

POCKET FIELD GUIDE TO
ASIATIC
GARDEN BEETLE

WITH EMPHASIS ON
GREAT LAKES FIELD CROPS



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Dedication: This flip book is dedicated to Bruce MacKellar, Michigan State University Extension Educator for Southwest Michigan. Bruce's observations, grower contacts, and field locations were invaluable to our work on AGB.

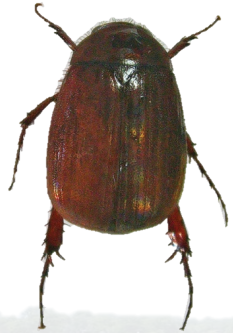
Cover photo taken by A. Pekarcik, USDAARS

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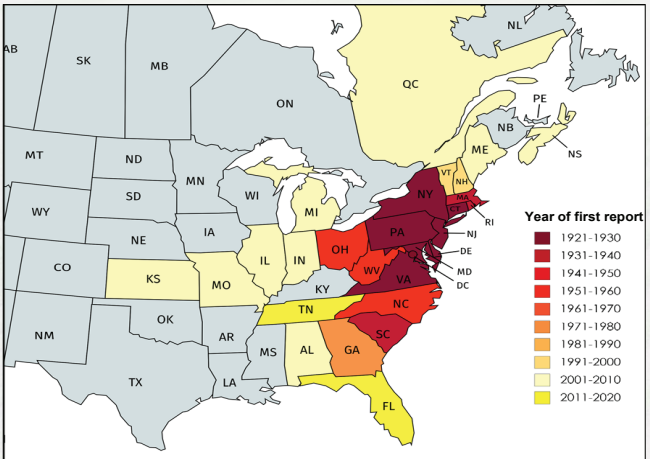
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INTRODUCTION

Asiatic Garden Beetle or AGB (formerly *Maladera castanea*, now *Maladera formosae*) is a scarab beetle (right) native to east Asia. It was first detected in New Jersey in 1921 and became established in the Mid-Atlantic U.S. It initially spread southward down the Atlantic coast, then rapidly west into the Great Lakes region and beyond as shown in the distribution map below.



G. Parsons, Michigan State University, Arthropod Collection

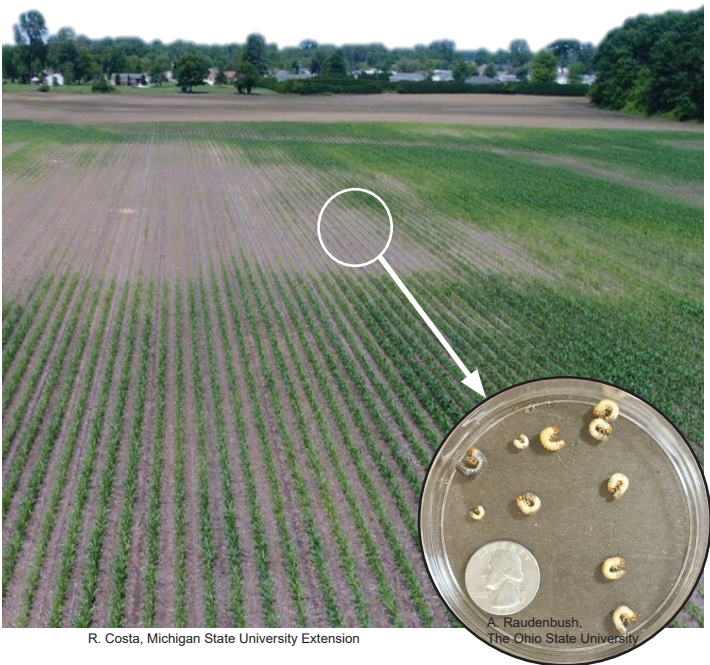


A. Pekarcik, USDAARS

Created with mapchart.net ©

INTRODUCTION

After its introduction into the U.S., AGB was a pest primarily due to the adult beetles defoliating vegetables, fruit, ornamentals, and nursery plants. Compared to other scarabs like Japanese beetle, AGB larvae (grubs, pictured below) are considered a minor pest of turf. But since 2007, grubs have been reported as a pest of multiple field crops in parts of northern Indiana, southern Michigan, and northern Ohio, causing stand variability and loss.



