionately affecting the world's poorest populations (Aizen et al., 2009). While managed honeybees (Apismellifera) are the most visible and commercially managed pollinators, research increasingly shows that wild, native pollinators are essential for optimal crop production and economic resilience. Garibaldi et al. (2013) demonstrated in a global study that wild pollinators, when present, are often more efficient than honeybees and are critical for stabilizing crop yields. Fruit set and yield were significantly higher in fields with abundant and diverse wild insect populations. This diversity provides a crucial "insurance policy" against the diseases and stressors, such as Colony Collapse Disorder (CCD), that can devastate honeybee populations (Potts et al., 2010). The economic implication is clear: protecting natural habitats around farms is not an ecological luxury but a direct investment in agricultural productivity and risk management.

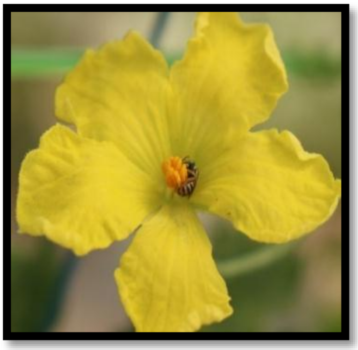
The profound economic reliance on insect pollinators makes their global decline a critical economic threat. This decline, driven by a combination of habitat loss, pesticide use (particularly neonicotinoids), climate change, and the spread of pathogens, jeopardizes the stable production of crops (Potts et al., 2010; Goulson, 2013). The economic costs of pollinator loss are already being felt in some regions, such as the famous case of Sichuan, China, where apple and pear orchards must be pollinated by hand a labor-intensive and costly practice following the local extinction of native bees (Breeze et al., 2021). This scenario provides a stark preview of the economic consequences of failing to protect pollinator populations, forcing us to substitute an efficient, free service from nature with an expensive and inefficient manual alternative.

Tetragonula Iridipennis

Apis Florea

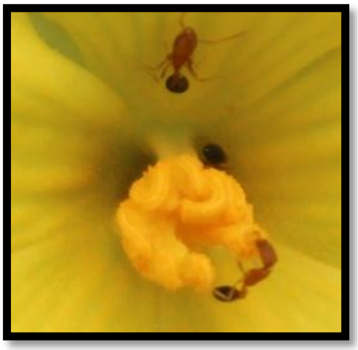
Apis Cerana Indica

Amegilla Zonata



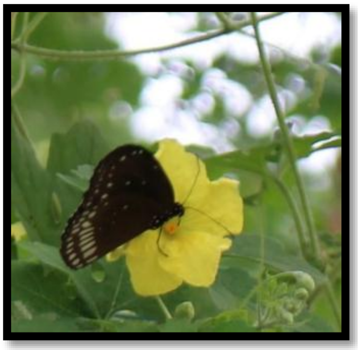
***Lasioglossum* sp.**

Xylocopa Violacea



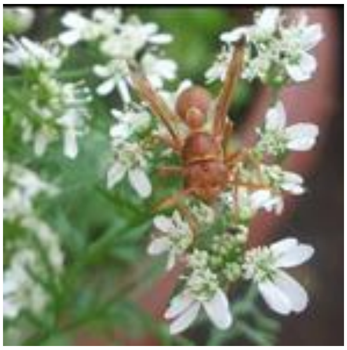
Dormyrmex sp.

