MORPHOLOGY OF LEPIDOPTERA

Figure 7 The second through fifth instars of *Hyalophora euryalus*.

CATERPILLAR

Initially, caterpillars develop in the egg then emerge (eclose) from the egg. After emergence, the caterpillar is called a first instar until it molts. The caterpillar enters the second instar after the molt and increases in size. Each molt distinguishes another instar. Typically, a caterpillar passes through five instars as it eats and grows. The general appearance of the caterpillar can change dramatically from one instar to the next. For instance, typically the first instar is unmarked and simple in body form. The second instar may exhibit varied colors and alterations deviating from a simple cylindrical shape. Thereafter, caterpillars of certain species exhibit broad shifts in color patterns between the third and fourth, or fourth and fifth instars (see Figure 7).

Caterpillars can be distinguished from other immature insects by a combination of the following features:

Adfrontal suture on the head capsule;

Six stemmata (eyespots) on the head capsule;

Silk gland on the labium (mouthparts);

Prolegs on abdominal segments A3, A4, A5, A6, and A10; or A5, A6, and A10; or A6 and A10;

Crochets (hooks) on prolegs.

There are other terrestrial, caterpillar-like insects that feed on foliage. These are the larvae of sawflies. Sawflies usually have only one or a few stemmata, no adfrontal suture, and no crochets on the prolegs, which may occur on abdominal segments A1, A2 through A8, and A10 (see Figure 9, page 19).

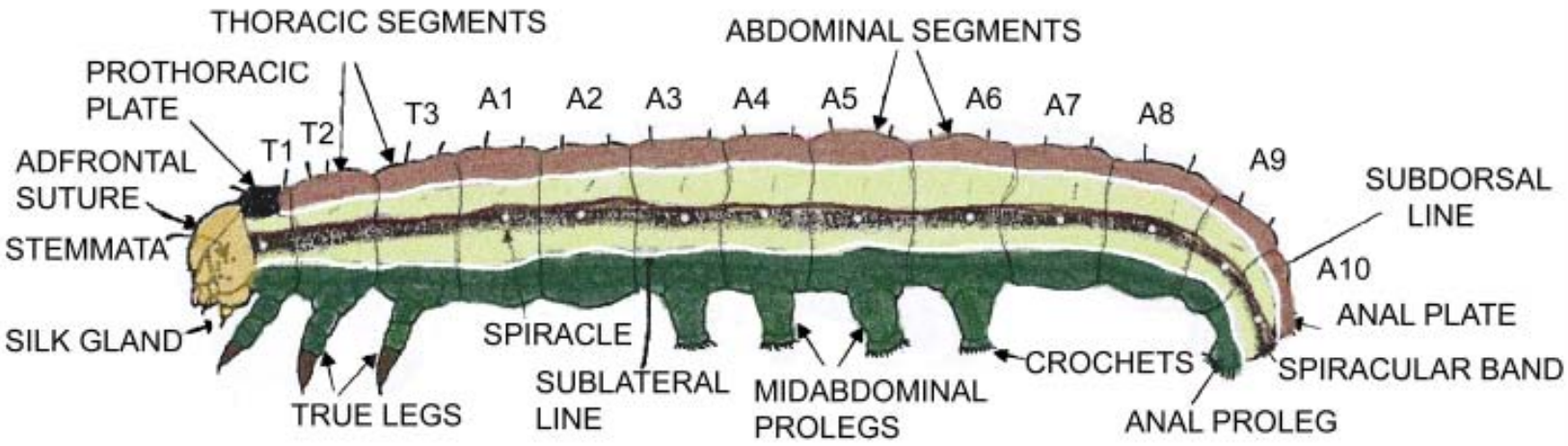

Figure 8 Caterpillar morphology.

The variety of form in the body parts plays an important role in distinguishing among and identifying caterpillar species. The caterpillar's body is divided into three sections: head, thorax, and abdomen.

Head Caterpillars have a well sclerotized head capsule, which in most species is marked with an adfrontal suture and typically contains six stemmata or eyespots. The head has one pair of small, three-segmented antennae located close to the base of the mouthparts.