R. Costa, Michigan State University Extension

AGB ADULT IDENTIFICATION

- $\frac{1}{3}$ inch long
- Barrel-shaped
- Iridescent, chestnut brown
- Last few segments of abdomen are often exposed beyond wings
- Underside of each abdominal segment with yellow hairs
- Night active, hiding below soil surface during the day
- Fly only on warm nights ($>70^{\circ}\text{F}$)
- Highly attracted to lights



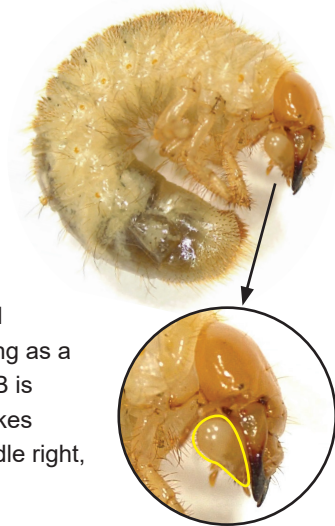
G. Parsons, Michigan State University,
Arthropod Collection



AGB adults
gathered under a
light in Southern
Michigan.

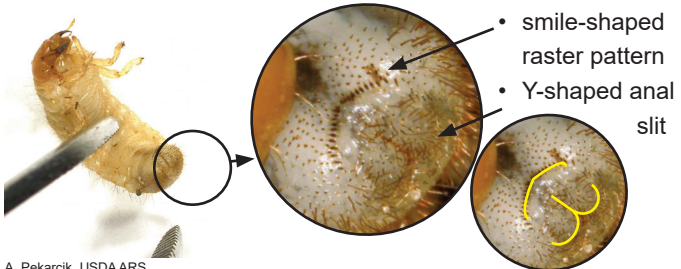
AGB GRUB IDENTIFICATION

- Up to $\frac{3}{4}$ inch long
- C-shaped (top right)
- Cream colored body with orangish head capsule
- Very active compared to other grub species (crawls almost immediately when picked up)
- Aggressive (may bite)
- Mouthparts have an enlarged structure on the jaw, appearing as a white bulb on its 'cheek' (AGB is the only grub in the Great Lakes region with this feature) (middle right, outlined in yellow)



A. Pekarcik, USDA ARS

Scarab grubs can also be identified by their rear ends using raster (hair) patterns; however, this is difficult to do in the field due to AGB active and aggressive behavior.



A. Pekarcik, USDA ARS

LOOK-A-LIKE SCARABS

Several other scarab beetles commonly co-occur with AGB in crops and fields.

FALSE JAPANESE BEETLE *STIGODERMA ARBICOLA*



G. Parsons, Michigan State University,
Arthropod Collection

- Found in same fields as AGB, but emerges 1-2 weeks earlier

JAPANESE BEETLE *POPILLIA JAPONICA*

- Adults can be found in same fields as AGB, but grubs rarely co-occur



G. Parsons, Michigan State University,
Arthropod Collection

ORIENTAL BEETLE *ANOMALA SP.*

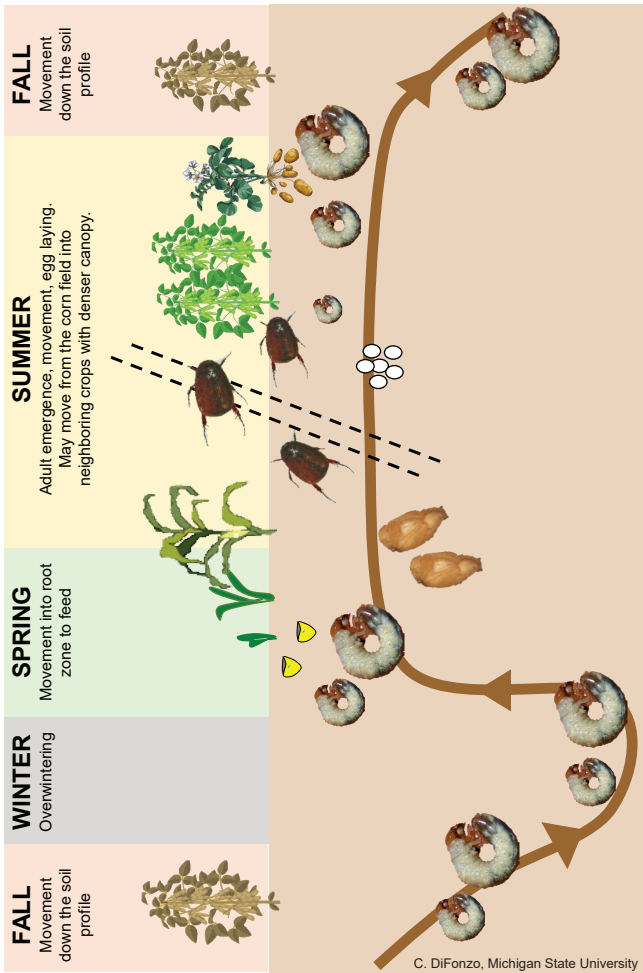


G. Parsons, Michigan State University,
Arthropod Collection

- Adults are smaller than AGB

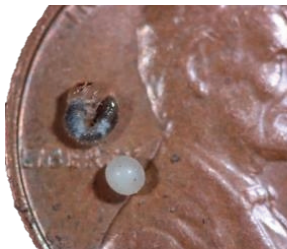


TYPICAL AGB LIFE CYCLE IN CORN



TYPICAL AGB LIFE CYCLE IN CORN

AGB is an annual grub, completing its life cycle (egg, three larval stages or 'instars', pupa, adult) in one year. An infestation in corn in the spring starts the previous summer, when adult beetles lay eggs in the previous crop. Beetles prefer to hide out and lay eggs under a shaded canopy. Thus, infestations in corn most often occur after soybean or potato (or other hosts with dense canopies) and less so after corn or wheat stubble.