Monomorium Minimum

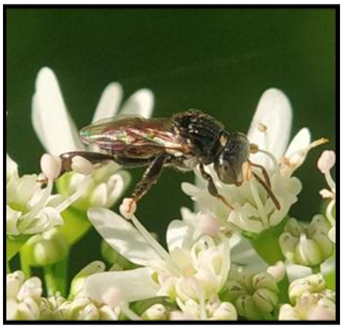


Danaus Chrysippus

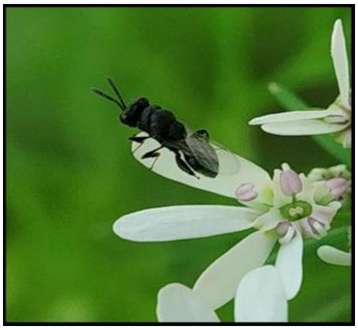
Tirumala Limniace



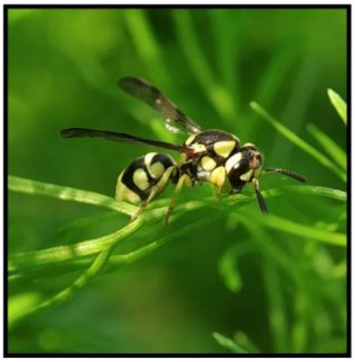
Delias Eucharis *Ropalidia Marginata*

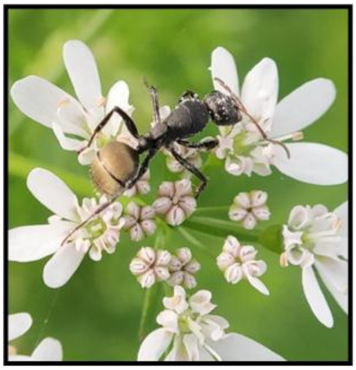


Tetragonula iridipennis *Nomia sp.*



Eurytoma sp. *Collestis* **sp.**





Antepipona sp. *Camponotus Sericeus*

Biological Control

Beyond pollination, the most significant economic service provided by insects is the natural suppression of pests. Biological control, or biocontrol, is a vital ecosystem service where the natural enemies of herbivorous insects namely predators, parasitoids, and pathogens act as a free, self-regulating "pest management" force (Bale et al., 2008). This service is a cornerstone of sustainable agriculture, providing an enormous, though often uncalculated, subsidy to farmers by reducing the populations of organisms that damage crops.

The economic value of this service is realized in two primary ways: (1) prevented crop losses from pest damage and (2) saved costs that would have otherwise been spent on synthetic chemical pesticides, fuel, and labour for their application (Naranjo et al., 2015).

The sheer scale of this contribution is difficult to overstate. A foundational study by Losey & Vaughan (2006) estimated that the value of pest suppression by native natural enemies in the United States alone was worth several billion dollars annually. This value is derived from predators like lady beetles (Coccinellidae), lacewings (Chrysopidae), and ground beetles (Carabidae) that consume vast numbers of aphids, mites, and caterpillars, as well as parasitoid wasps that lay their eggs in or on pest species, killing the host. In cotton production, for example, conservation of these natural enemies is a primary IPM strategy, and their activity provides a quantifiable economic benefit that can often exceed the cost-benefit ratio of insecticide applications when long-term environmental and resistance costs are factored in (Naranjo et al., 2015). The economic models of biological control are diverse. Conservation biological control, which seeks to enhance the habitat for native natural enemies (e.g., by planting flower strips or cover crops), represents a long-term farm investment. The "cost" is the land and seed, while the "return" is a more resilient and less-intensive cropping system. In contrast, augmentative biological control, the commercial rearing and release of natural enemies, has created its own multi-million dollar global market (Van Lenteren et al., 2006). In this model, greenhouse growers, for instance, purchase Phytoseiulus persimilis (a predatory mite) to control spider mites, directly substituting a biological product for a chemical one. This commercial industry is a tangible economic sector, complete with production facilities, supply chains, and quality-control standards, all built upon the predatory efficiency of beneficial insects.

Table 3.1. Economic Contributions of Beneficial Insects and Their Key Services

Sl. No	Ecosystem Service	Key Insect Group(s)	Economic Value / Impact	Reference
1.	Crop pollination	Bees, flies, butterflies, wasps, beetles	The global value of crop production dependent on pollinators is estimated at €153 billion annually.	(Gallai et al., 2009)
2.	Pest suppression (Biocontrol)	Predators (e.g., lady beetles, lacewings) &Parasitoids (e.g., wasps)	Value from natural enemies is estimated at several billion dollars annually in the U.S. alone from crop loss prevention.	(Losey& Vaughan, 2006)
3.	Decomposition	Dung roller (Scarabaeinae)	Provides critical services to livestock industries by suppressing pests, cycling nutrients, and improving soil.	(Nichols et al., 2008)

