= Grasshopper =

Grasshoppers are insects of the order Orthoptera , suborder Caelifera . They are sometimes referred to as short @-@ horned grasshoppers to distinguish them from the katydids (bush crickets) which have much longer antennae . They are typically ground @-@ dwelling insects with powerful hind legs which enable them to escape from threats by leaping vigorously . They are hemimetabolous insects (do not undergo complete metamorphosis) which hatch from an egg into a nymph or " hopper " which undergoes five moults , becoming more similar to the adult insect at each developmental stage . At high population densities and under certain environmental conditions , some grasshopper species can change colour and behaviour and form swarms . Under these circumstances they are known as locusts .

Grasshoppers are plant @-@ eaters , sometimes becoming serious pests of cereals , vegetables and pasture , especially when they swarm in their millions as locusts and destroy crops over wide areas . They protect themselves from predators by camouflage ; when detected , many species attempt to startle the predator with a brilliantly @-@ coloured wing @-@ flash while jumping and (if adult) launching themselves into the air , usually flying for only a short distance . Other species such as the rainbow grasshopper have warning coloration which deters predators . Grasshoppers are affected by parasites and various diseases , and many predatory creatures feed on both nymphs and adults . The eggs are the subject of attack by parasitoids and predators .

Grasshoppers have had a long relationship with humans . Swarms of locusts have had dramatic effects that have changed the course of history , and even in smaller numbers grasshoppers can be serious pests . They are eaten as food and also feature in art , symbolism and literature .

= = Characteristics = =

Grasshoppers have the typical insect body plan of head , thorax and abdomen . The head is held vertically , at an angle to the body with the mouth at the bottom . It bears a large pair of compound eyes which give all @-@ round vision , three simple eyes which can detect light and dark and a pair of thread @-@ like antennae which are sensitive to touch and smell . The downward @-@ directed mouthparts are modified for chewing and there are two sensory palps in front of the jaws .

The thorax and abdomen are segmented and have a rigid cuticle made up of overlapping plates composed of chitin . The three fused thoracic segments bear three pairs of legs and two pairs of wings . The forewings , known as tegmina , are narrow and leathery while the hind wings are large and membranous , the veins providing strength . The legs are terminated by claws for gripping . The hind leg is particularly powerful ; the femur is robust and has several ridges where different surfaces join and the inner ridges bear stridulatory pegs in some species . The posterior edge of the tibia bears a double row of spines and there are a pair of articulated spurs near its lower end . The interior of the thorax houses the muscles that control the limbs .

The abdomen has eleven segments , the first of which is fused to the thorax and contains the auditory organ and tympanum . Segments two to eight are ring @-@ shaped and joined by flexible membranes . Segments nine to eleven are reduced ; segment nine bears a pair of cerci and segments ten and eleven house the reproductive organs . Female grasshoppers are normally larger than males , with short ovipositors . The name " Caelifera " comes from the Latin and means chisel @-@ bearing , referring to the sharp ovipositor .

Those species that make easily heard noises usually do so by rubbing a row of pegs on the hind femurs against the edges of the forewings (stridulation) . These sounds are produced mainly by males to attract females , though in some species the females also stridulate .

Grasshoppers are easily confused with the other sub @-@ order of Orthoptera , Ensifera (crickets) , but differ in many aspects , such as the number of segments in their antennae and structure of the ovipositor , as well as the location of the tympana and modes of sound production . Ensiferans have antennae that can be much longer than the body and have at least 20 ? 24 segments , while caeliferans have fewer segments in their shorter , stouter antennae .

= = Phylogeny and evolution = =

The phylogeny of the Caelifera based on mitochondrial RNA of 32 taxa in six out of seven superfamilies is shown as a cladogram . The Ensifera , Caelifera and all the superfamilies of grasshoppers except Pamphagoidea appear to be monophyletic .

In evolutionary terms , the split between the Caelifera and the Ensifera is no more recent than the Permo @-@ Triassic boundary ; the earliest insects that are certainly Caeliferans are in the extinct families Locustopseidae and Locustavidae from the early Triassic . The group diversified during the Triassic and have remained important plant @-@ eaters from that time to now . The first modern families such as the Eumastacidae , Tetrigidae and Tridactylidae appeared in the Cretaceous , though some insects that might belong to the last two of these groups are found in the early Jurassic . Morphological classification is difficult because many taxa have converged towards a common habitat type ; recent taxonomists have concentrated on the internal genitalia , especially those of the male . This information is not available from fossil specimens , and the palaentological taxonomy is founded principally on the venation of the hindwings .

