= Helicoverpa zea =

Helicoverpa zea , commonly known as the corn earworm , is a species (formerly in the genus Heliothis) in the family Noctuidae . The larva of the moth Helicoverpa zea is a major agricultural pest . Since it is polyphagous (feeds on many different plants) during the larval stage , the species has been given many different common names , including the cotton bollworm and the tomato fruitworm . It also consumes a wide variety of other crops .

The species is widely distributed across the Americas with the exception of northern Canada and Alaska . It has become resistant to many pesticides , but can be controlled with integrated pest management techniques including deep ploughing , trap crops , chemical control using mineral oil , and biological controls .

The species migrates seasonally , at night , and can be carried downwind up to 400 km . Pupae can make use of diapause to wait out adverse environmental conditions , especially at high latitudes and in drought .

= = Distribution = =

The corn earworm is found in temperate and tropical regions of North America , with the exception of northern Canada and Alaska as it cannot overwinter in these areas . Helicoverpa zea found in the eastern United States also do not overwinter successfully . They live in Kansas , Ohio , Virginia , and southern New Jersey , but survival rate is mainly affected by the severity of the winter . Corn earworm moths regularly migrate from southern regions to northern regions depending on winter conditions . They are also found in Hawaii , the Caribbean islands , and most of South America , including Peru , Argentina , and Brazil .

Cotton earworms have also been reported from China in 2002 .

= = Life cycle and Description = =

= = = Eggs = = =

Eggs are individually deposited on leaf hairs and corn silks (not in reference given) . The eggs are initially pale green in color , but over time they turn yellowish and then grey . Eggs are 0 @.@ 5 mm in height and average about 0 @.@ 55 mm in diameter . They hatch after 66 to 72 hours of development . Once larvae have breached the chorion , they spend up to 85 % of their time emerging from their shell . In this eclosion process , the larvae work to make the exit hole larger than their head . Larvae spend the rest of the time making a silk meshwork around the exit hole ; this both helps them escape the shell and helps them find the shell afterwards so they can feed on it . After feeding on their shell , larvae rest for approximately 3 minutes before they begin feeding on the plant material around them .

= = = Larvae = = =

Following hatching , larvae feed on the reproductive structures of the plant and usually develop through four to six instars . Initially , the young larva feed together , and this stage is their most destructive stage . Through maturation , older larvae become aggressive and cannibalistic , leaving one or two larvae per feeding site (See Interfamilial Predation) . They usually have orange heads , black thorax plates , and a body color that is primarily black . Their bodies can also be brown , pink , green , and yellow with many thorny microspines . Mature larvae migrate to the soil , where they pupate for 12 to 16 days .

= = = Pupae = = =

Larvae pupate 5 to 10 cm below the soil surface . Pupae are brown in color ; they measure 5 @.@ 5 mm wide and 17 to 22 mm long . The biggest environmental factor that affects the pupal developmental rate is temperature , primarily soil temperature . This is because proper insulation facilitates development , and soil temperatures below 0 degrees Celsius correlate to higher pupal mortality . Another factor that influences pupal development is soil moisture . Pupal mortality is high in wet soil , where the moisture level is between 18 and 25 percent . Dehydration can also lead to high death rates among pupae , if soil moisture is as low as 1 to 2 percent .

= = = Adults = = =

Adults have forewings that are yellowish brown in color and have a dark spot located in the center of their body . The moths have a wingspan ranging from 32 to 45mm , and live over thirty days in optimal conditions . However , the life span ranges from five to fifteen days on average . They are nocturnal and hide in vegetation during the day . Adult moths collect nectar or other plant exudates from a large number of plants , and live for 12 to 16 days . Females can lay up to 2 @,@ 500 eggs in their lifetime .

= = Economic impact = =

= = = Damage = = =

The corn earworm is a major agricultural pest , with a large host range encompassing corn and many other crop plants . Helicoverpa zea is the second most important economic pest species in North America , next to the codling moth . The estimated annual cost of the damage is more than 100 million US dollars , even though expenditure on insecticide application has reached up to 250 million dollars . The moth ? s high fecundity , ability to lay between 500 to 3 @,@ 000 eggs , polyphagous larval feeding habits , high mobility during migration , and a facultative pupal diapause have led to the success of this pest .

= = = Control = = =

Two kinds of control measures have been advocated since the 19th century . One aims at total pest population reduction , while the other is aimed at protection of the particular crop . As of 2013 integrated pest management (IPM) , an array of techniques and approaches to control pests , was recommended . Practices such as deep ploughing , mechanical destruction , and trap crops are also used to kill different instars . Chemical control is widely successful , and includes the use of applying mineral oil inside the tip of each corn ear , which suffocates the young larvae . Pesticides are one method by which corn earworm populations are controlled ; however , since they have been widely used , the insects have become resistant to many pesticides . The use of biological controls , such as the bacterium Bacillus thuringiensis and various forms of nematodes , is also common , although not without its own problems . Corn earworm moths are not always vulnerable to the bacterium , and they are only afflicted by nematodes once the larvae have pupated and dropped to the ground .

