INTEGRATED PEST MANAGEMENT FOR CABBAGE AND COLLARD
A GROWER’S GUIDE
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The purpose of this guide is to help cabbage and collard growers improve pest management on their farms, through the adoption of Integrated Pest Management (IPM) practices. The guide will help growers to properly identify pests, verify pest density, and recognize damage symptoms, natural enemies and diseases. Most importantly it will allow growers to make spraying decisions based on pest activity in the field. This, in turn, will reduce production costs and ultimately increase farm income. Additionally, the guide will assist growers to comply with federal guidelines on good agricultural practices (GAPs), which will provide a safer food supply to consumers.

Imported cabbageworm (ICW), diamondback moth (DBM) and cabbage looper (CL) are the key insect pests attacking cabbage, collard and other cole crops. Additionally, a diverse complex of other pests attacks these crops. Because of the devastating effects the key pests can have feeding on these crops, growers rely entirely on chemicals to control them. Currently, some growers spray their crop on a weekly basis, regardless of crop damage and pest densities. This practice is mainly driven by market demands for a blemish-free crop and the growers’ desire to meet this demand. Insect resistance problems, human health hazards, harmful effects on natural enemies, honey bees and the environment can result from this practice.

The guide is designed to be user-friendly, highlighting the biology of key pests, field sampling techniques and management options. It will stress the use of Bt-based control agents as a major component of an IPM program.
Finally, the objective of any pest control strategy is to reduce pest populations to non-economic levels. The authors hope that the adoption of IPM practices will lead growers towards a pest management strategy that is a balance between biological, cultural and environmentally safe chemical control rather than the current system that relies entirely on pesticides.
This guide is designed to help cabbage and collard growers start and maintain an IPM program. The key to a successful IPM program is to sample fields frequently, identify harmful pests and beneficial insects, and make spraying decisions based on what is in the field rather than what the farmer thinks might be there.

The names of the harmful insect pests appear in yellow. The names of the natural enemies (helpful agents) appear in green. Growers should use the color pictures to try to identify the insects that they might find in their fields. For example, if during sampling, a grower finds an insect that is not familiar, he should use this guide as a reference to determine if the insect is harmful or helpful. A decision was made not to include any chemical control measures in the guide. If a grower is not sure about what the best control of a particular pest is, he should check with the local extension agent.

Use the sampling suggestions and the data record sheet to develop a sampling plan for field scouting. Again, check with your local extension agent for help, if needed. Keep the data record sheets for future reference.

This IPM guide will help growers to be less reliant on chemical pesticides and utilize natural enemies of pests and other biological agents more in their farming operations. Consumers, farmers and the environment will ultimately benefit from adopting an IPM approach in cabbage and collard production.
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Life cycle: Aphids multiply in the field very rapidly. A generation may develop within a week to 10 days. However, the cabbage aphid is not nearly as destructive as the caterpillars that attack brassica plants.

Damage symptoms: Aphids are most often found in colonies. Sometimes the colonies may reach high numbers. Feeding is by sucking mouthparts and severe infestations can cause the leaves to become discolored and puckered.

Status as pest: In general, aphids are normally considered a minor pest of cabbage and collards but in certain circumstances, their numbers can explode.

Other remarks: Some ants may “farm” aphids thereby protecting them from some natural enemies. Aphid populations are usually kept low by the action of natural enemies, especially predators such as ladybeetles, syrphid fly larvae and parasitoids. Cabbage aphids often have a waxy appearance.
**Cross-striped Cabbageworm**

![Cross-striped Cabbageworm](image)

**Life cycle:** Pale yellow eggs are laid in flat “rafts” underneath leaves. These hatch in 5 or so days depending upon temperature. The small larvae hatch together and molt into 4 or 5 instars then form pupae. Larvae are distinctive with many transverse black and white stripes along their body and yellow and black stripes along the length of the body. Adults are about an inch long with brownish grey forewings. Because they fly at night, they are not often seen.

**Damage symptoms:** This pest prefers the young, tender terminals of cabbage and collard plants. Because several larvae hatch from the egg mass and feed together, plants can become riddled with holes.

