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Look at those feet

Scientists classify all living things into different groups, or phyla, according to their shared features. Insects belong to the group called 'arthropods', which means 'jointed feet'. Other members of the arthropod group include spiders, crabs, scorpions and centipedes.

You can find arthropods everywhere, in the soil, in the sea and in the air. All arthropods are invertebrates which means that, unlike us, they do not have internal skeletons. Instead they have a hard exoskelton, or 'outside skeleton'. Their legs are tubes of tough material called chitin. They are moved by muscles inside.

You can tell whether or not an arthropod is an insect by counting its legs. Insects have three pairs of legs. Spiders belong to the arachnids and have four pairs of legs. Crabs and lobsters are crustaceans, which have five pairs. Millipedes trundle around on as many as three hundred pairs of legs. Centipedes can have as few as fifteen, plus a pair of poison fangs.

Meet the relatives

Insects have been around for 400 million years. They have adapted to live in almost every kind of habitat.

Through the process of natural selection, many types of insects have evolved. This means that the organisms that survive are the ones best adapted to their habitat. When you compare insect species you find that they all have the same basic features: a head, thorax, abdomen and six legs. In other ways they are amazingly diverse. Here are some of the types of insects that scientists have identified, along with their scientific names.

Familiar insects that are found in Britain include beetles (Coleoptera), earwigs (Dermaptera), flies (Diptera), ants, bees and wasps (Hymenoptera), and butterflies and moths (Lepidoptera). You will need to go to ponds and streams to find dragonflies and damselflies (Odonata). Grasshoppers and crickets (Orthoptera) prefer long grasses and hedgerows.

Insects that are common in countries with hotter climates include mantises (Mantodea), ant lions (Neuroptera) and stick insects (Phasmida).

Seeing it their way

How do insects see? Some insects perceive light through their skin. Others have simple eyes with a clear lens that focuses light on to light-sensitive cells connected to nerve cells in the brain. Many insects have compound eyes which are divided into lots of separate facets. A house-fly's eyes can have 4,000 facets. Butterflies and moths have up to 17,000 and dragonflies have as many as 28,000. The more facets, the sharper the image.

What does an insect see through compound eyes? It may be a mosaic of light and dark dots, like black-and-white photographs in old newspapers. Compound eyes are so good at detecting movement that insects can fly fast through thick vegetation. Bees can see colours and ultra-violet. We can see the coloured flowers, but not the ultra-violet patterns that attract bees to some flowers containing nectar.

Masters of disguise

Birds, mammals, fish and other animals feed on insects. To avoid becoming an easy meal, insects have developed a whole range of survival methods.

'Protective resemblance' is when an insect can make itself hard to spot, or resemble something that is not very tasty. Stick insects and mantises can imitate dry twigs. Many moths are camouflaged so that they are difficult to see in their usual habitat during daylight. Peppered moths have wings the same colour and pattern as a patch of lichen. When the Indian leaf butterfly closes its wings they look like unappetising dead leaves.

Some insects defend themselves by mimicking other species. For example, a hornet moth has no sting, but because it looks like a fierce hornet predators avoid eating it. Hoverflies have evolved to resemble wasps. You have to look closely to tell them apart.

Insect sex lives

Some insects find it advantageous to camouflage themselves from predators.

But then, how do they find a mate? They rely on factors like size, strength, smell and colour. Male insects are often larger than females. Female glow-worms use light to attract the males. The light is generated by bioluminescent organs in the glow-worm's abdomen.

Many insects have a highly developed sense of smell. Some female moths cannot fly, but they emit an attractive scent or pheromone. This enables the male moths to find them.

Grasshoppers and crickets live hidden in long grasses, so they use sound to communicate. Some 'sing' by scraping their hind legs against their wings. They 'listen' with a thin membrane on their legs or in their abdomen. Not all insect sounds can be heard by humans. The male fruit fly produces a 'love song' that can only be recognised by a female fly of the same species.

Once they have found a potential mate insects often perform an elaborate courtship ritual. Sometimes the partners stroke each other with their legs or antennae.

Wonder wings

Butterflies often have colourful wings that make them easy to spot in flight. Their wings look silky smooth, but when you magnify them you may see that they are covered in little scales like overlapping tiles. Lepidoptera is the scientific name for butterflies and moths. It means 'scaly wing'.