= = Diversity and range = =

The Caelifera includes some 2 @,@ 400 valid genera and about 11 @,@ 000 species . Many undescribed species probably exist , especially in tropical wet forests . The Caelifera have a predominantly tropical distribution with fewer species known from temperate zones , but most of the superfamilies have representatives worldwide . They are almost exclusively herbivorous and are probably the oldest living group of chewing herbivorous insects .

= = Biology = =

= = = Diet and digestion = = =

Most grasshoppers are polyphagous , eating vegetation from multiple plant sources , but some are omnivorous and also eat animal tissue and animal faeces . In general their preference is for grasses , including many cereals grown as crops . The mandibles chew the food slightly and salivary glands in the buccal cavity chemically begin to digest the carbohydrates present in it . The food is then passed via the oesophagus to the crop where it is stored temporarily and chemical digestion continues . Next it moves to the gizzard which has muscular walls and tooth @-@ like plates which grind the food . From here , food enters the stomach , where six hepatic caeca add further enzymes and digestion is completed . At the junction between mid and hind @-@ gut , several fine tubes known as malpighian tubules add the excretory products (uric acid , urea and amino acids) to the contents of the gut . Absorption of nutrients takes place in the ileum and any undigested residue is passed on to the colon . Here water is absorbed and the residue becomes solid . After storage in the rectum , the faeces are expelled as small dry pellets .

= = = Sensory organs = = =

Grasshoppers have a typical insect nervous system , and have an extensive set of external sense organs . On the side of the head are a pair of large compound eyes which give a broad field of vision and can detect movement , shape , colour and distance . There are also three simple eyes (ocelli) on the forehead which can detect light intensity , a pair of antennae containing olfactory (smell) and touch receptors , and mouthparts containing gustatory (taste) receptors . At the front end of the abdomen there is a pair of tympanal organs for sound reception . There are numerous fine hairs covering the whole body that act as mechanoreceptors (touch and wind sensors) , and these are most dense on the antennae , the palps (part of the mouth) , and on the cerci at the tip of the abdomen . There are special receptors (campaniform sensillae) embedded in the cuticle of the

legs that sense pressure and cuticle distortion . There are internal " chordotonal " sense organs specialized to detect position and movement about the joints of the exoskeleton . The receptors convey information to the central nervous system through sensory neurons , and most of these have their cell bodies located in the periphery near the receptor site itself .

= = = Circulation and respiration = = =

Like other insects , grasshoppers have an open circulatory system and their body cavities are filled with haemolymph . A heart @-@ like structure pumps the fluid to the head from where it percolates past the tissues and organs on its way back to the abdomen . It circulates nutrients throughout the body and carries metabolic wastes to be excreted into the gut . The haemolymph and the circulatory system are not involved in gaseous exchange . Respiration is performed using tracheae , air @-@ filled tubes , which open at the surfaces of the thorax and abdomen through pairs of valved spiracles . Larger insects may need to actively ventilate their bodies by opening some spiracles while others remain closed , using abdominal muscles to expand and contract the body and pump air through the system .

= = = Jumping = = =

A large grasshopper such as a locust can jump about a metre (twenty body lengths) without using its wings ; the acceleration peaks at about 20 g . Grasshoppers jump by extending their large back legs and pushing against the substrate (the ground , a twig , a blade of grass or whatever else they are standing on) ; the reaction force propels them into the air . They jump for several reasons ; to escape from a predator , to launch themselves for flight , or simply to move from place to place . For the escape jump in particular there is strong selective pressure to maximize take @-@ off velocity , since this determines the range . This means that the legs must thrust against the ground with both high force and a high velocity of movement . However , a fundamental property of muscle is that it cannot contract with both high force and high velocity , which seems like a problem . Grasshoppers overcome this apparent contradiction by using a catapult mechanism to amplify the mechanical power produced by their muscles .

