

The role of insect metamorphosis in improved insect management

by Wendy Gelernter, Ph.D. and Larry J. Stowell, Ph.D.

Bottom line: Insect metamorphosis, the dramatic change in form that takes place in some insects during their lifetimes, can transform an unattractive caterpillar into a gorgeous butterfly, or a non-descript, soil-dwelling grub into a hard-shelled, flying beetle. An understanding of this complex process can help turf managers identify pest insects more easily, monitor for insect pests more effectively, predict when insect problems will develop, and select the most effective products and practices for control.

Nature's Super Heroes

The fertile imaginations of comic book writers and artists have produced some of the greatest examples of human metamorphoses – Clark Kent to Superman; Bruce Wayne to Batman; or Peter Parker to Spiderman. Yet none of these can compare to the dramatic real-life metamorphoses that take place when a soft-bodied, flightless caterpillar turns into a beautiful moth, or when a non-descript, soil-dwelling grub that feeds voraciously on turf roots turns into a heavy-bodied, flying beetle that feeds on little, or nothing at all

Figure 1. It's hard to imagine any two insects more different in color, shape and behavior than the hungry larval caterpillar (top photo) and the winged adult moth below. Yet these are different stages of exactly the same insect – a giant silkworm moth, *Eupackardia calleta*, which is found in the southern U.S. and Mexico. This moth, and indeed all moths and butterflies, undergo complete metamorphosis.



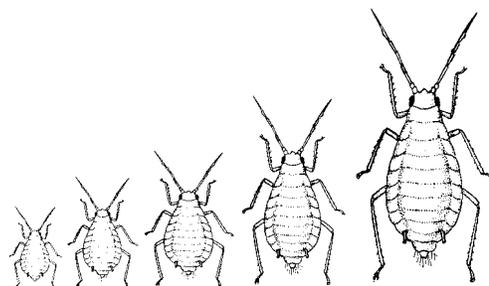
Photographs courtesy of Kirby Wolfe

Metamorphosis defined

meta-mór-pho-sis: striking alteration in appearance, character or circumstances.

As for other organisms, insects grow larger and age with time. Some insects such as aphids undergo very little change in their appearance or feeding habits, other than to grow larger with age. These insects are said to undergo **simple metamorphosis**. Within this group fall crickets and grasshoppers, aphids, whiteflies, mole crickets, chinch bugs and silverfish. For these insects, all stages tend to feed on the same food sources.

Figure 2. Simple metamorphosis, as illustrated by the development of an aphid, from newly hatched immature nymph (smallest aphid on left) to an adult female (largest aphid on right) that is capable of reproduction. Note the lack of change in appearance of the insect, other than gradually increasing size.



In contrast, insects such as moths (Figures 1 and 5) butterflies, beetles (Figures 3 and 4), flies and wasps, undergo a much more complicated growth process, where the young stages of the insect are entirely different in appearance and behavior than the adult, sexually mature insects. These are the insects that illustrate the true meaning of the word "metamorphosis." They are said to undergo **complete metamorphosis**.

For these insects, the immature or larval forms are usually soft-bodied, without wings, and devoted primarily to feeding, feeding and more feeding. The dramatically different adult stage is usually hard bodied, has wings, and is primarily devoted to the more "adult" activities of copulation and laying eggs so that a new generation can be produced. The adult stages of these insects usually feed on different foods than the larvae, and sometimes the adults don't feed at all.

The pupa

What the telephone booth was for Clark Kent, the pupa is for insects that undergo complete metamorphosis -- a quiet, out of the way place where the transformation between one life stage (the larva) and another (the adult) can occur.

Figure 3. Another example of complete metamorphosis. This root-feeding masked chafer *Cyclocephala pasadenae* white grub (photo on left) is the immature form of the insect and lives in the soil for roughly 11 months, during which time it never sees the light of day. Like caterpillars, the white grub stage lives for one key reason – to eat as much plant material as possible. When this large (up to 1" long) grub feeds on the roots of turf plants, serious damage can result. In contrast, the adult form of the insect is a beetle (photo on right) that lives only a few weeks, and whose life has one major purpose – to rapidly find a mate, copulate, and produce more offspring.



Insects with simple metamorphosis, such as aphids and mole crickets, have no pupal stage. But in insects such as butterflies and beetles, where complete metamorphosis occurs and major changes occur between larvae and adult, the pupae is the place where the transformation occurs.

During the first days or weeks that the insect is in the pupal stage, the large majority of larval tissues are broken down, and the insect as we've known it is no more. If you were to cut a pupa open at this point, most would be full of liquid, and unrecognizable as an animal of any type. But soon the insect begins to reconstitute itself in the form of the adult insect. The body develops to include mature reproductive organs, as well as wings.