= = Survival = =

= = = Natural Enemies = = =

More than one hundred insect species prey on Helicoverpa zea , usually feeding on eggs and larvae . The insidious flower bug (Orius insidiosus) , a pirate bug , feeds on the eggs of H. zea , thus acting as a biological control agent . Some plants emit a blend of chemicals in response to damage from H. zea , which attract parasitic insects . Cardiochiles nigriceps , a solitary

endoparasitoid wasp , makes use of these volatile plant compounds to identify the presence of H. zea . When the wasp finds a damaged host plant , they hover around and then search for the host with their antennae . When the females find their prey , they use their antennae to position themselves and deposits eggs into the host . The braconid wasp Microplitis croceipes , which deposits its eggs inside a living caterpillar , is also an important parasitoid of both H. zea and the related species Heliothis virescens . When larval densities are high , a fungal pathogen , Nomuraea rileyi , can cause an outbreak of disease . However , pupal mortality is high not because of predators , but because of harsh weather conditions , collapsing pupal chambers , and disease .

= = = Larval predation = = =

As the larvae mature , they become increasingly aggressive . Although they have host plants surrounding them , Helicoverpa zea attack and eat other insects . When presented with a second instar larva of Urbanus proteus , the corn earworm larvae grasps the insect , rolls onto its side to form a semicircle , and begins feeding on the insect 's posterior end . If the U. proteus begins to bite out of defense , Helicoverpa zea rotates the larva 180 degrees and uses its mandibles to puncture the head capsule , killing the insect . Then , the H. zea larva rotates the U. proteus back to its original position and continues feeding until the insect is entirely consumed . Even when presented with up to 5 U. proteus larvae , the Helicoverpa zea engages in the unique behavior , as the larvae have a higher affinity for Lepidopterous prey over plant material . Helicoverpa zea raised in a low moisture environment have lower pupal weight and a longer developmental time than those raised in environments of high moisture , so there is a nutritional benefit to such aggressive feeding behavior under such conditions .

= = Movement = =

= = = Migration = = =

Helicoverpa zea is a seasonal , nocturnal migrant , and adults disperse , weather permitting , when there are poor reproductive conditions . In short @-@ range dispersal , the moths move within the crop and low over the foliage . This type of dispersal is mostly independent of wind currents . Long @-@ range dispersal involves adults flying up to 10 meters above the ground and moving downwind from crop to crop . Migratory flights occur up to 1 ? 2 km above the ground and can last for hours . Migration of 400 km is
common for such flights as moths are carried downwind . Helicoverpa zea caterpillars are usually intercepted on produce transported by air @-@ freight transportation . Most activity is restricted to the night @-@ time . Some moths display vertical take @-@ off flight , which carries them above the flight boundary layer and allows them to undertake migratory movement in upper wind systems . During mating , males engage in high @-@ speed directed flight in search of pheromone plumes (See Pheromone Production) .

= = = Diapause = = =

Pupae have the ability to enter facultative diapause , the state of arrested development and growth in response to a change in the environment . By preparing themselves for a major change in environmental conditions , they can increase reproductive success . Diapause increases with increasing latitude . In tropical conditions , populations breed continuously , and only 2 @-@ 4 % of pupae diapause . In subtropical and temperate regions , most individuals diapause . Individuals who don 't enter diapause in these areas emerge in late fall and die without reproducing . Drought @-@ responsive diapause has also been observed in the summer .

= = Feeding = =

= = = Host plants = = =

Helicoverpa zea has a wide host range , attacking vegetables that include corn , tomato , artichoke , asparagus , cabbage , cantaloupe , collards , cowpea , cucumber , eggplant , lettuce , lima bean , melon , okra , pea , pepper , potato , pumpkin , snap bean , spinach , squash , sweet potato , and watermelon . However , not all of these are good hosts . While corn and lettuce are shown to be great hosts , tomatoes are less beneficial , and broccoli and cantaloupe are poor hosts . Corn and sorghum are most favored by corn earworms . Various signs reveal the presence of these moths . Young maize crops have holes in their leaves , following whorl @-@ feeding on the apical leaf . Eggs can be found on silks on larger plants , and silks display grazing evidence . The soft , milky grains in the top few centimeters of corn cobs are eaten as the corn ears develop . One larva per cob can be observed . Bore holes are observed in cabbage and lettuce hearts , flower heads , cotton bolls , and tomato fruits . Sorghum heads are grazed , and legume pod seeds are eaten .

