The pest caterpillars of cole crops in Virginia

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Caterpillars, or the larval stage of Lepidoptera, are probably the most damaging of insect groups that feed on cole crops, such as collard, kale, cabbage, broccoli, cauliflower, kohlrabi, Brussels sprouts, and Chinese cabbage. Caterpillars typically feed on foliage reducing marketability or outright killing plants. The most common and damaging caterpillars in Virginia cole crops are diamondback moth (DBM), cabbage looper (CL), and imported cabbageworm (ICW). In addition to these key species, there are several other species of caterpillars that will be observed feeding on cole crops that may or may not be a threat to yield of the crop. These species are summarized in Table 1. Normally pest management is meant to target all caterpillars, treating them as one pest "complex;" however, there are some noteworthy differences between the caterpillar species in their life histories and feeding behaviors where proper identification is sometimes necessary.

Table 1: A list of major caterpillars found on cole crops in Virginia. Key pests are those that are often economically damaging. Sporadic pests are those that are less common, but can be economically damaging when they do occur. Rarely economically damaging species may be commonly observed on cole crops, but rarely cause economic damage.

Species	egg mass	Overwintering Lifestage	Feeding Injury
Key Pests			
Diamondback moth (*Plutella xylostella*)	Single or 2-3 clustered	adult	small larvae mine, larger larvae cause "windowpane" defoliation
Cabbage looper (*Trichoplusia ni*)	single or up to 6-7	pupa	small larvae prefer lower surface of leaves, large larvae chew large holes, avoiding leaf margin
Imported cabbageworm (*Pieris rapae*)	single	pupa	defoliate, holes and at leaf margin
Sporadic pests			
Cabbage webworm (*Hellula rogatalis*)	single or small masses	larvae or pupa	small larvae mine, larger larvae produce webbing, leaf rolling
Cross-striped cabbageworm (*Evergestis rimosalis*)	25-May	larvae	larvae chew small holes in leaves
Beet armyworm (*Spodoptera exigua*)	50-150 w/cottony covering	pupa, migrates from southern regions	small larvae skeletonize leaves, larger larvae chew large holes
Cutworms	in soil	egg	larvae often feed at the base of the plant, cutting down small plants

Rarely economically damaging			
Southern cabbageworm (*Pontia protodice*)	single	pupa	larvae prefer flower buds and older leaves
Saltmarsh caterpillars (*Estigmene acrea*)	400-1000	mature larvae	small larvae skeletonize leaves, larger larvae chew large holes
Fall armyworm (*Spodoptera frugiperda*)	up to 400 w/ cottony covering	pupa, migrates from southern regions	larvae chew holes in leaves
Corn earworm **(***Helicoverpa zea*)	single	pupa	larvae chew holes in leaves

Lifecycle

Members of this pest complex complete several, overlapping generations during the growing season. Beet armyworm (BAW) and fall armyworm (FAW) do not overwinter in Virginia and must migrate from southern regions, so these species will not be observed until later in the summer. Scouting foliage for eggs or caterpillars (larvae) should be conducted periodically for the duration of the crop.

Egg Many species lay their eggs singly or in small groups on the upper and lower surface of host plant leaves, like the ICW, DBM, and CL (Figs. 1-3). Eggs laid singly are very small and can be difficult to see. BAW and FAW egg masses are more conspicuous as females lay their eggs in larger masses and cover them with a protective cottony wax material (Fig. 4 and 5).

Figure 1: Imported cabbage worm eggs
(Whitney Cranshaw, CSU, bugwood.org)


Figure 2: Diamondback moth eggs


Figure 3: Cabbage looper eggs

Figure 4: Beet armyworm egg masses
(Ronald Smith, AU, bugwood.org)