Mouthpart components include a labrum, mandibles, maxillae, and a labium. The labrum serves as an upper lip and may be notched to function as a leaf guide and assist in orienting food between the mandibles. The mandibles, located below the labrum, are paired, opposable, hardened tooth-like structures used to bite and crush food. The maxillae are located behind the mandibles and contain sensory organs that distinguish between food and non-food foliage. The labium is located behind the maxillae and contains the silk gland, which emits a strand of silk used for producing pads, life lines (see *Pero mizon*), and cocoons. The overall shape of the head capsule, color patterns, the location of hairs on the head, and the morphology of the mouthparts are helpful in identifying species of caterpillars. However, these features require the aid of a microscope and will not be emphasized here.

Thorax The three thoracic segments include the prothorax, nearest the head (T1); mesothorax, in the middle (T2); and metathorax, which connects to the abdomen (T3). Each thoracic segment has a pair of segmented legs. The thoracic legs assist in locomotion and clinging to substrates. Some caterpillars—in particular certain leaf mining species—have no segmented legs on the thorax. Each side of the prothorax has a spiracle, which is an external opening of the respiratory system. The presence or absence and shape of sclerotized plates, the location of primary setae (and setal clusters), the location, color and shape of the prothoracic spiracle, and morphology of the legs also aid in identifying caterpillar species (see Peterson [1962] and Stehr [1987] for further details).

Abdomen Typically, the abdomen has ten segments, A1-A10. Segments A1-A8 possess spiracles, and an anal plate may occur on A10. Depending on the family group, certain abdominal segments have fleshy prolegs bearing crochets (hooks). The typical pattern for

prolegs is one pair per segment on A3-A6 (midabdominal prolegs), and A10 (anal prolegs). Exceptions include the Plusiinae of the Noctuidae, which have prolegs only on A5, A6 and A10, and the Geometridae, which have prolegs on A6 and A10. Some leaf mining caterpillars have reduced prolegs, the remnants of which are merely crochets on the abdominal wall, while other leaf miners may have no prolegs. If prolegs occur on segments A1, A2 or A7-A9, the specimen is most likely a sawfly (Figure 9).

Figure 9 Sawfly larva. Note the eyespots and midabdominal prolegs.

The prolegs on the abdomen are not true legs; they are fleshy extensions of the body wall and not segmented appendages. The crochets at the ends of the prolegs occur in a variety of configurations and can be characteristic of specific family groups. The crochets may occur as a closed or open circle, an ellipse, paired longitudinal lines, or a transverse line. Also, the base of the crochets might be inserted into the flesh of the prolegs in single rows (uniserial), double rows (biserial), or triple rows (triserial). Likewise, the tips of the crochets might form a single row (uniordinal), a double row (biordinal), or a triple row (triordinal).

Projections An array of projecting features may occur on various caterpillars. The location and number of many of the following traits may allow for a quick and accurate identification of a particular caterpillar. The projections may be attached to the body wall such as soft and flexible hairs, or modified hairs that are sclerotized and hard or stiffened into spines. Also, projections may be extensions of the body wall in the form of warts, tubercles, or horns.

Hairs The types and arrangements of hairs are helpful in identifying caterpillars. Hairs may be multicolored; short or long; single in clusters (hair pencils) or tufts (tussocks); end in a tapered point or a "club". In most of the Noctuidae and Geometridae, a few single, short hairs (the primary setae) may be the only hairs present; in these species the caterpillar is essentially naked.

The primary setae occur in specific locations on the body segments. Secondary setae do not occur in specific locations and are scattered over the body. Caterpillars of certain families, e.g., Lycaenidae and Satyridae, are covered by a dense pile of very short secondary setae, giving them a velvet-like appearance. The presence of long hairs usually is indicative of a relatively dense array of hairs. Also, long hairs may occur in clusters or in densely packed tufts in the middorsal area. Tufts usually are associated with glands, serving as a wick for the gland exudate. Species of Arctiidae, Lasiocampidae and Lymantriidae have notably hairy caterpillars.

Spines A single pointed spine is a chalaza; a spine with multiple points is a scolus. Spines typically occur at defined positions along a certain region of the body, e.g. dorsal, subdorsal, lateral, at the locations of the primary setae. Numerous species, such as Saturniidae and Nymphalidae, have spines of various kinds and colors.

Warts Small bumps or very short finger-like projections that extend from the body wall are called warts. In caterpillars warts can occur in specific locations and exhibit recognizable patterns which assist in identification.