When adult development is complete and it's time to emerge from the pupa, the adult swallows air to increase its volume, thus splitting the pupa in half. The soft, wet adult then pulls itself out. Within a few hours, the adult's cuticle has hardened, the wings have expanded, and the insect is ready to go out and meet the world.

Figure 4. Life cycle of a typical beetle, illustrating the four stages that occur in the development of an insect with complete metamorphosis. Eggs (1) are typically laid by the adult female in an area that will provide immediate food for the newly hatched larva (2a) – on leaves or plant roots for many pest insects. As the larva feed, they increase in size (2b) until they finally undergo pupal formation (3), usually in the soil, leaf litter or other protected area. After several days or weeks, the adult insect (4) emerges from the pupa. It is now ready to mate and lay eggs, thus beginning the life cycle over again.

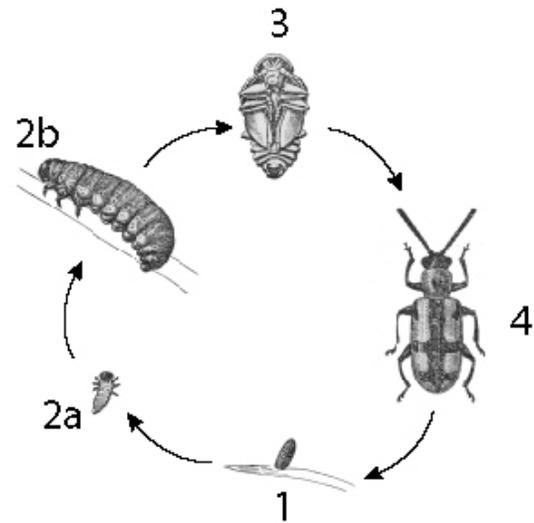


Figure 5. Probably the most famous and useful pupae in the world are made by the caterpillars, or larvae (photo at left below) of the silkworm, *Bombyx mori*. The photo on the right is the adult moth stage of this insect. Silkworm caterpillars are raised in large silk factories, where they are fed on mulberry leaves. Once the caterpillars hatch from their eggs, it takes them 6 weeks to develop to the stage where they are ready to pupate. At this time, they spin a silken cocoon, which serves as a protective layer which helps protect the insect from the environment. Unfortunately for the insect, the cocoon, which is composed of a single silken thread about 3,000 feet long, is also of great value to humans. In silk production, the pupae are destroyed and the silk is harvested. It takes about 3,000 cocoons to make a pound of the silk that we use in clothing and other luxury items (Borror et. al., 1989).

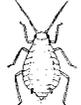


Metamorphosis and improved insect control

A good understanding of insect metamorphosis is basic to the development of good insect control strategies for a variety of reasons, including:

Proper identification of insect pests (Tables 1 and 2): Knowing which insects are present on the golf course is naturally critical in the development of sound management strategies. Yet because the larvae and adults of many key insect pests are so different in appearance, there is a great deal of confusion about which insects are present, and therefore which management practices will be most effective. Knowing how to identify both stages of the insect can therefore be very helpful. Similarly, many larval insects look alarmingly similar. They are almost all soft-bodied, flightless, and without distinguishing marks. However, the management practices for white grubs vs. caterpillar larvae, for example, are quite different. For this reason, it is important to be able to distinguish among the key groups of larvae.

Table 1. Turf insect pests with simple metamorphosis. These insects retain similar appearance and behavior throughout their life cycle, though some may develop wings as adults. These wings first appear as small, bud-like protuberances on immature nymphs, and gradually become full-sized as the insect matures.

INSECT	APPEARANCE	
Aphids Example: Greenbug	Small (<1/4" long), soft-bodied, pear-shaped; yellow, green and pink are most common colors. Most feed on foliage. Adults of some species have wings	 non-winged aphid
Chinch bugs Examples: hairy, Southern and common chinch bugs	Very small (<0.15" long), brownish to black insects. White wings with a black spot are held flat over the body. Wings first appear as tiny protuberances on nymphs, but are fully developed on adults. Legs are red to yellow-red. Feed on turf stems & crowns	 adult chinch bug w/wings
Mole crickets Examples: Tawny, southern, short-winged and northern mole crickets	Large (1 1/4" – 1 1/2" long), stout bodied, brownish insects, with large front legs adapted for digging. Shortened, undeveloped wings appear on older nymphs, and are full-sized on adults. Feed on turf roots and foliage.	 winged, adult mole-cricket

Predicting when insects will appear: For many insect pests, the larval stage causes the most damage and for this reason, most control practices are directed

towards the larvae. Unfortunately, the larvae of many insects are non-descript, hard to find and difficult to identify. Because the adult stages are frequently easier to find and easier to identify, their presence can provide useful predictive information.