Figure 5: Fall armyworm egg masses

Larva Most threshold recommendations for chemical control are based on the average number of caterpillars present (regardless of species) on 50 plants. However, the amount of feeding injury potential varies from species to species, as does the resistance to certain insecticides. Thus, proper

identification of the pest is an important step in the pest management process. DBM, CL and ICW are all green caterpillars, but are easily distinguished by a few characteristics. DBM larvae are small and have two prologs that make a v-shaped at their end (Fig. 4). DBM larvae tend to feed on leaf tissue on the underside of the leaf, leaving the upper side tissue intact, creating "windowpanes" rather than holes. Also, DMB larvae wriggle violently and drop off the plant on a silken thread when disturbed. ICW, which shows little response when disturbed, is fuzzy and has yellow dots along its side and a yellow line along its back (Fig. 5). ICW will often rest along the leaf vein and can be difficult to see but produce a great deal of fecal matter that is more conspicuous. CL has a distinctive "looping" movement or "inchworm" behavior and will often rear up on its prologs when disturbed (Fig. 6).

Figure 4: Diamondback moth larva

Figure 5: Imported cabbageworm larva

Figure 6: Cabbage looper larva

BAW larvae have longitudinal stripes along their sides, the dorsal half is usually a darker green than the ventral half, and they possess a distinctive black dot on the side of the third body segment (Fig. 7). Cabbage webworms (CWW) are yellowish-grey with darker brown longitudinal stripes (Fig. 8). CWW can be more easily identified by the presence of webbing with which they surround themselves when they feed, often rolling the leaf around them as well. Cross-striped cabbageworm (CSCW) are bluish-grey and are the only caterpillar with transverse stripes in addition to the distinctive yellow and black longitudinal stripe (Fig. 9).

Figure 7: Beet armyworm larva

(Russ Ottens, UG, bugwood.org)

Figure 8: Cabbage webworm larva

Figure 9: Cross-striped cabbageworm

Several other caterpillars will be seen feeding on cole crops, but these species are rarely known to cause economic damage. The southern cabbageworm (SCW) has blue and yellow longitudinal stripes with black dots on each segment (Fig. 10). The saltmarsh caterpillar (SMC) is particularly conspicuous with many long hairs (Fig. 11). The FAW larva bears a resemblance to a BAW larva, but lacks the distinctive black dot and will also have a white line on its head in the shape of an inverted "Y" (Fig 12). Corn earworm (CEW) can be yellow, brown, pink or green and will look similar to the armyworms. Two

small dots can be found on each segment above each proleg (Fig. 13). Cutworms will rarely be observed on the plant as they feed at night and return to the soil surface during the day.

Figure 10: Southern cabbageworm larva

(Clemson, bugwood.org)

Figure 11: Saltmarsh caterpillar larva

Figure 12: Fall armyworm larva head

(Steve Brown, UG bugwood.org)

Figure 13: Corn earworm larva

Pupa ICW and SCW pupate in a similarly looking chrysalis (Fig. 14). DBM and CL larvae spin loose cocoons before they pupate and can be found on the undersides of leaves (Fig. 15 and 16). Other species in the complex will pupate in the soil and will not be observed on foliage.

Figure 14: Imported cabbageworm pupa

Figure 15: Cabbage looper pupa

Figure 16: Diamondback moth pupa

Adult The adult form of ICW and its native cousin, SCW, are similar in appearance. Also known as whites and checkered whites, respectively, ICW and SCW adults are quite conspicuous as they are large, white and active during the daytime (Figs 17 and 18). DBM adults can be observed flying in the daytime but are inconspicuous due to their small size (~6mm long). DBM adults are very narrow and have a cream colored band with one or more diamond shapes (Fig. 19). The adult form of CL, CWW, BAW, FAW and CEW are nocturnal and are rarely seen flying during the day but can be monitored using light traps. All of these night fliers have forewings that are mottled in color but CL adults can be distinguished by a white tear shape on wings (Fig. 20) and BAW has a distinguishing brown, bean-shaped mark in relatively the same spot (Fig. 21).