**Status as pest:** This is only an occasional pest throughout its range.

**Other remarks:** This pest has several important natural enemies such as parasitoids of the eggs and larvae. It is usually not difficult to control if field scouting detects it early.
Imported Cabbageworm

Life Cycle: Adults deposit single eggs that hatch in 3 – 4 days, depending on temperature. Larvae undergo 5 developmental stages and pupate on the plant. Mature larvae can reach a length of over an inch.

Damage symptoms: Larval feeding on leaves of crucifers can cause serious damage.

Status as pest: The species is widely distributed and, depending upon location, can be very important. Interestingly, in some areas where crucifers are grown, it is not a serious pest.

Other remarks: There are a number of natural enemies such as parasitoids, predators and some diseases that attack this pest. The pest is very easily controlled with Bacillus thuringiensis (B.t.).
**Cabbage Looper**

**Life cycle:** Eggs are laid singly on leaves. The egg stage lasts from 3 – 4 days. There are 5 larval instars lasting about 13 days. Full grown larvae are about 1.5 inches long.

**Damage symptoms:** Larvae feed extensively on leaves and can cause serious defoliation.

**Status as pest:** Cabbage loopers are one of three major foliage-feeding caterpillars in cabbage and collard. The other two are imported cabbageworm and diamondback moth.

**Other remarks:** This pest has several natural enemies (predators, parasitoids and insect diseases) that attack it. Careful and frequent (two times per week) field scouting is required to detect young larvae before extensive damage occurs by larger larvae.
**Salt-marsh Caterpillar**

**Life cycle:** The eggs are laid in groups of from 400 – 1000 and hatch in 4 – 5 days. The hairy larvae go through from 5 to 7 stages before pupating among leaf debris on the soil. The pupal stage lasts about 2 weeks. Adult moths are whitish in color with numerous small black spots. The adults live only a few days.

**Damage symptoms:** The larvae can occasionally cause serious defoliation. Young larvae skeletonize the leaves, and larger ones eat large holes in the leaves.

**Status as pest:** This caterpillar can cause some defoliation and can be locally important. It is not usually a serious pest. Because it raises concerns with growers, however, it is important to know that it is present.

**Other remarks:** Salt-marsh caterpillar larvae are attacked by a number of natural enemies, particularly parasitoids. There is also a virus disease that attacks the larvae. In addition, many generalist predators attack the eggs and larvae.
**Diamondback Moth**

**Life Cycle:** Development depends upon temperature. In warmer climates, the life cycle may be half of that in cooler areas. Eggs are laid singly on the lower surface of the leaves. In cooler areas, the egg stage may last up to 6 days. There are 4 larval instars which complete their development in about 14 days. The full-grown caterpillar is about ½-inch long. Pupation occurs on the undersides of leaves inside a silken cocoon. The adult moth emerges after about 7 days.

**Damage symptoms:** Caterpillars feeding on leaves can cause severe damage. The younger caterpillars often cause a “window pane” effect.

**Status as pest:** It is a most serious pest in areas where heavy chemical insecticides are used. In many areas, natural enemies, particularly parasitic wasps, *Diadegma* sp., control the pest.

**Other remarks:** In all areas where the diamondback moth is a very serious problem, it has acquired resistance to a wide range of insecticides. It is recommended that farmers understand the role of natural enemies in controlling the pest.
**Common name:** Vegetable Weevil

**Life cycle:** Vegetable weevils are most active during warmer times of the year but during the hottest periods, adult weevils may go into a “resting stage” or aestivation. Eggs hatch in about two weeks and larvae feed from 25 – 45 days, depending upon temperature. Larvae pupate in the soil and the pupal stage may last two to three weeks, depending upon temperature. Adults (1/4 to 1/3 inch long) have been known to live for up to two years and reproduce without mating.

**Damage symptoms:** Feeding occurs mostly at night. Damage occurs on buds, foliage, stems and roots. Larvae are the most likely stages to be found feeding on the developing buds or “crown” of the plants. Even a small amount of feeding can cause plants to be deformed as they develop. Sometimes stems are cut off at the soil line which resembles cutworm damage. Leaves are “skeletonized” when high populations occur.

**Status as pest:** Both adults and larvae damage plants but numbers are generally low, if present at all. The most serious damage comes from larval feeding in the crown of plants.