The jump is a three @-@ stage process . First , the grasshopper fully flexes the lower part of the leg (tibia) against the upper part (femur) by activating the flexor tibiae muscle (the back legs of the immature grasshopper in the top photograph are in this preparatory position) . Second , there is a period of co @-@ contraction in which force builds up in the large , pennate extensor tibiae muscle , but the tibia is kept flexed by the simultaneous contraction of the flexor tibiae muscle . The extensor muscle is much stronger than the flexor muscle , but the latter is aided by specializations in the joint that give it a large effective mechanical advantage over the former when the tibia is fully flexed . Co @-@ contraction can last for up to half a second , and during this period the extensor muscle shortens and stores elastic strain energy by distorting stiff cuticular structures in the leg . The extensor muscle contraction is quite slow (almost isometric) , which allows it to develop high force (up to 14 N in the desert locust) , but because it is slow only low power is needed . The third stage of the jump is the trigger relaxation of the flexor muscle , which releases the tibia from the flexed position . The subsequent rapid tibial extension is driven mainly by the relaxation of the elastic structures , rather than by further shortening of the extensor muscle . In this way the stiff cuticle acts like the elastic of a catapult , or the bow of a bow @-@ and @-@ arrow . Energy is put into the store at low power by slow but strong muscle contraction , and retrieved from the store at high power by rapid relaxation of the mechanical elastic structures .

= = = Lifecycle and reproduction = = =

Grasshoppers lay their eggs in pods in the ground near food plants , generally in the summer . The eggs in the pod are glued together with a froth in some species . After a few weeks of development , the eggs of most species go into diapause , and pass the winter in this state ; in a few species the

eggs hatch in the same summer they were laid . Diapause is broken by a sufficiently low ground temperature ; development resumes as soon as the ground warms above a threshold temperature . The embryos in a pod generally all hatch out within a few minutes of each other . They soon shed their membranes and their exoskeletons harden . These first instar nymphs can then jump away from predators .

Grasshoppers have incomplete metamorphosis : they repeatedly moult (undergo ecdysis) , becoming larger and more like an adult , with for instance larger wing @-@ buds , in each instar . The number of instars varies between species . At the final moult , the wings are inflated and become fully functional . The migratory grasshopper , Melanoplus sanguinipes , spends about 25 ? 30 days as a nymph depending on sex and temperature , and about 51 days as an adult .

Males stridulate , rapidly rasping the hind femur against the forewing to create a churring sound , to attract mates . Females select suitable egg @-@ laying sites , such as bare soil or near the roots of food plants according to species . Males often gather around an ovipositing female ; in some species she is mated as soon as she takes her ovipositor out of the ground . After laying the eggs , the female covers the hole with soil and litter .

= = Predators , parasites and pathogens = =

Grasshoppers have a wide range of predators at different stages of their life @-@ cycle . Eggs are eaten by bee @-@ flies , ground beetles and blister beetles . Hoppers and adults are taken by predators including other insects such as ants , robber flies and sphecid wasps ; spiders ; many birds ; and small mammals .

Parasitoids include blowflies , fleshflies , and tachinid flies . External parasites include mites . It has been found that female grasshoppers parasitised by mites produce fewer eggs and thus have fewer offspring . This is probably because the individuals concerned allocate resources in response to the parasitism which are then not available for reproduction .

Spinochordodes tellinii and Paragordius tricuspidatus are parasitic worms that infect grasshoppers and alter the behaviour of their hosts . The grasshopper is persuaded to leap into a nearby body of water where it drowns , thus enabling the parasite to continue with the next stage of its life cycle which takes place in water . The grasshopper nematode (Mermis nigrescens) is a long slender worm that infests grasshoppers , living in the insect 's hemocoel . Adult worms lay eggs on plants and the host gets infected when it eats the foliage .

Grasshoppers are affected by diseases caused by bacteria , viruses , fungi and protozoa . The bacteria Serratia marcescens and Pseudomonas aeruginosa have both been implicated in causing disease in grasshoppers , as has the entomopathogenic fungus Beauveria bassiana . This widespread fungus has been used to control various pest insects around the world , but although it infects grasshoppers , basking in the sun has the result of raising the insect 's temperature above a threshold tolerated by the fungus , and the infection is not lethal . The fungal pathogen Entomophaga grylli is able to influence the behaviour of its grasshopper host , causing it to climb to the top of a plant and cling to the stem as it dies . This ensures wide dispersal of the fungal spores liberated from the corpse .