4.	Apiculture	Honeybees	Multi-billion dollar global market for honey, with additional value from wax, propolis, and paid pollination.	(Rattan, 2012)
5.	Sericulture	Silkworm	The foundation of the global silk textile industry provides a vital livelihood for rural economies.	Mushtaq et al., (2023)
6.	Animal feed	Black Soldier Fly, Mealworms, Crickets	An emerging market providing a sustainable protein alternative to fishmeal and soy in animal feed.	(Makkar et al., 2014)
7.	Natural dyes	Cochineal Insect (*Dactylopius coccus*)	A high-value natural red dye for food and cosmetics, creating a key export market for producers.	(van Huis et al., 2013)

Decomposition and Nutrient Cycling

While pollination and biological control have visible impacts on agricultural outputs, the "hidden" services of decomposition and nutrient cycling are fundamental to the long-term sustainability of all terrestrial ecosystems. Insects are a critical component of the "brown food web" the community of organisms that breaks down dead organic matter. This service, primarily performed by beetles, flies, ants, and termites, is essential for waste removal, soil formation, and the liberation of nutrients, which would otherwise be locked away in dead plants and animals (Losey& Vaughan, 2006). The economic value of this service is measured in the avoidance of sanitation costs, the maintenance of public health, and the reduced need for synthetic fertilizers.

The most-studied and perhaps most economically significant example is that of dung roller (Scarabaeinae). In pasture-based livestock systems, the accumulation of dung is a major economic and environmental problem. It fouls the pasture, rendering large areas unpalatable to grazing animals, and provides a breeding ground for pestilent flies that stress livestock and transmit disease (Scholtz et al., 2009). Dung beetles provide a suite of services by rapidly tunneling and burying dung.

Pest Control: They disrupt the life cycle of pests like the horn fly and face fly, saving the cattle industry billions of dollars in lost productivity and pesticide costs (Nichols et al., 2008).

Pasture Fecundity: By removing the dung from the surface, they increase the available grazing area, a direct economic gain for the producer.

Nutrient Cycling: They move nitrogen and other key nutrients from the dung into the soil root zone, acting as free "fertilizer spreaders" and improving soil fertility.

Soil Health: Their tunneling activity aerates the soil and improves water infiltration, reducing nutrient-laden runoff into nearby waterways.

Similarly, termites, often viewed only as pests, are essential decomposers of wood and other plant materials in tropical and subtropical ecosystems, playing an indispensable role in soil turnover and carbon cycling.

The larvae of carrion flies (e.g., blowflies) are incredibly efficient at disposing of carcasses, a critical sanitation service that limits the spread of pathogens. The economic value of these decomposer communities is, in essence, the cost that society would have to pay for waste management, soil remediation, and fertilizer application if these insects were to disappear.

Insects as Direct Products

Moving from indirect ecosystem services, insects also contribute billions of dollars to the global economy through the direct production of commercial goods. Unlike the "free" services of pollination or biocontrol, these are established industries based on the harvesting or cultivation of insects and their metabolic products. These ancient markets, particularly for apiculture and sericulture, represent some of the earliest forms of human-insect co-management and remain economically significant today.

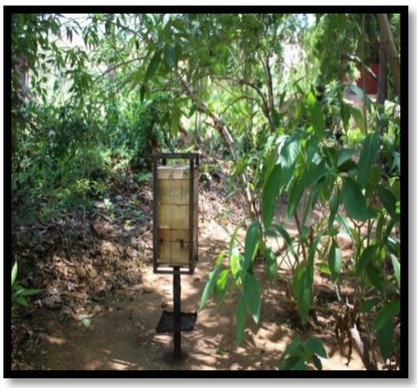
Apiculture

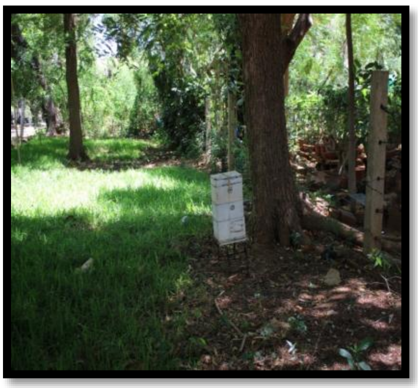
Apiculture, the practice of beekeeping, is a multi-faceted, global industry. While the primary economic driver is honey, a multi-billion-dollar international commodity, the value of the honeybee (*Apis mellifera* and related species) extends far beyond this single product (Rattan, 2012). The "hive economy" is a model of vertical diversification:

Beeswax: A secondary product of honey extraction, beeswax is a high-value input for the cosmetics, pharmaceutical, and food industries. It is also used in high-end candle making and as a natural material for products like food wraps.