Table 2. Turf insect pests with complete metamorphosis. These insects look and act differently in their larval and adult stages. They usually live in different areas, feed on different food sources, and are controlled by different products.

INSECT	LARVAE	ADULTS
Moths Examples: black cutworm, sod webworm, armyworms	 Long, thin, soft bodied insects usually feeding on turf foliage; many small legs present	 Strong fliers with 4 wings, usually flying late in day or at night; do not feed on turf
White grubs Examples: ataenius, chafers, June beetles, Japanese beetle	 Fat, soft-bodied, white insects with 6 legs; body held in "C" shape. Feeds on turf roots	 Hard bodied, flying insects w/shield shape. Do not feed on turf
Billbugs & weevils Annual bluegrass weevil, billbugs	 Small (<1/2" long), legless, soft white insects with brown head. Feed inside stems & crowns of turf.	 Small (<1/3" long), dark, hard bodied insects with prominent, elephant-like "snout". Adults may feed a bit on turf foliage, but cause minor damage.
Crane flies	 Caterpillar-like, but with no legs. Known as "leatherjackets", may reach 1" or longer. Feed on turf roots and crowns	 2 wings, similar to large mosquito. Body 1" or longer, exclusive of legs. Does not feed on turf.

For example, the presence of adult chafer beetles flying around your porch lights on evenings in June or July indicates that white grub larvae will be hatching in the soil a few weeks later. Likewise, the sight of sod

webworm moths flitting around the surface of the turf in the late afternoons indicates that sod webworm larvae may be feeding on turf foliage about two weeks later. The small, black turfgrass ataenius beetle adult, though non-damaging to turf, can signal that damaging grubs are a few weeks away when they are found walking on the surfaces of greens, or congregating in piles of turf clippings.

becoming more and more selective, which means that they may be active against only a few insect types (for example billbugs, but not caterpillars), or against only the larval stage, but not the adult stage (for example white grubs, but not beetles) or only on soil dwelling insects, but not on foliage feeding insects. Knowing which stage you have is therefore critical in the selection of the most effective product.

Selecting the most effective product or practice (Tables 3 - 5): The newer insect control products are

Table 3. Root feeding vs. leaf feeding insects. Different control strategies apply to leaf feeding vs. root feeding insects, as illustrated below.

Insect Common Name	Insect Scientific Name	Larvae	Adults	Site of insecticide attack
Annual bluegrass weevil	<i>Listronotus maculicollis</i>		X	TURF FOLIAGE: leaves stems and crowns • Use 2 gallons of water/1000 sq ft to deliver insecticides • Avoid post-treatment irrigation until sprays have dried on foliage • Contact insecticides most frequently used
Billbugs	<i>Sphenophorus</i>		X	
Black turfgrass ataenius	<i>Ataenius spretulus</i>		X	
Chinch bugs	<i>Blissus leucopterus</i>	X	X	
Cutworms and armyworms	<i>Agrotis, Spodoptera, Pseudaletia</i>	X		
Sod webworms	<i>Crambus, Parapediasia, Pediasia, Fissicrambus, Herptogramma</i>	X		
Billbugs	<i>Sphenophorus</i>	X		ROOTS/SOIL • Use 3 – 4 gallons water/1000 sq ft • Post-treatment irrigation (1/10") immediately after treatment • Systemic insecticides most frequently used
Crane flies (leatherjackets)	<i>Tipula</i>	X		
Mole crickets	<i>Scapteriscus</i>	X	X	
White grubs, including:		X		
• Asiatic garden beetle	<i>Maladera castanea</i>	X		
• Black turfgrass ataenius	<i>Ataenius spretulus</i>	X		
• European chafer	<i>Rhizotrogus majalis</i>	X		
• Green June beetle	<i>Cotinis nitida</i>	X		
• Japanese beetle	<i>Popillia japonica</i>	X		
• Masked chafers	<i>Cyclocephala</i>	X		
• May & June beetles	<i>Phyllophaga</i>	X		
• Oriental beetle	<i>Exomala orientalis</i>	X		



NOTE: Tables 1 through 5 (for Tables 4 and 5, see Reference 8:3) present information that can help you select the most effective strategies for controlling the insect pest or pests present on your golf course. After identifying the pest (Tables 1 and 2) and determining whether it is a foliar or root pest (Table 3) use Tables 4 and 5 to determine which products are best suited for use on the pests that are present.

References

Borror, D.J., Triplehorn, C.A and N.F. Johnson. 1989. An Introduction to the Study of Insects, 6th Edition. Harcourt Brace College Publishers, Fort Worth.

The Kirby Wolfe Saturniid Collection (photographs): www.insectcompany.com/silkmoth/kirbywolfe.htm