**Other remarks:** Adults are brown with a pale gray v-shaped mark on the wing covers. When disturbed, adults will pretend to be dead. Larvae are legless and are pale yellow or greenish-yellow.
Common name: Harlequin bug

Life cycle: The harlequin bug requires from 50 – 80 days to complete its development. Black and white barrel-shaped eggs are laid in double rows of about 12 eggs, usually on the undersides of leaves. Eggs hatch from 5 – 25 days, varying with temperature. There are usually 5 nymphal stages that feed and grow from 4 – 9 weeks before becoming adults that can mate and reproduce. Adults are orange or red and black-spotted and easily recognized in the field.

Damage symptoms: Feeding damage shows up as white areas where the sucking mouthparts have removed plant juices. Heavy damage can cause losses of entire leaves or plants.

Status as pest: Harlequin bugs, although widely distributed throughout the United States, are only important in local situations and their infestations are “spotty”.

Other remarks: The adult stage survives the winter. There are tiny wasp parasitoids that attack the eggs as do predators such as crickets, fire ants and others.
Common Name: Cabbage Webworm

Life Cycle: Eggs are laid on leaves. Larvae can be recognized by several brown stripes along their body. Larvae feed inside the cabbage heart under protective silk. Larvae pupate in the soil. Life cycle takes from 23 – 25 days.

Damage Symptoms: Feeding is concentrated in the center or “heart” of the cabbage. Only a small amount of feeding can cause the plant to be deformed and unmarketable.

Status as Pest: This is a highly destructive pest, but its populations are not nearly as large as other caterpillars.

Other Comments: Larvae are more difficult to kill by B.t. or other insecticides because they are protected by a silken web within the cabbage heart.
**Common name:** Southern green stink bug

**Life cycle:** The white to pale-yellow eggs are laid in rafts glued together on the undersurfaces of leaves. The incubation time for eggs in the summer is about 5 days but may take two or three weeks in early spring when the weather is cooler. Eggs turn pinkish orange when nymphs are about to hatch. The first instars aggregate on the empty eggs and do not feed. The first nymphal stage lasts about 3 days. Feeding begins with the second instar. This stage lasts about 5 days, and the third and fourth instars last about 7 days each. The fifth instar takes about 8 days before molting to the adult stage. Female adults are capable of laying over 260 eggs over their life spans.

**Damage symptoms:** This pest has piercing-sucking mouthparts which suck the plant sap causing whitish patches on leaves, much like the harlequin bug.

**Status as pest:** Sucking bugs, in general, are not nearly as important as the caterpillar complex. However, localized populations can build and cause considerable damage. Good field scouting is essential to detect this pest and to take appropriate action.

**Other remarks:** Two major natural enemies of the Southern green stink bug are a small parasitic wasp, (*Trissolcus basalis*) (page 16) that attack and kill the eggs, and a larger, orange and black “feather-legged” fly (page 15) that lays its eggs on the adult stink bug. These eggs hatch into small larvae that bore into the bug and eventually kill it. Other major egg predators include the fast-calling tree cricket and red imported fire ants.
There is a large group of predatory insects and spiders that attack various stages of insect pests of cole crops. These include, Damsel bugs and big-eyed bugs (photos above and below), ants, lady beetles, ground-dwelling beetles, earwigs and predatory crickets. These predators are at work day and night helping to protect the crop. Unnecessary chemical sprays kill these natural enemies and increase the chances for outbreaks of pests such as the diamondback moth. Microbial agents such as B.t do not kill these and other natural enemies. For this reason, these agents should be the first choice for caterpillar management.
Predators

