

INSECT CONSERVATION

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Summary

Insects have been an immensely successful animal group, with possibly 2-10 species on Earth today. Less than 10% of these have scientific names. Although evidence suggests that many insect specialists died out at the end of the Cretaceous, most have survived many geological events over the last few millions of years. This is now changing, with the human impact estimated to be threatening the survival of a quarter of all insect species. The task is now urgent to conserve this immense variety of life which is so vital to many ecosystem functions. Threats are many and varied, with habitat destruction the worst threat, especially in the tropics where most insect diversity lives. Other threats include those from invasive alien organisms, certain biological control practices, use of pathogens, genetically modified crops and global climate change. Many of these threats interact, causing synergistic effects. Great efforts are being made to counter these threats using both landscape planning and special projects focusing on particular

species. This is an active research field with conservation management being put urgently in place. This management includes maintaining reserves, promoting natural landscape variety, putting corridors in place and restoring the original quality of the habitat as far as possible. Sometimes whole landscapes are restored, with special attention then being given to the needs of individual species that are especially threatened and have greater chances of survival when given particular attention. Insects are covered under many international conventions, including the pivotal Convention on Biological Diversity. Insects are also being included in many national Biodiversity Action Plans and Agri-environment schemes. This goes hand in hand with raising public awareness of the plight of insects through pleasurable encounters with these small creatures at butterfly houses.

1. Introduction

1.1. The Rise of Insects

Throughout all warm terrestrial ecosystems, insects are a dominant component. They have been highly successful both in terms of number of species and abundance. Over the last 400 million years, the number of insect families has been steadily rising, with about 600 today (Figure 1). Although insects at the family level have survived various major impacts over the last 100 million years, it is the specialists that died out during the mass extinction event at the end of the Cretaceous.