Tubercles The length and location of extensions of longer finger-like projections (tubercles) of the body wall also assist in identification. Tubercles will often occur in pairs or in a series encircling one or more segments.

Horns The body wall can be drawn into relatively short, pointed, fleshy projections (horns). As found in sphingid caterpillars, commonly called hornworms, the horn occurs singly, typically in the middorsal area of segment A8.

Body Shape

Typically, caterpillars are cylindrical. Variations in this shape include bodies that are flattened, humped, otherwise swollen, or constricted. The flattened shape is indicative of a leaf-mining habit while the cylindrical shape is characteristic of borers, tunnelers, and external leaf-feeders. The humps, swellings, and constrictions serve as camouflage and help caterpillars blend into their surroundings. The location and size of humps and constrictions help identify certain species.

Humps Obvious bulges in the body profile can be found in many species. Large, dorsal, pyramid-like, posterior swellings are typical of *Amphipyra pyramidoides* and *Feralia februalis*. Thoracic and midabdominal swellings are typical of *Catocala*, *Schizura*, and *Zale lunata*.

Constrictions A distinctive narrowing of the body. The neck region is noticeably constricted among the Hesperiidae.

Colors and Patterns

Caterpillars display a wide range of colors and patterns. The location of a color and its pattern is helpful in identifying caterpillars. Common colors are brown, tan, cream, white, silver, gray, black, red, pink, orange, yellow, green, blue, and purple. These colors are displayed in a wide assortment of patterns that can be categorized as bands, lines, rings, streaks, dashes, circles, dots, saddles, and patches. However, the pattern may differ subtly or markedly from one instar to another. The most common locations of definitive patterns are middorsal, subdorsal, lateral, sublateral, and ventral.

Middorsal longitudinal bands Wide lines extending from head to tail along the middle of the back.

Lateral longitudinal bands Wide lines extending from head to tail along the sides where the spiracles occur. In some species the top edge of the band barely touches the spiracles and may appear to be a subspiracular band.

Middorsal longitudinal lines Narrow lines extending from head to tail along the middle of the back.

Subdorsal longitudinal lines Narrow lines extending from head to tail more or less halfway between the middle of the back and the spiracular area.

Lateral longitudinal lines Narrow lines extending from head to tail along the sides where the spiracles occur. In some species the top edge of the line barely touches the spiracles and may appear to be a subspiracular line.

Rings Bands of color around the body segment, often in two or three alternating colors, typically black, white, and or orange. Also, the intersegmental area may be colored in a manner that shows a faint ring pattern.

Streaks Narrow lines of color longer than half the width of a body segment.

Middorsal dashes Narrow lines of color shorter than half the width of a body segment and located along the middle of the back.

Subdorsal dashes Narrow lines of color shorter than half the width of a body segment and located along the subdorsal area of the body.

Middorsal line of circular or elliptical spots Relatively large spots of a solid color (or middle of spot of variable color) located along the middle of the back.

Scattered speckles Small dots or specks, usually white or black, randomly and usually densely scattered over the body. Some species may show black specks at the base of primary hairs, which are not scattered.

Midabdominal saddles Irregularly shaped patches of color extending across multiple segments along the middorsal area.

Dorsal transverse bands or lines Colored bands or lines that extend from side to side across the back but not all the way around the body.

Anal transverse bands or lines Colored bands or lines that extend from side to side across the dorsum of A9 or A10.

Oblique lines on midabdominal segments Lines, usually white, yellow, or black, that extend between anterior lateral areas, and posterior subdorsal or dorsal areas.

