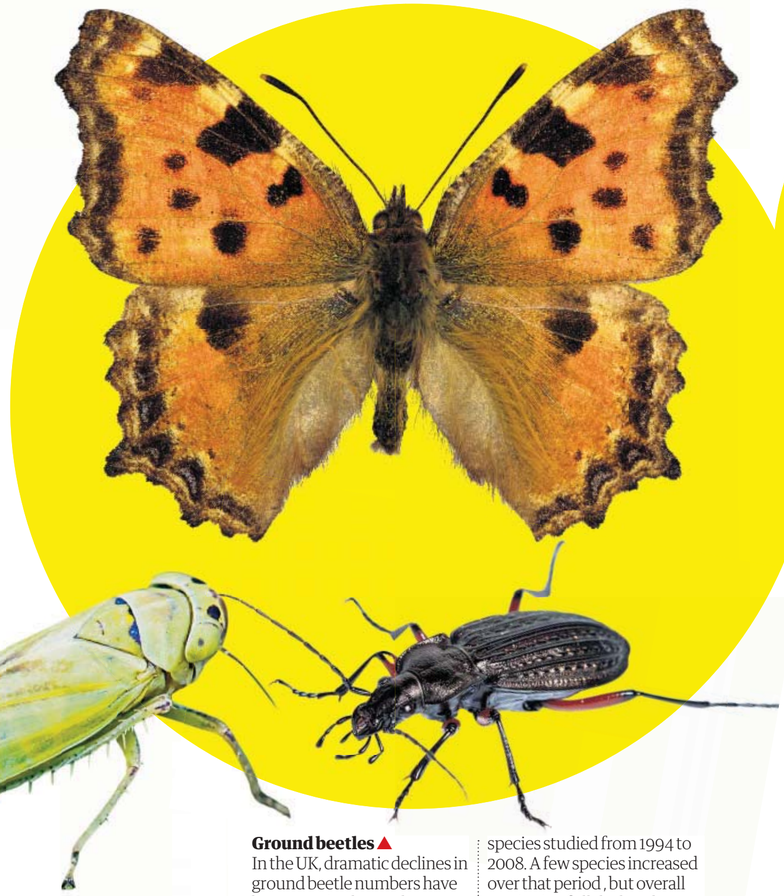
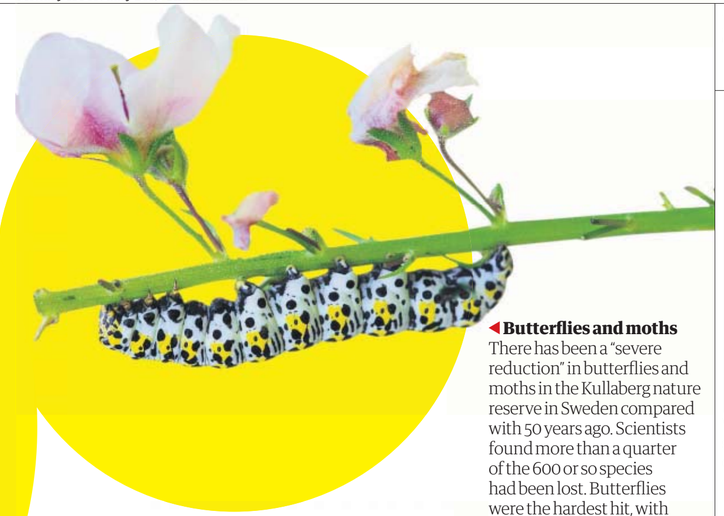
Dragonflies ▲
Red dragonfly populations have fallen sharply in Japan since the mid-1990s. Scientists have linked this to the use of insecticides in rice paddies, which stop the water-living nymphs emerging into adults. In the US, recent surveys across California and Nevada found 65% of dragonflies and damselflies had declined in the 100 years since 1914.



Leafhoppers ▶
Leafhoppers and planthoppers often make up a large proportion of the flying insects in European grasslands. But scientists found their numbers in Germany had plunged 66% in the 50 years to 2010. Soil acidification, partly due to heavy fertiliser use, was identified as the main cause.