Some of the scales are coloured. Others have minute ridges that reflect the light. The wing patterns are often bright on the upper side but dull underneath, so that the butterfly is camouflaged while it rests with folded wings.

Some butterflies have spots like eyes on their wings, perhaps to frighten off a bird or make it peck the wing but not the head. Brilliant colours or complex patterns may help to confuse predators or attract a mate.

Under a microscope, you can examine the thousands of facets that make up a butterfly's compound eye. Or you can see the delicate structure of its antennae which can detect the scents of plants and other butterflies in the air.

Shape changers

After we are born, we keep the same body form all our lives. Insects take different shapes. This process is called metamorphosis which means 'shape changing'. It enables insects to survive cold and lack of food.

Butterflies undergo complete metamorphosis. They lay their eggs on, or near, their food plant. When the eggs hatch, caterpillars often eat their egg followed by the plant's leaves until they are fully grown, when their skin hardens. Inside this protective case, the soft tissue changes into a butterfly. This is the pupal stage. The butterfly breaks out of its casing to feed or reproduce.

Dragonflies undergo incomplete metamorphosis. A dragonfly nymph hatches from an egg and changes into an adult without the pupal stage.

Arachnids

Arachnids are a class of arthropods that includes spiders, scorpions, ticks and mites.

They have four pairs of walking legs, rather than the three pairs insects have. Arachnids may also have a front pair of limbs adapted for defence or a sensory function.

1 - Tarantula

Probably *Pamphobeteus* species South America

Spiders are the most familiar of the arachnids, although few of us will encounter specimens as large as this one. Their front pair of limbs, known as pedipalps, is used for feeling and grasping prey.

2 - Tailless whip-scorpion

Found in tropical regions worldwide

The arachnids also include more unusual species like the tailless whip-scorpion, also known as a whip-spider.

3 - Scorpion

Found on all continents except Antarctica

Scorpions use their powerful claws and venomous sting to capture prey. Chemicals in their exoskeletons cause scorpions to glow when viewed under ultraviolet light.

Horseshoe crabs

Despite their name, horseshoe crabs are not a type of crab. They are related to spiders, and are the closest living relatives of the extinct trilobites.

4 - Atlantic horseshoe crab

Limulus polyphemus Found in the Gulf of Mexico

Unusually, the blood of horseshoe crabs is bright blue. This is because it contains copper. Human blood is red because it contains iron. Horseshoe crab blood has other unusual properties that make it useful in medical research.

Crustaceans

This group contains some familiar animals like crabs, lobsters, shrimp and woodlice.

Most crustaceans live in water, where they are as numerous and successful as the insects are on land.

5 - Harbour crab

Liocarcinus depurator Found widely, including the Atlantic Ocean and Mediterranean

6 - Velvet swimming crab

Necora puber Found in Dawlish

Crabs have five pairs of legs. They are adapted for walking, swimming, feeding and sensing. They also have branched limbs with gills for breathing.

Earwigs

Order: Dermaptera Approximately 1,800 species

Earwigs use the pincers at the end of their abdomens to defend themselves. Most earwigs have thin skin-like wings which they keep folded under their elytra, or wing covers. The name Dermaptera means 'skin wings'.

In many species, female earwigs will care for their young once they have hatched. Such care of offspring by the parents is unusual in the insect world.

Cockroaches

Order: Blattodea Approximately 4,000 species

Cockroaches have quite flat, oval-shaped bodies. Some have wings and are able to fly. Female cockroaches lay their eggs in cases, called oothecas.

Cockroaches have gained a reputation as a pest. This is because many adapt easily to new environments. They prefer the warm, food-rich habitats provided by our homes. Who can blame them?

In fact very few species associate with people. Those that are pests often live in very large groups.

Butterflies and moths

Order: Lepidoptera Over 120,000 species

Butterflies and moths have two pairs of wings which are often brightly coloured with attractive patterns. The name Lepidoptera comes from Greek and means 'scaly wing'. It is the scales which give rise to the colourful patterns.