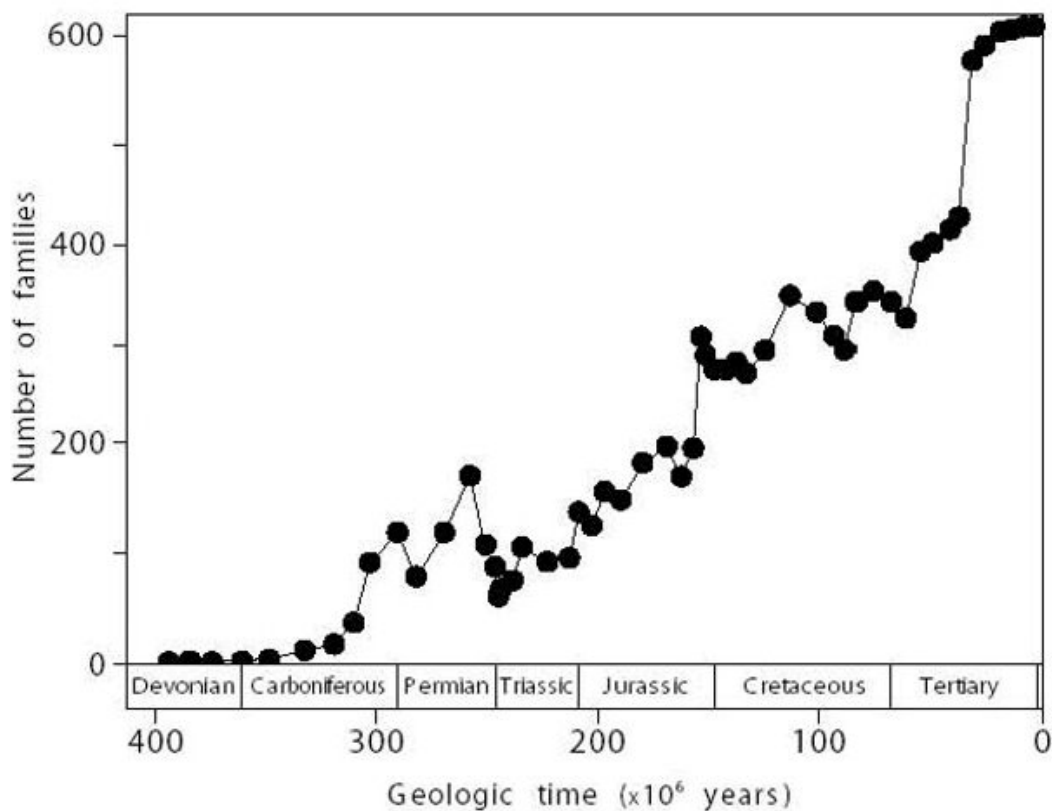


Figure 1. Family-level diversity of fossil insects over the last 400 million years (Reprinted with permission from Labandeira, C.C. and Sepkoski, J.J. Jr (1993) *Science*)

261, 310-315).

The success of insects has been due to their versatile methods of feeding and their ability to fly and locate those food sources, sometimes over many kilometers. So even though they are so small, they have agility and resourcefulness for finding food for their progeny, hence their remarkable survival ability. Part of this is due to their polymorphisms which genetically equips them for various ecological scenarios. Even the humble butterfly is effectively the disperser, and its polymorph, the caterpillar, the eating and growing stage.

This historical and ecological stage is important for underpinning insect conservation, because it is inhibition of dispersal and loss of resources for feeding and habitat specialists that are among the most threatening of processes to the current level of insect diversity.

1.2. Current World Species Richness

It is not known how many insect species there are, although it is certainly millions, most of which are still to be described. Of course, arguing about numbers of species depends on our definition of species. The phylogenetic concept of species is one of the most useful for insect conservation biology, and is the smallest aggregation of populations diagnosable by a unique combination of character states. However, conservation also considers genetic diversity and so sub-specific units, known as Evolutionarily Significant Units, are also important. While the Gypsy moth *Lymantra dispar* became extinct in Britain around 1907, a different genetic variety, from Asia, became a pest in Britain in 1995. Thus we have two extremes, an ultimate rarity and an abundant competitor with humans.

Although estimates of the number of insects are crude, there have been some attempts. Some early estimates of the number of species, or at least multicellular organisms, on earth is around 30 – 50 million. Later estimates have downscaled this figure to 10 – 12.5 million. Estimates of the number of insects range from about 2 – 10 million, with the issue still being debated as new knowledge becomes available.

1.3. Insect Survival prior to Human Impact

During the last one million years or so, the glaciers have advanced and retreated, sometimes with a reversal taking place in a matter of a few decades. Despite these changes, insects suffered very few extinctions, with populations shifting back and forth with the cold and warm fronts (Figure 2). The survival of these insects was because they were sufficiently mobile and suitable habitat was available to receive them. However, there were earlier glaciations which may have selected out less mobile or adaptable forms with the Pleistocene glaciations affecting an already well-adapted fauna.

1.4. Early Human Impact

Starting about 6000 years or so ago, humans began to extensively impact on the European landscape, opening up to the once extensive forest and changing the

hydrology. There is evidence that the early forest clearances caused increased sedimentation of rivers. Certainly these clearances led to some local extinctions. For example, 20 species of Neolithic log-inhabiting beetles no longer occur in Britain. Yet other species benefited, including those that favor warm, chalk grasslands now devoid of trees.