Ground beetles ▲
In the UK, dramatic declines in ground beetle numbers have been seen in almost three-quarters of the 68 carabid species studied from 1994 to 2008. A few species increased over that period, but overall one in six of all the beetle species disappeared.



◀ Butterflies and moths
There has been a "severe reduction" in butterflies and moths in the Kullaberg nature reserve in Sweden compared with 50 years ago. Scientists found more than a quarter of the 600 or so species had been lost. Butterflies were the hardest hit, with almost half of all species disappearing, including the large tortoiseshell and scarce copper. In England, two-thirds of 340 moth species declined between 1968 and 2003.

Bumblebees ▶
Museum records enabled scientists to assess the fate of 16 species of bumblebees in the US midwest from 1900 to 2007. They found four had died out, while eight were declining in number. They blamed intensive agriculture and pesticides.

Catastrophic insect decline 'risks a total collapse in global ecosystems'

Continued *from page 1*

was "shocking", Sánchez-Bayo told the Guardian. "It is very rapid. In 10 years you will have a quarter less, in 50 years only half left and in 100 years you will have none."

One of the biggest impacts of insect loss is on the many birds, reptiles, amphibians and fish that eat them. "If this food source is taken away, all these animals starve to death," he said. Such cascading effects have already been seen in Puerto Rico, where a recent study revealed a 98% decline in ground insects over the past 35 years.

The new analysis selected the 73 best studies carried out to date to assess insects' decline. Butterflies and moths are among the worst hit. For example, the number of widespread butterfly species fell 58% on farmed land in England between 2000 and 2009. Britain has suffered the biggest recorded drop in insects overall, though that is probably a result of being more intensely studied than most places.

Bees have also been seriously affected, with only half of the bumblebee species found in the US state of Oklahoma in 1949 being present in 2013. There were 6m honeybee colonies recorded in the US in 1947, but 3.5m have since been lost.

There are more than 350,000 species of beetle and many are thought to have declined, especially dung beetles. But there are also big gaps in knowledge, with very little known about many flies, ants, aphids, shield bugs and crickets. Experts say there is no reason to think they are faring any better than the studied species.

A small number of adaptable species are increasing in number, but not nearly enough to outweigh the big losses elsewhere. "There are always some species that take advantage of vacuum left by the extinction of other species," said Sánchez-Bayo. In the US, the common eastern bumblebee is increasing thanks to its greater tolerance of pesticides.

Most of the studies analysed were carried out in western Europe and the US, with a few ranging from Australia to China and Brazil to South Africa, but very few exist elsewhere.

"The main cause of the decline is agricultural intensification," said Sánchez-Bayo.

"That means the elimination of all trees and shrubs that normally surround the fields, so there are plain, bare fields that are treated with synthetic fertilisers and pesticides."

The demise of insects appeared to have started at the dawn of the 20th century, accelerated during the 1950s and 1960s, and reached "alarming proportions" over the last two decades.

Species in decline

2.5%
The annual fall in the mass of insects, over the last 25-30 years, suggesting they could vanish within a century

98%
The decline in the number of ground insects in Puerto Rico over the last 35 years, according to a recent study

3.5m
The fall in the number of US honeybee colonies since 1947, when there were 6m. Bumblebee species have halved

Sánchez-Bayo thinks new classes of insecticides introduced in the last 20 years, including neonicotinoids and fipronil, have been particularly damaging as they are used routinely and persist in the environment: "They sterilise the soil, killing all the grubs." This has effects even in nature reserves nearby: the 75% insect losses recorded in Germany were in protected areas.

The world must change the way it produces food, Sánchez-Bayo said, noting that organic farms had more insects and that occasional pesticide use in the past did not cause the level of decline seen in recent decades. "Industrial-scale, intensive agriculture is the one [factor] that is killing the ecosystems," he said.

In the tropics, where industrial agriculture is often not yet present, rising temperatures due to climate change are thought to be a significant factor in the decline. Species there are adapted to stable conditions with little ability to change, as seen in Puerto Rico.