To tell the difference between a moth and a butterfly you must look at the antennae. Almost all butterflies have thin antennae with a small ball or club at the end. Moths do not have this ball. Their antennae can be thin and straight, or even look like a feather.

Praying mantids

Order: Mantodea Approximately 2,200 species

Praying mantids have a triangular head with large eyes which give them excellent sight.

When searching for food they wait motionless. They strike a pose as if they are praying and this is how they got their unusual name. Really, they are waiting to pounce on prey as it passes by. They are even able to catch flying insects with their sharp, spiny front legs.

Female praying mantids lay their eggs in a foamy mass called an ootheca. They can attach this to walls and trees. Sometimes the female will eat the male once she has mated with him.

True flies

Order: Diptera Approximately 100,000 species

Diptera comes from Greek and means 'two wings'. All true flies have just one pair of wings. What were once hind wings have evolved into halteres. These are tiny peg-like structures that keep flies balanced in flight.

Many flies benefit humans. They pollinate our crops and help to recycle decaying plant and animal matter. However, flies can also transmit diseases, damage plants and even feed on the blood of living animals.

Stick and leaf insects

Order: Phasmida Approximately 2,700 species

Stick and leaf insects are experts at camouflage. Their bodies look just like leaves, twigs, bark or even the forest floor. Some use bright warning colours to deter predators from eating them, while others are able to spray chemicals.

Only some species of stick and leaf insect have wings. In some cases only the males have wings and they are capable of a fluttering flight.

Females that are carrying eggs are usually too heavy to fly. They use their wings to glide to the ground if they fall from the trees.

Lacewings, antlions and others

Order: Neuroptera Approximately 5,000 species

Insects in this order are often known as 'net-wings'. They have many tiny veins in their wings which makes them look like stitched fabric, lace or net.

Neuropteran insects have large eyes and biting mouthparts. Some feed on pollen, whereas others can capture insect prey whilst in flight.

Grasshoppers, crickets and others

Order: Orthoptera Approximately 20,000 species

Crickets and grasshoppers make sound by rubbing their long hind legs against their wings, or by rubbing their wings together. They also use their long legs for leaping. The mole cricket has short hind legs but powerful front legs for burrowing underground.

Most crickets and grasshoppers are vegetarian, though some will also feed on small insects. One particularly large species of bush cricket has spiny front legs which it uses to capture its prey, including other crickets.

Dragonflies and damselflies

Order: Odonata Approximately 5,000 species

Adult dragonflies and damselflies are expert fliers. They can hover, catch prey and even mate whilst in the air. Dragonflies are the only insects which can fly backwards.

Odonata were around at the time of the dinosaurs, when their wing span was as much as 70cm. Today they are much smaller.

Dragonflies and damselflies often have vivid, metallic colouration. They are quite a sight on a summer's day by a river as they glint in the sun.

Beetles

Order: Coleoptera Approximately 300,000 species

Beetles are characterised by hardened wing cases, called elytra. These are not used for flight, butform a hard shield to protect the folded wings underneath. Elytra are often brightly coloured.

Beetles are the most diverse insect order with the greatest number of species. They are found on land and in freshwater environments.

Coleoptera come in an enormous variety of colours, shapes and sizes. The goliath beetle is possibly the largest insect in the world.

True bugs

Order: Hemiptera Up to 80,000 species

Although the name 'bug' is often used for many different creepy crawlies, Hemiptera are the only insects that can correctly be called bugs. Many have evolved sucking mouthparts which pierce the skin of plants and animals.

Bugs are found on land and in freshwater, varying in size from minute to those large enough to catch frogs and fish. Many species of bug are considered plant pests and some can transmit diseases.

Ants, bees and wasps

Order: Hymenoptera Approximately 100,000 species

Many ants, bees and wasps are very social. They live in huge colonies of sterile female workers with one reproductive queen. Males are only produced occasionally. In many species the female insects are able to sting.

Lots of wasps hunt prey or else they parasitise other animals and plants, in other words they obtain their food by living in or on another species. Most flowering plants need bees and wasps to pollinate them, and farmers rely on the honey bee to pollinate their crops.