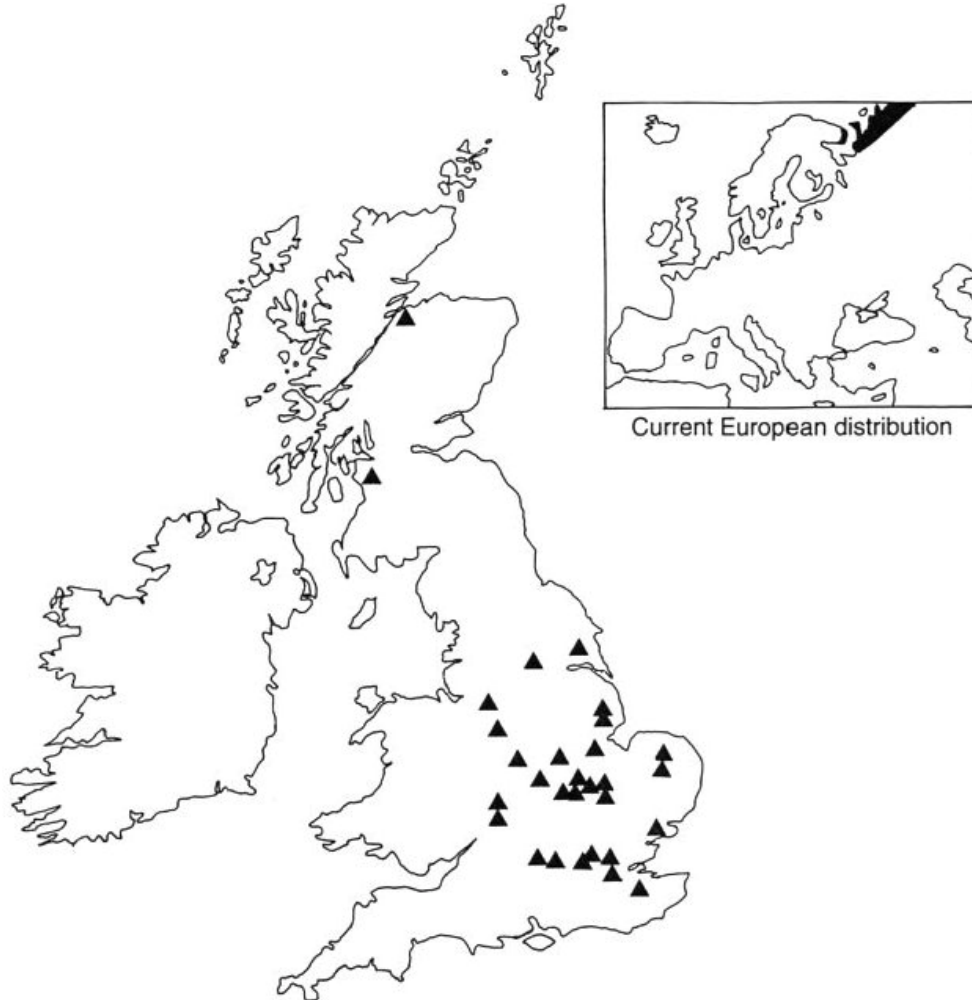


Figure 2. Fossil sites in Britain of the flightless beetle *Diacheila polita* which was common in Britain during the middle period of the last Glaciation. It did not recolonize Britain at the end of the glacial period, and today is confined to much more northerly continental areas. (Reprinted with permission from Coope, G.R. (1995) pp. 55-74 in Lawton, J.H. and May, R.M. (eds) *Extinction Rates*. Oxford University Press).

1.5. Current Extinctions

There are many estimates of extinction rates and there is no clear idea of what they currently are in insects. Estimates based on extrapolation suggest that 11 200 species of insects have gone extinct since 1600, and that possibly half a million insect species will go extinct in the next three centuries. Other estimates also suggest that the loss is dramatic, with perhaps even a quarter of all insect species under threat of imminent extinction. Most of these are in the tropical rain forests, which are home to at least half of all insect species.

1.6. Taxonomic Challenges

Possibly only 10% at most of all insects have scientific names (Figure 3). Of these, only a small fraction has been biologically studied. In short, the vast majority of insects remain unknown, and getting them described before they go extinct, is the taxonomic challenge. Yet for much meaningful conservation there is a need for named species, simply so as to know what we are dealing with. Currently, it is essential to improve taxonomic knowledge on insect groups that would truly benefit from conservation. These groups may be a whole array in a small but important area, as is being done in the Seychelles. Or it may be on one group across a wide geographical area, such as dragonflies across the whole African continent. There is another side to the taxonomic challenge, which involves not just describing new species, but making available user-friendly keys that can be used by conservation practitioners who may be non-specialists. Other identification aids are also coming into being, such as computer recognition of specimens.



Figure 3. Probably today still less than 10% of all insect species have scientific names.

1.7. Perception Challenges

While many people are very fond of colorful butterflies that visit flowers, few have a similar affinity for cockroaches, the word ‘cockroach’ even being used in disrespect (Figure 4). The challenge is that humans are historically tuned to seeing insects at large as conveyors of disease, and irritants at least. Yet all organisms have the right to live, and this includes the vast majority of insects that neither impact on humans nor are even for a moment in the collective conscience of humankind.