Propolis and Royal Jelly: These hive products are harvested and marketed as high-value health supplements, commanding premium prices in nutraceutical markets due to their perceived antimicrobial and anti-inflammatory properties.

Pollination Services: In many developed economies, the primary income for beekeepers now comes from "renting" their colonies for commercial pollination. The almond industry in California, for example, is entirely dependent on the annual migration of over two million bee colonies, a service for which beekeepers are paid billions of dollars, often exceeding the value of their honey crop (Breeze et al., 2021).





An Indian Beehive Placed in a Mango Field

Little Bee Colony **Indian bee (frame in managed colony)**

Sericulture

Sericulture, the cultivation of silkworms for silk production, is an ancient industry that remains a cornerstone of the textile economy in many nations. The industry is centered on the domesticated silkworm, *Bombyx mori*, whose larva (fed exclusively on mulberry leaves) spins a cocoon of continuous filament. This raw silk is then reeled, spun, and woven into one of the world's most prized luxury fabrics. The economics of sericulture represent a complete value chain, particularly vital for rural economies in Asia. China and India are the dominant global producers, where the industry is not just a commercial enterprise but a cultural heritage The silk industry operates through an integrated value chain that supports a wide range of economic activities, particularly in rural and semi-urban areas. At its foundation lies agriculture, where farmers cultivate mulberry plantations the primary food source for silkworms. This agricultural base sustains the rearing sector, consisting mostly of rural households engaged in raising silkworms, which provides vital supplementary income and promotes rural employment. The next stage involves reeling, where small-scale enterprises or filatures process the cocoons into raw silk thread, creating additional livelihood opportunities and supporting small entrepreneurs.

Finally, the manufacturing sector transforms the raw silk into high-value products through large textile mills that weave, dye, and finish the fabric for both global fashion and upholstery markets. Moreover, niche markets for "wild silks" such as Tussah silk, produced from non-domesticated moth species, further enhance the diversity and resilience of this economically significant industry.

Cocoon of the Mulberry Silkworm

Other Products

Beyond honey and silk, several other insect-derived products have carved out significant and often high-value economic niches:

Shellac: This natural, non-toxic resin is secreted by the female lac insect (Kerrialacca), which lives on trees in India and Thailand. For over a century, shellac was the primary material for gramophone records. Today, it remains an economically important product used in food-grade glazes (e.g., on candies and apples), pharmaceuticals (as a pill coating), and as a high-quality wood varnish (Sharma et al., 2013).

Cochineal: This vibrant, stable red dye (also known as carmine) is derived from the cochineal scale insect (*Dactylopius coccus*), which is farmed on prickly pear cacti, primarily in Peru. As consumers have increasingly demanded natural alternatives to synthetic food dyes (like Red No. 40), the market for cochineal has surged. It is now a high-value, export-oriented commodity used in food, beverages, and cosmetics.

Maggot Debridement Therapy (MDT): In a modern medical application, "medical-grade" sterile larvae of the green bottle fly (*Luciliasericata*) are used for wound care. These maggots efficiently debride non-healing wounds by consuming only necrotic (dead) tissue, disinfecting the wound, and promoting healing. This represents a direct economic service to healthcare systems, often proving more effective and less costly than surgical debridement for chronic wounds like diabetic foot ulcers.