Stick insects

Order: Phasmida

Stick insects shed their skin in order to grow. Each leg and antenna must be carefully pulled out from the old skin. Even the skin over their eyes is shed. Sometimes the old skin looks just like the living creature. Stick insect life cycles can take just a few months to complete, in other species it takes several years.

1-4 - Indian stick insect

Carausius species Collected in the Balkans

1 Eggs

2 Adult

3 Shed skin

4 Nymphs

Beetles

Order: Coleoptera

All beetles pass through larval and pupal stages during development. Large species such as the goliath beetle may spend many months as a pupa before emerging. It's believed that the underground pupae of scarab beetles influenced ancient Egyptian beliefs in rebirth.

5 - Scarab beetle pupa

From Guyana

Scarab beetle pupae are protected inside a 'pupal cell'. This cell is made from leaves and mud which are glued together by the beetle larva to form an egg-shaped capsule, similar to the silk moth caterpillar spinning its cocoon. The fully grown adult beetle will emerge from the cell.

Praying mantids

Order: Mantodea

Female mantids lay their eggs in foamy cases called oothecas. The nymphs that hatch from them shed their skin in order to grow. Only when the nymphs have completed their final moult and become adult, will they have working wings.

6-7- Praying mantid

Collected in the Balkans

6 Ootheca (egg case)

7 Nymphs

Butterflies and moths

Order: Lepidoptera

Butterflies and moths undergo complete metamorphosis. The larva, or caterpillar, sheds its skin several times as it grows and then becomes a pupa. In the pupal stage the larva becomes an adult.

8-10 - Death's head hawkmoth

Acherontia atropos Collected in Norfolk

This moth is a rare visitor to the British Isles. Its name comes from the skull-shaped marking on the adult's thorax. The larvae feed on potato leaves.

8 Larva (caterpillar)

9 Pupa

10 Adult

Atlas moth

Attacus atlas Occurs in South East Asia

The atlas moth is one of the largest species of moth in the world. It is a type of silk moth. The larva creates a cocoon from broken strands of silk to protect itself while in the pupal stage. These cocoons are used by humans to make fagara silk. Adult moths do not have mouthparts and so do not feed at all during their two-week lifespan

11 Eggs

12 Pupa

13 Silken cocoon

14 Adult

Leaves and twigs?

Insects often use camouflage to make them difficult for predators to see. Many mimic the appearance of a plant. Some species of butterfly look just like a leaf when their wings are closed. The shape of the violin beetle resembles a seed pod.

- 1-3 Indian oakleaf-butterfly
- 4-5 Eared commodore butterfly
- 6-7 Comma butterfly
- 8-10 Leaf-mimic butterfly
- 11 Leaf mantis
- 12 Wandering violin-mantis
- 13 Giant devil's-flower-mantis
- 14-15 Stick insect
- 16 Aztec katydid
- 17 Violin beetle

18-19 Peppered moth

This moth exists in two forms. The pale one is more common in unpolluted areas. It is camouflaged against lichen-covered tree bark. In industrial areas, where tree bark is much darker and there is less lichen, the melanistic, or dark, form is better able to hide from predators.

Warning colours

Instead of trying to hide, some insects have bright red, orange or yellow stripes. The orange and black markings of the viceroy and monarch butterflies warn predators that they contain poisonous chemicals and have a foul taste. The black and yellow markings of bees and wasps are a warning that they can sting.

20 Monarch butterfly

- 21 Viceroy butterfly
- 22 Tree wasp
- 23 Bumblebee
- 24 Hornet

Only pretending

Insects also use warning colours even if they are not harmful at all. Some flies and butterflies mimic the colouring of bees and wasps.

This tricks predators into thinking that they are also able to sting.

25 Narrow-bordered bee-hawkmoth

26 Hornet moth

27-28 Hoverfly

29 Narcissus fly

30-31 Elephant hawkmoth

An elephant hawkmoth caterpillar would make a tasty snack for a foraging bird. However, it has alarming eye spots. By rearing up and retracting its head the caterpillar tricks the bird into thinking it is a snake.

RAMM's butterfly collection

RAMM's butterfly collection comes from all over the world. Look closely at this selection of specimens and see if you can find the following:

Eye spots

Many butterflies have eye-shaped markings on their wings which can alarm or confuse predators.