FIRE ANTS

LADY BEETLE
Predators

JUMPING SPIDER

GREEN LYNX SPIDER
Predators

TREE CRICKET

EARWIG
As with predators, there are rich communities of parasitoids and insect pathogens that help to control insect pests naturally. Examples of these include the feather-legged fly (above) that lays eggs on stink bugs, and the developing fly larvae devour the insides of the insect pest. The cabbage looper (below) has been parasitized by a tachinid fly.
The feather-legged fly lays eggs on the southern green stink bug adult (see photo above) and the small fly larvae hatch, bore inside the adult and kill it. The fly larvae crawl outside, pupate in the soil and produce new flies in about a week. Other parasitoids lay eggs inside individual stinkbug eggs (below).
As with other animals, insects have diseases. The diamondback moth larvae, shown above, are infected with a granulosis virus. Viruses occur mainly in larvae of caterpillars such as the cabbage looper, the imported cabbageworm and the diamondback moth. The granulosis virus infects and kills the imported cabbageworm (photo below) and the cabbage looper. In addition, a number of fungi also infect and kill insect pests.
Cabbage and collard are not only affected by insect pests but also diseases. Although there are many diseases that affect them, only a few are prevalent or cause much damage. The first three diseases listed below will affect the leaves; downy mildew and Alternaria leaf spot may be seen each year. Black rot is not seen every year except where contaminated seed is used or poor crop rotation is practiced. Fusarium wilt disease is a warm-weather, soil-borne disease. If cabbage and collard are not grown during the summer months and if good crop rotation is practiced, this disease may not cause much of a problem. Damping-off and wirestem disease are related diseases and are caused by soil fungi.
**Black Rot** – This bacterial disease can be carried on seed, come from crop residue in the field, or come from weeds in or near the field. Warm, rainy weather favors this disease, and, under rainy, windy conditions like thunderstorms or hurricanes, it can be spread to almost every plant. It causes large V-shaped spots on the edges of the leaves. These spots have a yellow margin, and the veins in the spots are black. They will run together when the disease is severe causing the whole leaf to be blighted. In collard, yield can be greatly reduced because so many leaves have to be removed. Cabbage can escape damage sometimes, because the disease is mainly on the outer leaves.
Downy Mildew – This fungus disease is favored by cool temperatures and rainy or foggy weather. It is mainly a problem in the early spring and late fall when the temperatures are ideal. It can be worse on heavily fertilized crops and in wet or shady areas of the field. It causes yellowish spots on the upper sides of leaves with a blackish “netted” area under these spots. During wet periods or early in the morning, a whitish “mold” can be seen on the spots on the bottoms of the leaves.
Fusarium Wilt – This is a disease caused by a fungus that lives in the soil. It is often called “yellows”. It causes the plants to become yellow and stunted, sometimes on only one side. It also may cause the leaf mid-veins to be very curved giving the leaves a “crooked” appearance. It is a hot-weather disease and is usually only found in the summer months in fields that have a long history of cabbage or collard production. If it is severe, the plants are too stunted or yellowed to be marketable.
Damping-off/Wirestem – This disease will reduce stand (damping-off) or cause stunted plants (wirestem). Although damping-off can be caused by several fungi, the most common cause of damping-off also causes wirestem. During cool, wet weather in the spring, emerging seedlings or small transplants can be killed by damping-off fungi. Wirestem is not common in the cooler months of spring. In late summer and fall when the weather is warm, damping-off can also kill emerging seedlings, although the fungus causing the problem is usually different from the spring. At this time of the year, transplants can also be affected. They may recover leaving a thin, wire-like portion of the lower stem from which the disease gets its name. The plants usually remain stunted and are unmarketable.
**Alternaria Leaf Spot** – This is a warm season fungus disease. Like most fungus diseases, it is favored by wet weather. Crowding the plants or having a lot of weed growth which reduces air circulation can make this disease worse. It is often seen on mature plants in the spring crop and can be found on both young transplants and mature plants in the fall crop. It causes large, grayish-black spots on the leaves often down near the stem. The spots will have rings in them like targets.
Field sampling is a key element in any cabbage and collard IPM program. Insect pests, diseases and weeds are major problems in cabbage and collard production. Insect pests are probably the most important constraint to production of a marketable head of cabbage or bunch of collard. How can growers meet market demands for cabbage and collard without an over-reliance on the use of pesticides? The simple answer is “Field Sampling”.

**What is Field Sampling?** Sampling is a systematic examination of a crop for pests, damage by pests, and natural enemies. Well-conducted field sampling will provide the grower with a good idea of what type of pest is present, how many there are, and the life stages of these pests. It also gives a good idea of beneficial insect populations in the field. With this information, the grower can make an informed decision about whether or not to spray if the established economic threshold for the particular crop is reached.

**Economic Threshold:** Economic threshold is based on the concept that plants can tolerate a certain amount of some pests without causing economic loss. Therefore, if you scout a field and find pests below the established economic threshold, you do not have to spray. Remember, every time you spray, there is a cost involved; therefore, if the pest population is below the economic threshold, the cost to spray will be greater than the returns.