The fungal pathogen Metarhizium acridum is found in Africa , Australia and Brazil where it has caused epizootics in grasshoppers . It is being investigated for possible use as a microbial insecticide for locust control . The microsporidian fungus Nosema locustae , once considered to be a protozoan , can be lethal to grasshoppers . It has to be consumed by mouth and is the basis for a bait @-@ based commercial microbial pesticide . Various other microsporidians and protozoans are found in the gut .

= = = Anti @-@ predator defences = = =

Grasshoppers exemplify a range of anti @-@ predator adaptations , enabling them to avoid detection , to escape if detected , and in some cases to avoid being eaten if captured . Grasshoppers are often camouflaged to avoid detection by predators that hunt by sight . Their

colouration usually resembles the background , whether green for leafy vegetation , sandy for open areas or grey for rocks . Some species can change their colouration to suit their surroundings .

Several species such as the hooded leaf grasshopper Phyllochoreia ramakrishnai (Eumastacoidea) are detailed mimics of leaves . Grasshoppers often have deimatic patterns on their wings , giving a sudden flash of bright colours that may startle predators long enough to give time to escape in a combination of jump and flight .

Some species are genuinely aposematic , having both bright warning coloration and sufficient toxicity to dissuade predators . Dictyophorus productus (Pyrgomorphidae) is a " heavy , bloated , sluggish insect " that makes no attempt to hide ; it has a bright red abdomen . A Cercopithecus monkey that ate other grasshoppers refused to eat the species . Another species , the rainbow or painted grasshopper of Arizona , Dactylotum bicolor (Acridoidea) , has been shown by experiment with a natural predator , the little striped whiptail lizard , to be aposematic .

= = Relationship with humans = =

= = = In art = = =

Grasshoppers are occasionally depicted in artworks , such as the Dutch Golden Age painter Balthasar van der Ast 's still life oil painting , Flowers in a Vase with Shells and Insects , c . 1630 , now in the National Gallery , London , though the insect may be a bush @-@ cricket .

Another orthopteran is found in Rachel Ruysch 's still life Flowers in a Vase , c . 1685 . The seemingly static scene is animated by a " grasshopper on the table that looks about ready to spring " , according to the gallery curator Betsy Wieseman , with other invertebrates including a spider , an ant , and two caterpillars .

= = = Symbolism = = =

Grasshoppers are sometimes used as symbols , as in Sir Thomas Gresham 's gilded grasshopper in Lombard Street , London , dating from 1563 ; the building was for a while the headquarters of the Guardian Royal Exchange , but the company declined to use the symbol for fear of confusion with the locust .

When grasshoppers appear in dreams , these have been interpreted as symbols of " Freedom , independence , spiritual enlightenment , inability to settle down or commit to decision " . Locusts are taken literally to mean devastation of crops in the case of farmers ; figuratively as " wicked men and women " for non @-@ farmers ; and " Extravagance , misfortune , & ephemeral happiness " by " gypsies " .

= = = As food = = =

In some countries , grasshoppers are used as food . In southern Mexico , grasshoppers , known as chapulines , are eaten in a variety of dishes , such as in tortillas with chilli sauce . Grasshoppers are served on skewers in some Chinese food markets , like the Donghuamen Night Market . Fried grasshoppers (walang goreng) are eaten in the Gunung Kidul area of Yogjakarta , Java in Indonesia . In the Arab world , grasshoppers are boiled , salted , and sun @-@ dried , and eaten as snacks . In Native America , the Ohlone people burned grassland to herd grasshoppers into pits where they could be collected as food .

It is recorded in the Bible that John the Baptist ate locusts and wild honey (Greek : ??????? ??? ???? ?????? , akrides kai meli agrion) while living in the wilderness ; attempts have been made to explain the locusts as suitably ascetic vegetarian food such as carob beans , but the plain meaning of ??????? is the insects .