> *'Love or loathe them, humans can't survive without insects'*
>
> **Prof Dave Goulson**
> *Sussex University*

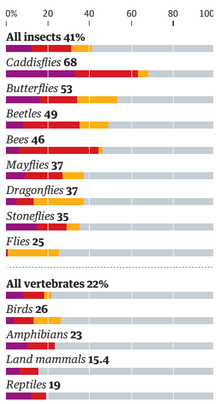
Sánchez-Bayo said the unusually strong language used in the review was not alarmist. "We wanted to really wake people up," he said, and the reviewers and editor agreed. "When you consider 80% of biomass of insects has disappeared in 25-30 years, it is a big concern."

Other scientists agree that it is becoming clear that insect losses are now a serious global problem. "The evidence all points in the same direction," said Prof Dave Goulson at Sussex University. "It should be of huge concern to all of us, for insects are at the heart of every food web, they pollinate the large majority of plant species, keep the soil healthy, recycle nutrients, control pests and much more.

"Love them or loathe them, we humans cannot survive without insects," he said.

Matt Shardlow, at the conservation charity Buglife, said: "It is gravely sobering to see this collation of evidence that demonstrates the pitiful state of the world's insect populations. It is increasingly obvious that the planet's ecology is breaking and there is a need for an intense and global effort to halt and reverse these dreadful trends." In his opinion, the review slightly overemphasises the role of pesticides and underplays global warming, though other unstudied factors such as light pollution might prove to be significant.

Insect species have declined by 41% globally over the past decade



Source: Sánchez-Bayo & Wyckhuys, Biological Conservation, 2019

Prof Paul Ehrlich, at Stanford University, California, has seen insects vanish first-hand through his work on checkerspot butterflies on Stanford's Jasper Ridge nature reserve. He first studied them in 1960 but they had all gone by 2000, largely as a result of climate change.

He praised the review, saying: "It is extraordinary to have gone through all those studies and analysed them as well as they have."

Ehrlich said the particularly large declines in aquatic insects were striking. "But they don't mention that it is human overpopulation and overconsumption that is driving all the things [eradicating insects], including climate change," he said.

Sánchez-Bayo said he had recently witnessed an insect crash himself. A recent family holiday involved a 400-mile drive across rural Australia, but he had not once had to clean the windscreen, he said. "Years ago you had to do this constantly."

What is the sixth mass extinction?
Many scientists think the current worldwide annihilation of wildlife is the beginning of a huge loss of species on Earth. It has happened five times before over the past 4bn years, due to meteorite impacts, long ice ages and huge volcanic eruptions. But this one is the result not of natural causes but of humanity's actions.

How bad is it?
Extremely. By some measures, the biodiversity crisis is even more profound than that of climate change. Since the dawn of civilisation, humanity has caused the loss of 83% of all wild mammals. In the past 50 years alone, the populations of all mammals, birds, reptiles and fish have fallen by an average of 60%.

What about insects?
The new global review indicates it's even worse for bugs, with the proportion of insect species declining being double that for vertebrates. The insect decline is at least a century old, but seems to have accelerated in recent decades.

Does that matter?

Yes. There are more than 1m species of insects, compared with just 5,400 species of mammals, and they are the cornerstone of all terrestrial ecosystems. Without insects, there is what scientists term a "bottom-up trophic cascade", in which the knock-on effects of the insect collapse surge up through the food chain, wiping out animals higher up. And without healthy ecosystems, there can be no clean air or water.

Why are we only noticing the collapse of insect populations now?
The relative lack of insects squashed on car windscreens after a drive in the countryside, compared with a few decades ago, is real. But hard scientific data requires careful and long-term research, and relatively little has been done. Insects are small and often hard to identify, and they are less charismatic than elephants or eagles, for example. Worse, just when we need more information, researchers say entomology courses are being cut.

What can be done?

Protecting remaining wild spaces is important, as is reducing the impact of agro-industrial farming. Fighting climate change is also vital, particularly for the many insect species in the tropics. So demanding political action, not eating so much intensively farmed meat and dairy products, and flying less will all help.

Damian Carrington