**How do I sample a field?** A sampling program is only as good as the samples that make up the program. Always try to get a good rep-
resentative sample of the plants in the field. In other words, do not select only big or small plants to check for pests. Field shape is important in sampling. Pests such as the diamondback moth prefer the edges of fields. If the field is narrow, most of the samples should come from the borders of the field. However, if the field is square or rectangular most of the samples should come from the interior of these fields.

Do not intentionally pick plants with insect damage. Select a plant far enough ahead of yourself that you can’t see damage. Research has shown that sampling groups of five consecutive plants in a row is much faster than sampling five widely separated plants and that the population estimate is no different. Your “sampling site” should then be five plants together in a row.

Walk a “zig-zag” (see figure 1 on next page) path through the field picking sampling sites near the edges in long narrow fields or sampling sites in the interior for square or irregularly-shaped fields.

**How often should I sample a field?**

Cabbage or collard fields should be sampled **two (2) times per week**. If this is not possible, the field must be sampled at least one time per week, but there is a risk that an insect pest could cause damage above the economic threshold during this time.

**What do I look for?**

Plants should be examined for pests such as plant lice (aphids), caterpillars, beetles, or bugs. Start at the bottom of the plant looking carefully on the undersides and tops of the leaves.
Figure 1. Suggested walking pattern for field sampling.

Take random samples from throughout the field using the suggested walking pattern. You can use a different walking pattern, but make sure all sections of the field are sampled. Sample sites along the path should consist of five consecutive plants in one row.
**Sample Size:**

A minimum of 20 plants should be sampled. Then consult the sampling chart to see if an application of insecticide is needed. This sampling chart is designed for **sequential sampling**. This type of sampling allows an informed decision to be made with fewer samples requiring much less time. Rather than estimating the pest population, the population is classified as damaging or non-damaging. The minimum number of plants needed to make a decision is 20, so look at four groups of five plants each. One group should be on each leg of the “W” sampling pattern. If the field is long and narrow, your groups should be near the edge. If the field is square or irregular, take more samples toward the interior of the field.

Use the following sampling data sheet as a guide for making spraying decisions:

To use the sheet, make a mark in the **Damaged plants with larvae** column each time you find a damaged plant with a caterpillar on it. Keep the total number of damaged plants with caterpillars in the **Cumulative total of damaged plants** column. After the 20th sample, compare your total number with the numbers shown in the **Low limit**, **Continue Sampling** and **High Limit** columns to the right. If the total number is 0 or less than the number shown in the **Low limit** column, you can stop sampling and you don’t need to treat the field now. If the number is higher than the number shown in the **High limit** column, you can stop sampling and treat the field. If number is equal to or between the numbers shown in the **Continue sampling** column, you will need to continue sampling until a decision is reached. If a decision hasn’t been reached by the 45th sample, check again in two days.
## Sampling Form For Insects of Cabbage and Collard