Can you find the owl butterfly? It has enormous yellow eye spots on the underside of its wings. Do you think they look like an owl's eyes? A predator may be put off attacking prey with such big eyes.

The Chinese three-tailed swallowtail has 'eye spots' and 'tails' at the very end of its hind wings. Any confusion with true eyes and antennae will hopefully distract birds from pecking at more vital parts.

Clear wings

The wings of some butterflies are almost completely seethrough. They lack the dense covering of scales that give other butterflies their vivid colouring and patterns.

When they fly through dense, light-dappled forest, these delicate butterflies flit in and out of view. It makes them hard

to track. Once settled, their transparent wings allow background colours to show through and they become difficult to spot.

Iridescence

Look for the morpho butterflies. They are the large ones with metallic blue wings. If you view the butterfly from different angles can you see how the colour of the morpho's wings changes slightly. This is caused by tiny structures on the surface of the wing scales, only visible using an electron microscope.

When you see blue iridescence, only the blue light has been bent and reflected into your eyes. When the wings appear dark you are seeing the true pigmented colour of the scales.

Camouflage

Imagine that these butterflies were in the forest or meadow. Would any of them be hard to spot?

The colour and patterning on the underside of a butterfly's wings is often a form of camouflage.

It helps hide the butterfly from predators when sitting with its wings closed. A broken pattern may help conceal the butterfly against a variety of backgrounds. Some patterns camouflage under very specific conditions. The leaf butterfly is well concealed against a background of dead leaves, but provides poor protection against green leaves.

Largest species

The largest butterfly in the case is a female Queen Alexandra's birdwing. It was named in 1907 in honour of Queen Alexandra, the wife of Edward VII. They are the largest butterflies in the world. Some have a wingspan of nearly 30cm (12 inches).

The female is dull brown with a yellow body. Can you find her? The male looks very different. He is smaller and very much brighter, with blue, black, green and turquoise wings.

Owing to her size, Queen Alexandra's birdwing was much sought after, but was very rare. Today, in New Guinea, they are bred in captivity to avoid depleting wild stocks.

Insects and us

Pollinators

Bees, butterflies, and some flies, are vitally important because they pollinate flowers. Farmers' crops must be pollinated to produce seeds, nuts, fruits and vegetables.

Without the insect pollinators we would be very short of food.

Dye makers

The cochineal bug is a type of scale insect found in southern America. These bugs have been used since the time of the Aztecs to make a crimson red dye called carmine. We still use cochineal today for colouring food, fabrics and cosmetics.

Pest eaters

Ladybirds and their larvae are some of the gardener's best friends. They feed on aphids, scale insects and other small insects that damage plants.

Soil fertilisers

Dung beetles bury dung underground for their larvae to feed on. In doing so the dung is returned to the soil and acts as a fertiliser for plants.

Ouch!

Stingers

Only female ants, bees, wasps and hornets can sting. This is because the sting has evolved from the female's ovipositor, or egg-laying tube.

Wasps have a straight sting that usually comes out of human skin easily. This means they can sting us more than once.

Worker honey bees have a barbed sting that catches in human skin and cannot be removed without killing the bee.

Biters

Some insects, including the hornet and many ants, have a powerful bite as well as a painful sting. The female horsefly uses its blade-like mouthparts to pierce mammal skin and feed on their blood.

Death dealers

Disease carriers

Cockroaches have a bad reputation for being a pest. While most species live in the wild, away from humans, some species like to invade our homes and kitchens.

They are attracted to waste food, and in good conditions they breed rapidly to produce colonies of thousands. They can transmit harmful diseases.

Blowflies, like the bluebottle, can be a real nuisance and carry unpleasant disease organisms. The female usually chooses to lay her eggs on dead animals, but will equally select an uncovered dish of cooked meat if it is available.

Crop eaters

Adult female small white butterflies lay their eggs on plants in the cabbage family. These include cabbages, Brussels sprouts and broccoli. When the eggs hatch the larvae, or caterpillars, eat the leaves in enormous quantities. They are a serious pest and can destroy crops.

The desert locust has a voracious appetite for plants. It is a serious threat to crops across Asia, Africa and the Middle East. Desert locusts gather together in enormous swarms and reproduce up to five times a year.