Figure 4. One of the greatest tasks facing insect conservation is overcoming the ‘perception challenge’, where most people find many insects as repugnant or a nuisance and unworthy subjects for conservation action.

Without doubt, one meaningful and effective way forward is focus conservation on icons and flagships, such as large colorful butterflies and dragonflies, that can ‘speak for’ other, more cryptic insect components. This approach of course does not stand in isolation but is complementary to conserving habitats.

2. Insects and Ecosystem Processes

2.1. Insects as Keystone Organisms

While insects are important conservation subjects in their own right, they have another feature that is important to conservation biology in a way that many other organisms are not. By virtue of their huge abundance and great variety, insects are major players in many ecosystem processes. They chew leaves and logs, suck nectar, pollinate flowers, bury dung, engineer the soil and transmit diseases. They also eat and parasitize each other, and then they die, returning nutrients to the soil. They thus perform keystone roles and largely maintain terrestrial ecosystems in the form that would be radically different in a matter of weeks without them.

2.2. Insect Ecosystem Engineers

Some insects have a large impact on soils, especially in arid areas. The Funnel ant *Aphaenogaster longiceps* in Australia can move some 80% of the soil to the surface that is moved by all soil fauna combined. Termites are also important engineers (Figure 5), and in West Africa, their nests can even cover almost a tenth of the land surface. Termites also influence the global carbon cycle and in tropical forests they can produce

1.5% of carbon dioxide and 15% of methane produced from all sources. The action of termites can be so extensive that they can influence plant communities.



Figure 5. Termites are ecological engineers modifying the shape of the land. They also play an enormous role in ecosystem functioning, and many in this regard are ‘keystone species’. Here termite mounds look almost like a village, and remain unscathed from a winter fire that has passed across the African Savanna.

2.3. Insects as Food

Insects are a major prey item for many vertebrates, which is not surprising when one considers that in temperate North America, their fresh weight can be 450 kg ha^{-1} , about 30x that of humans in the same area. Indeed it is the loss of some of the insect food items that has been implicated in the decline of European birds. There are similar impacts on bats, with their decline being associated with intensification of agriculture and consequent loss of nocturnal insects. In the Seychelles, the highly threatened Seychelles magpie robin ironically owes its continued tenuous survival to an invading small cockroach that is very much to its liking.

2.4. Insect Pollinators

It is conceptually interesting that evolution has driven flowers to be so diverse and complex, yet leaves so uniform and conservative. The driving force for such flower diversity has been the mutualism between specialist insect and specialist flower. The point is that today many flowering plants are threatened because their pollinators have disappeared giving rise to the oxymoron that some plants are the ‘living dead’. Additionally, many crop plants are under threat because their wild pollinators are in decline.

2.5. Insect Interactions with Plants

Plants are massive and species-poor in comparison with insects which are small and species rich. This means that many insect species are feeding on few plants. Some of these insects can be so abundant that they transfer several times the amount of energy as the vertebrates in the same area. Additionally, grasshoppers can fast cycle nutrients as their frass is so soft and friable compared to that of vertebrates (Figure 6).



Figure 6. Grasshoppers can consume nearly a fifth of the above-ground standing crop of savanna grass, and their soft faeces, known as frass, play a major role in returning nutrients to the soil.

Insects can be so numerous and have such impact that they can actually determine plant succession. This may not be just through impact on the leaves but also on seeds and roots. Nevertheless, the fate of plants can also determine that of insects, with five Hawaiian moth species going extinct as a result of plant extinctions. The upshot is that as more evidence accumulates, insect diversity conservation is heavily contingent upon plant conservation, especially through maintaining a whole range of plant communities and all their natural biotic and abiotic interactions. What is concerning is that computer models suggest that if there is a loss of even a small number (tenth or even twentieth) of important, keystone members of food webs, this can radically change ecosystem function, sometimes termed a ‘catastrophic regime shift’.

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Biographical Sketch

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