**Field:**________  **Date:**__

| Sample No. | Damaged plants with larvae | Cumulative total of dam. plants | D T O N’E T A T | Low limit | Continue sampling | High-limit | T R E A T |
|------------|----------------------------|---------------------------------|----------------|-----------|-------------------|-----------|
| 1          | X X X                      |                                 |                |           |                   |           |
| 2          | X X X                      |                                 |                |           |                   |           |
| 3          | X X X                      |                                 |                |           |                   |           |
| 4          | X X X                      |                                 |                |           |                   |           |
| 5          | X X X                      |                                 |                |           |                   |           |
| 6          | X X X                      |                                 |                |           |                   |           |
| 7          | X X X                      |                                 |                |           |                   |           |
| 8          | X X X                      |                                 |                |           |                   |           |
| 9          | X X X                      |                                 |                |           |                   |           |
| 10         | X X X                      |                                 |                |           |                   |           |
| 11         | X X X                      |                                 |                |           |                   |           |
| 12         | X X X                      |                                 |                |           |                   |           |
| 13         | X X X                      |                                 |                |           |                   |           |
| 14         | X X X                      |                                 |                |           |                   |           |
| 15         | X X X                      |                                 |                |           |                   |           |
| 16         | X X X                      |                                 |                |           |                   |           |
| 17         | X X X                      |                                 |                |           |                   |           |
| 18         | X X X                      |                                 |                |           |                   |           |
| 19         | X X X                      |                                 |                |           |                   |           |
| 20         | 0 1—5 >5                  |                                 |                |           |                   |           |
| 21         | 0 1—5 >5                  |                                 |                |           |                   |           |
| 22         | 0 1—5 >5                  |                                 |                |           |                   |           |
| 23         | 0 1—5 >5                  |                                 |                |           |                   |           |
| 24         | 0 1—5 >5                  |                                 |                |           |                   |           |
| 25         | 0 1—5 >5                  |                                 |                |           |                   |           |
| 26         | 0 1—6 >6                  |                                 |                |           |                   |           |
| 27         | 0 1—6 >6                  |                                 |                |           |                   |           |
| 28         | <2 2—6 >6                 |                                 |                |           |                   |           |
| 29         | <2 2—6 >6                 |                                 |                |           |                   |           |
| 30         | <2 2—6 >6                 |                                 |                |           |                   |           |
| 31         | <2 2—6 >6                 |                                 |                |           |                   |           |
| 32         | <2 2—7 >7                 |                                 |                |           |                   |           |
| 33         | <2 2—7 >7                 |                                 |                |           |                   |           |
| 34         | <2 2—7 >7                 |                                 |                |           |                   |           |
| 35         | <3 3—7 >7                 |                                 |                |           |                   |           |
| 36         | <3 3—7 >7                 |                                 |                |           |                   |           |
| 37         | <3 3—7 >7                 |                                 |                |           |                   |           |
| 38         | <3 3—7 >7                 |                                 |                |           |                   |           |
| 39         | <3 3—8 >8                 |                                 |                |           |                   |           |
| 40         | <3 3—8 >8                 |                                 |                |           |                   |           |
| 41         | <3 3—8 >8                 |                                 |                |           |                   |           |
| 42         | <4 4—8 >8                 |                                 |                |           |                   |           |
| 43         | <4 4—8 >8                 |                                 |                |           |                   |           |
| 44         | <4 4—8 >8                 |                                 |                |           |                   |           |
| 45         | <4 4—8 >8                 |                                 |                |           |                   |           |

Sample at least 2 times per week.  Take a minimum of 20 samples.  Count only damaged plants with live larvae.  Spray decision based on threshold results from table.
Pest control probably represents the highest portion of vegetable crop production costs. Reasons for this are the rising cost of pesticides and market requirements. Proper calibration of spraying equipment is an important step in any pest management program, whether conventional or IPM-based. Listed below are some of the advantages of sprayer calibration:

Saves money

Provides more effective pest control

Reduces pesticide use—less waste, uses rates recommended by the pesticide label

Reduces the number of spray applications per crop

Minimizes risks of damage to natural enemies such as honey bees and other beneficial insects

Reduces damage to the environment

Reduces human health risks

Ensures effective use of equipment.

To get the best results from pesticide applications, growers should make sure that their sprayer is properly calibrated at the beginning of each growing season.

Growers who need assistance with calibration of their sprayer should contact their local county extension office.
What is Insecticide Resistance?
The process by which an insect can change so that chemicals that once would have killed it are no longer able to affect it.

How does Insecticide Resistance occur?
Insects can change by a process called mutation. Sometimes these changes will result in the ability to resist the effects of a pesticide. These insects then will reproduce producing a population in which many individuals are no longer affected by the pesticide.

How does Insecticide Resistance affect me?
Resistant insects are no longer affected by a particular pesticide. Thus, the pesticide used will no longer be effective. The grower loses not only money spent on the pesticide but also suffers crop losses from the resistant insects.

What can I do to prevent or reduce Insecticide Resistance?
Use scouting and economic thresholds to determine the need to apply insecticides. Do not expose insects to any more insecticide applications than necessary. Do not “calendar” spray.

Rotate the classes of insecticide used between insect generations (about every three to four weeks). Learn about insecticide classes.

Choose insecticides that do not affect natural enemies. These include B.t. products; let natural enemies help manage pest populations.
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Photograph on page 15, courtesy of Dr. Powell Smith, Entomologist, Edisto Research and Education Center, Blackville, S.C.

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