Figure 17: Imported cabbageworm adult
(David Cappaert, MSU, bugwood.org)

Figure 18: Southern cabbageworm adult
(Whitney Cranshaw, CSU, bugwood.org)

Figure 19: Diamondback moth adult

Figure 20: Cabbage looper adult

Figure 21: Beet armyworm adult
(Merle Shepard, Gerald Carner, bugwood.org)

Management Options

Cultural For home gardeners, removal of larvae by hand can be the best method of control. In larger scale settings, row covers can be used to prevent egg-laying on young plants. Removal of Brassicaceous weeds and destruction of cole crop field residues can reduce habitat for these pests. If such a cultural control is not practical, it is good to keep in mind that fields bordering such habitats will have higher pest densities in edge-rows. Chemical controls may only need to be applied to those edge-row areas. Early planted or early maturing plant varieties can be planted in the fall to avoid feeding damage from those species that are normally only a problem later in the year, such as CWW or BAW. A high percentage of DBM larvae are reported to be killed after heavy rainfall or when overhead irrigation is used.

Biological control There are many species of predators, parasitic wasps, tachinid flies, and insect pathogens that attack the eggs, larvae and pupae of these pest species. Often pest populations are kept below threshold if these biological control agents are conserved; this can be done by eliminating broad-spectrum insecticides, like Sevin or pyrethroids, or maintaining shelter habitats that are not treated with

insecticide. CWW is an exception in that its leaf-rolling behavior and production of webbing act to protect it from natural enemies as well as foliar insecticide sprays.

A wide range of parasitic wasps attack the various caterpillars on cole crops (Fig. 22). Often each caterpillar species has its own complex of parasitoids. In Virginia, we typically observe very high levels of parasitism (>50%) of most caterpillars. It is important to keep in mind that it may take time after a switch away from heavy use of broad-spectrum insecticides for natural enemy populations to grow large enough to have a strong impact on pest species. *Bacillus thuringiensis (Bt)* (strains kurstaki and aizawai) is a bacterium that is pathenogenic to caterpillars and is available in commercial formulations that provide effective control of caterpillars without negative effects on natural enemies. There are also several synthetic chemical insecticides that will also control caterpillars without affecting natural enemies and this information can be found in the Commercial Vegetable Production Recommendations Guide for Virginia. VCE Publication No. 456-420.

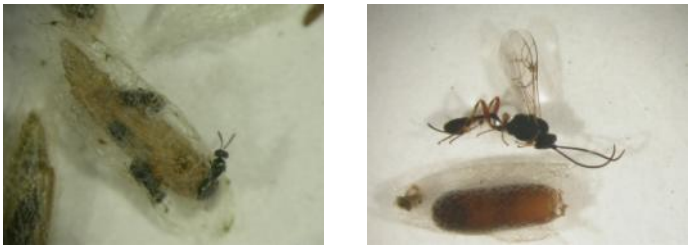

Figure 22: Parasitiods from DBM pupa, *Oomyzus* sp. (left) and *Diadegma* sp. (right).

Chemical There are many products registered for use on cole crops that provide effective control of caterpillars. Proper coverage is challenging on the waxy leaves of cole crops so the use of a spreader-sticker or adjuvant is recommended for all foliar sprays. Consult pest management guides for more detailed recommendations for application rates and insecticide resistance management. CWW can be difficult to control because of its cryptic feeding behavior and production of webbing on leaves. Early detection of this pest is important in order to target young larvae for control. Action thresholds are available for crops such as cabbage and these numbers are normally based on average number of larvae per 40-50 plants observed. For young cabbage plants treatment should be applied when are 50% of plants infested with DBM larvae or 30% infested with ICW or CL. Once plants begin cupping, action threshold is 10% of plants infested with any species. There have been several reports of resistance of DBM to certain carbamates, pyrethroids, and organophosphate insecticides. There are numerous alternative insecticides available that provide excellent control of lepidopteran larvae. These insecticides are more IPM-friendly and typically much safer for the user. These alternatives include the following: chlorantraniliprole (found in the products Coragen, Durivo, Voliam flexi, and Voliam Xpress), flubendiamide (found in the products Belt and Vetica), *Bacillus thuringiensis* (Bt) (found in the products Dipel, Agree, Xentari, Javelin, and others), spinosad (found in Entrust and Blackhawk), indoxacarb (found in Avaunt), methoxyfenozide (found in Intrepid), and spinetoram (found in Radiant). Consult pest management guides for more information on rotation of insecticide classes and resistance management.

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