= = = As pests = = =

Grasshoppers eat large quantities of foliage both as adults and during their development , and can be serious pests of arid land and prairies . Pasture , grain , forage , vegetable and other crops can be affected . Grasshoppers often bask in the sun , and thrive in warm sunny conditions , so drought stimulates an increase in grasshopper populations . A single season of drought is not normally sufficient to stimulate a massive population increase , but several successive dry seasons can do so , especially if the intervening winters are mild so that large numbers of nymphs survive . Although sunny weather stimulates growth , there needs to be an adequate food supply for the increasing grasshopper population . This means that although precipitation is needed to stimulate plant growth , prolonged periods of cloudy weather will slow nymphal development .

Grasshoppers can best be prevented from becoming pests by manipulating their environment . Shade provided by trees will discourage them and they may be prevented from moving onto developing crops by removing coarse vegetation from fallow land and field margins and discouraging luxurious growth beside ditches and on roadside verges . With increasing numbers of grasshoppers , predator numbers may increase , but this seldom happens sufficiently rapidly to have much effect on populations . Biological control is being investigated but with little success . On a small scale , neem products can be effective as a feeding deterrent and as a disruptor of nymphal development . Insecticides can be used , but adult grasshoppers are difficult to kill , and as they move into fields from surrounding rank growth , crops may soon become reinfested .

Grasshoppers , like the Chinese rice grasshopper , are a pest in rice paddies . Ploughing exposes the eggs on the surface of the field , to be destroyed by sunshine or eaten by natural enemies . Some eggs may be buried too deeply in the soil for hatching to take place .

= = = Locusts = = =

Locusts are the swarming phase of certain species of short @-@ horned grasshoppers in the family Acrididae . It has been shown that swarming behaviour is a response to overcrowding . Increased tactile stimulation of the hind legs causes an increase in levels of serotonin . This causes the grasshopper to change colour , feed more and breed faster . The transformation of a solitary individual into a swarming one is induced by several contacts per minute over a short period .

Following this transformation , under suitable conditions dense nomadic bands of flightless nymphs can occur , producing pheromones which attract them to each other . With several generations in a year , the locust population can build up from localised groups into vast accumulations of flying insects known as plagues , devouring all the vegetation they encounter . The largest recorded locust swarm was one of the now @-@ extinct Rocky Mountain locust in 1875 , which was 1 @,@ 800 miles (2 @,@ 900 km) long and 110 miles (180 km) wide .

An adult desert locust can eat about 2 g (0 @.@ 1 oz) each day so the billions of insects in a large swarm can be very destructive , stripping all the foliage from plants in an affected area and also consuming stems , flowers , fruits , seeds and bark . Locust plagues can have devastating effects on human populations , causing famines and population upheavals . They are mentioned in both the Koran and the Bible and have been held responsible for cholera epidemics , resulting from the corpses of locusts drowned in the Mediterranean Sea and decomposing on beaches .

The FAO and other organisations monitor locust activity around the world . Timely application of pesticides can prevent nomadic bands of hoppers joining together and proliferating before dense swarms of adults are built up . Besides conventional control using contact insecticides , biological pest control using the entomopathogenic fungus Metarhizium acridum which specifically infects grasshoppers has been used with some success .

= = = In literature = = =

The Egyptian word for locust or grasshopper was written sn?m in the consonantal hieroglyphic writing system . The pharaoh Ramesses II compared the armies of the Hittites to locusts : " They covered the mountains and valleys and were like locusts in their multitude . "

One of Aesop 's Fables , later retold by La Fontaine , is the tale of The Ant and the Grasshopper . The ant works hard all summer , while the grasshopper plays . In winter , the ant is ready but the grasshopper starves . Somerset Maugham 's short story " The Ant and the Grasshopper " explores the fable 's symbolism via complex framing . The Canadian philosopher Bernard Suits retells the story with the grasshopper as " the exemplification of the life most worth living . " Other human weaknesses besides improvidence have become identified with the grasshopper 's behaviour . So an unfaithful woman (hopping from man to man) is " a grasshopper " in " Poprygunya " , an 1892 short story by Anton Chekhov , and in Jerry Paris 's 1969 film The Grasshopper .

The 1957 film Beginning of the End portrayed giant grasshoppers attacking Chicago . In the 1998 film A Bug 's Life , the heroes are the members of an ant colony , and the lead villain and his henchmen are grasshoppers .

= = = In aviation = = =

The name " Grasshopper " was used for light aircraft such as the Aeronca L @-@ 3 and Piper L @-@ 4 used for reconnaissance and other support duties in World War II .