= = = Corn = = =

Helicoverpa zea earns its nickname the corn earworm for its widely known destruction of cornfields . The corn earworm feeds on every part of corn , including the kernels . Severe feeding at the tip of kernels allows entry for diseases and mold growth . Larvae begin feeding on the kernels once they have reached third instar . Larvae penetrate 9 to 15 cm into the ear , with deeper penetration occurring as the kernels harden . Larvae do not eat the hard kernels , but take bites out of many kernels , lowering the quality of the corn for processing .

= = = Soybeans = = =

Helicoverpa zea is the most common and destructive pest of soybean growth in Virginia . About one @-@ third of Virginia acreage is treated annually with pounds of insecticide , costing farmers around 2 million dollars . The degree of damage varies on the size of the pest infestation , the timing , and the stage of the plant . However , soybean plants are capable of withstanding a large amount of damage without substantial yield loss depending on soil moisture , planting date , and weather . If the damage is early in the plants life , then damage will mostly be to the leaves . Plants compensate for the damage by processes such as increasing seed size in remaining pods . Most damage happens in August , when the plants are flowering . Attacks that happen after August do much less damage because many pods have developed tougher walls that H. zea can 't penetrate . Infestations that affect pod formation and seed filling have the potential to reduce yields , and because this happens in the later stages of plants , they have less time to compensate .

Female moths are attracted to flowering soybean fields . The most severe infestations occur between flowering and when pods become fully developed . Large @-@ scale outbreak is associated with time of peak flowering , when most pods are developed , and peak moth flight , for giant . Moths are also attracted to drought stressed soybeans or fields with poor growth . Dry weather leads to quick drying of corn plants , compelling moths to leave and seek other hosts . Heavy rainfall also decreases corn earworm populations because it drowns pupae in their soil chambers , limits moth flight , washes eggs from leaves , and creates favorable conditions for fungal diseases that kill caterpillars .

= = Mating = =

= = = Pheromone production = = =

A hormone produced in the brain of the female moths controls sex pheromones . The hormone is

released into the hemolymph to stimulate pheromone production . Pheromone biosynthesis @-@ activating neuropeptide (PBAN) is a peptide that regulates pheromone production in moths . It acts on the pheromone gland cells using calcium and cyclic AMP . Although the photoperiod regulates the release of PBAN to some extent , the chemical signals from the host plant supersede the effect from the time of day . Female Helicoverpa zea in corn fields do not produce pheromones during the night until they encounter corn . Several natural corn silk volatiles like the plant hormone ethylene induce H. zea pheromone production . The presence of the silk from an ear of corn is enough to cause pheromone production , and physical contact between females and corn is unnecessary . This evolutionary mechanism enables the moths to coordinate their reproductive behavior with the availability of food . Female moths often become depleted of sex pheromone after mating within 2 hours of separation from the male . The pheromonostatic peptide (PSP) , a protein 57 amino acids long found in the male accessory gland , is what causes depletion of the female ? s sex pheromone . This capability in males has been selected for because it increases the reproductive fitness of those that carry it , since other males will not be attracted to a female without a sex pheromone ; thus , the female will bear only the first male 's offspring . The transfer of a spermatophore without accessory gland products does not stop female pheromone production , but does stop the female 's calling behavior . Intense selection acting on males to manipulate female reproductive physiology promotes rapid evolution of specific molecules , and male @-@ derived pheromone suppressing factors exhibit positive selection .

= = = Mortality = = =

Sperm competition and chemicals introduced to females through mating have a negative effect on females and their lifespan . In males , production of the spermatophore , sperm , and secondary chemicals reduces their lifespan . As the number of copulations increase , the rate of mortality also increases in both sexes .

= = = Flight behavior = = =

Males must first wait to sense a female ? s pheromones before they can locate her . Before males engage in flight to find a female , they warm @-@ up by shivering the major flight muscles to reach thoracic temperature optimal to sustain flight , around 26 degrees Celsius . The thermoregulatory shivering activities of males were measured as they were exposed to different sex @-@ related olfactory cues . Males are found to heat up more quickly in the presence of a female pheromone and take @-@ off at a lower thoracic temperature than males who are exposed to other chemical scents . Since heating up to the right temperature leads to better flight performance than flying immediately , there is a trade @-@ off between sub @-@ optimal flight performance and rapid onset of directed flight . Helicoverpa zea males exposed to an attractive pheromone blend thus spend less time shivering and increase their heating rate . Thermoregulatory behavior of unrestrained moths is associated with competition for access to females , showing the ecological trade @-@ off .

= = Gallery = =

= = Literature = =

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