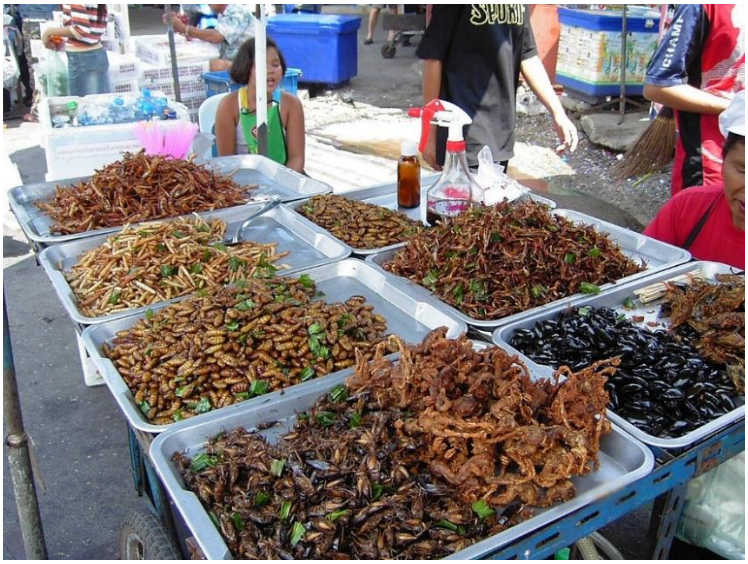
Insects as Food and Feed (Entomophagy)

Entomophagy is emerging as a rapidly expanding sector with immense economic potential as a sustainable protein source. This growing industry is driven by factors such as environmental sustainability, efficient feed conversion ratios, and the need for alternative proteins to meet rising global food demands.

Key species used include crickets, mealworms, and the black soldier fly, all recognized for their high nutritional value and low ecological footprint. The economics of entomophagy encompass the entire value chain, from start-up investments and production systems to market projections for both human consumption and animal feed industries.

Foundational studies such as the FAO report by van Huis et al. (2013) and subsequent works by Makkar et al. (2014) and Lundy and Parrella (2015) highlight its potential to transform global food security while promoting sustainable agricultural practices.

Entomophagy - Wax Moth Larvae



Entomophagy – street food in Thailand

Economic Threats and the Cost of Inaction

Beneficial insect populations, including pollinators, predators, and decomposers, face mounting threats from habitat loss, climate change, and widespread pesticide use (Sánchez-Bayo and Wyckhuys, 2019).

These pressures represent not only environmental challenges but also significant economic risks that undermine the vital ecosystem services these insects provide. The decline of pollinators directly affects global crop yields and the quality of fruits, vegetables, and oilseeds, leading to substantial losses in agricultural productivity.

Predatory and parasitic insects that naturally control pest populations are also diminishing, increasing reliance on chemical pesticides and raising production costs for farmers. Likewise, the reduction of decomposer species disrupts nutrient cycling and soil fertility, threatening long-term agricultural sustainability. Studies have shown that the economic value of pollination alone reaches hundreds of billions of dollars annually, underscoring the immense financial importance of conserving insect biodiversity. Climate change further intensifies these problems by altering insect distribution, life cycles, and interactions with plants. Pesticide overuse compounds the crisis by causing both direct mortality and sublethal effects that reduce reproduction and foraging efficiency (Daily & Matson, 2008). Restoring natural habitats, adopting integrated pest management, and promoting sustainable agricultural practices are therefore crucial strategies to reverse these trends. Protecting beneficial insects is not only an ecological necessity but also a sound economic investment to ensure food security and resilient ecosystems for the future.

Conclusion

In conclusion, the economic importance of beneficial insects is far more than an academic concept; it forms a cornerstone of global economic stability and ecological resilience. These insects play vital roles as pollinators, predators, decomposers, and providers of raw materials, contributing billions of dollars annually to agriculture, industry, and environmental health. Recognizing their value requires a shift in perspective from viewing insects merely as pests to understanding them as essential partners in maintaining productivity and biodiversity. The chapter highlights that the continued decline of beneficial insect populations due to habitat loss, climate change, and pesticide misuse poses serious economic and ecological risks. Addressing these challenges calls for new economic models and policy frameworks that explicitly incorporate the value of insect-mediated ecosystem services. Investing in conservation, habitat restoration, and sustainable management practices will not only protect these valuable species but also ensure long-term food security and environmental stability. Ultimately, valuing and safeguarding nature's hidden workforce is an investment in the health, resilience, and prosperity of the global economy.

Disclosure Statement

The authors reported no potential conflict of interest.

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