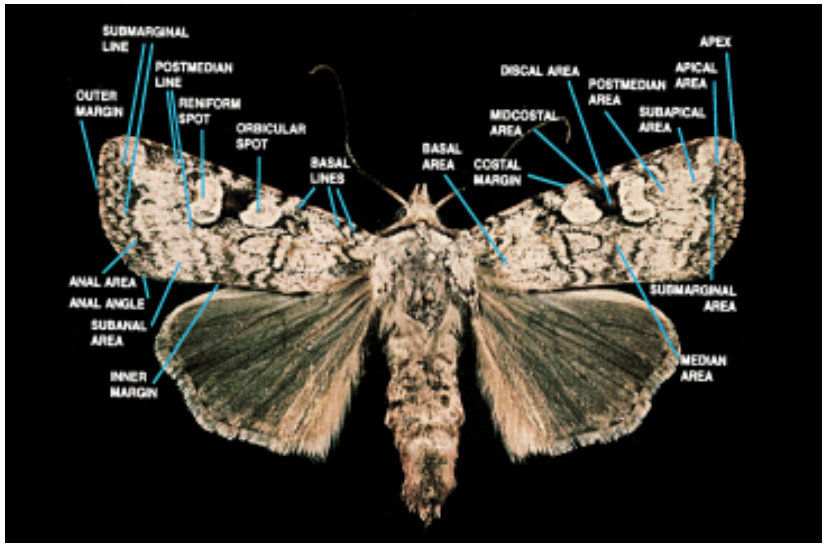

Figure 10 The areas, lines, and spots on the forewing on *Euxoa vetusta, a* typical adult Lepidoptera.

ADULT

The field identification of adult Lepidoptera is done by comparing combinations of features including colors, patterns, wingspan and shape, head, thorax, and abdomen (Figure 10). Taxonomists rely strongly on the morphology of genitalia and, more recently, DNA sequences.

Wings Two general criteria distinguish wings among species: span/size and color/pattern. For the purposes of this guide, wingspan measurements were taken from properly spread specimens of representative size for each species. The distance from the tip of the left forewing to the tip of the right forewing was used and is presented with a resolution to within 1 millimeter. We did not attempt to assess the statistical distribution of wingspan values for each species; in general most species exhibit a size range of 15 - 20 percent above and below the average value. Thus, it would not be unusual to collect a specimen slightly smaller or larger than the dimensions presented in the species diagnostic traits. (***Note:*** The photographs in Chapter 5 of this guide were printed to maximize the size of the individual to the print dimensions of the image. In print the small species appear to be the same size as the large species. Thus, it is not possible to directly compare sizes among the species. Numerical measurements of a typical wingspan are included for each species.)

The specific terms we use to describe wing patterns, and their usefulness in distinguishing species, are dashes, lines, bands, patches, special spots, and special areas.

Dashes Narrow, short marks extending less than half the distance along the width or length of the wing.

Lines Narrow marks extending more than half the distance along the width or length of the wing, and associated with a specific area on the wing. The postmedian line may be broken or continuous and occurs distal to the reniform spot (see below) and demarks the proximal edge of the postmedian band. The submarginal line may be broken or continuous and is proximal to the outer margin.

Bands Wide areas typically extending more than half the distance along the width or length of the wing, often demarked by lines, and associated with a specific area on the wing.

Patches Small, restricted areas of the wing demarked by distinct colors but not delimited by lines. Basal patches occur in the basal area.

Special spots The orbicular spot is a single irregularly shaped (typically near-round shaped) spot that occurs just short of half way along the front edge of the forewing. The reniform spot is a single irregularly shaped (often kidney shaped) spot that occurs just past half way along the front edge of the forewing. The discal spots are the combination of the reniform and orbicular spots.

Special areas The basal area is the area of the wing nearest the thorax. The midcostal area is in the center of the front edge of the wing below the costal margin. The discal area is bounded by the orbicular and reniform spots. The median area is the central area of the wing. The postmedian area is distal to the reniform spot and proximal to the subapical area. The subapical area is proximal to the apical area. The apical area is immediately below the apex of the wing. The submarginal area is proximal to the outer margin. The anal area is between the outer margin and the inner margin, proximal to the anal angle. The subanal area is proximal to the anal area.

Head The most obvious features are the eyes, mouthparts, and antennae. However, with the exception of pectinate antennae, which aid in identifying similar-looking species, these features are not the most useful for field identification.

Thorax Three segments: prothorax, nearest the head; mesothorax, in the middle; and metathorax, connecting to the abdomen. Forewings attach to the mesothorax, hindwings attach to the metathorax. Like-colored hairs of similar lengths might be arranged in collars and tufts on the thorax. Each thoracic segment has one pair of legs. The colors of leg hairs vary among species. In some species, the forelegs are shorter than the mid- and hindlegs.

Abdomen The general size and shape of the abdomen is useful in identifiying families. For example, the abdomen of geometrids is typically thin and appears small relative to the wing area, whereas the abdomen of sphingids is robust and distinctly tapered. The abdomen is the body segment that contains the genitalia, which are used in describing and differentiating species.