C. DiFonzo, Michigan State University

Clusters of eggs are laid in the soil and hatch in approximately 10 days (left). Tiny 1st instars are present by August (left). They feed on root hairs and organic residue in the soil.

By late summer into early fall, both 2nd and 3rd instars (right) are present. The percentage of each differs by field, with some locations having mostly 3rd instars, and other fields having a mixture of both stages.



A. Pekarcik, USDA ARS

TYPICAL AGB LIFE CYCLE IN CORN

Grubs feed until soil temperatures drop, then move as far as 12 inches down into the soil profile to overwinter. As the soil warms in the spring, grubs move back up into the top six inches of soil to feed and complete development. Crop injury occurs at this time, when grubs attack germinating seeds (pictured below) or prune roots of emerging plants. The damage period is likely longer and more intense in fields with a higher proportion of 2nd instars, which have a longer time left to develop and feed compared to grubs already in the 3rd (and last) instar.



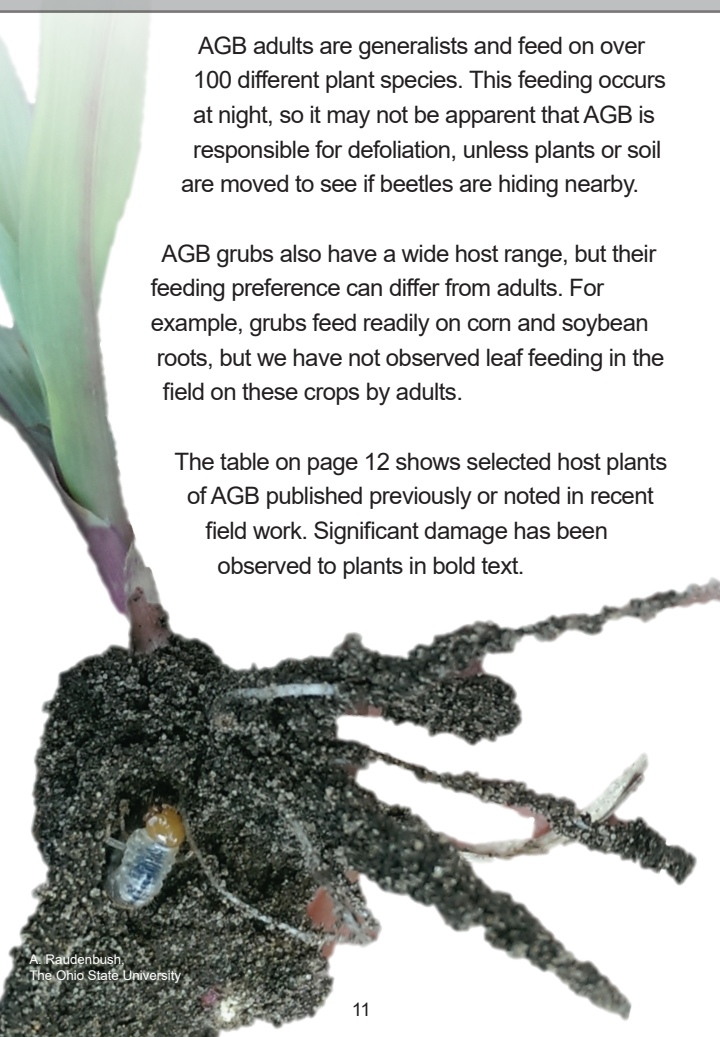
C. DiFonzo, Michigan State University

Grubs stop feeding and pupate (pictured below, right) beginning in late May. The first adults emerge in late June. Adults hide during the day in the soil or under hosts, emerging at night to feed and mate. Flight occurs only on warm nights above 70°F. In corn, beetles tend to move out of the field into weedy borders and neighboring fields with a dense canopy for egg laying, starting the next generation.



C. DiFonzo,
Michigan State University

SELECTED AGB HOST PLANTS

A photograph showing the root system of a plant, likely a corn plant, with a large, light-colored grub (AGB grub) visible in the soil. The grub is positioned near the roots, which are dark and fibrous. The soil is dark and moist.

AGB adults are generalists and feed on over 100 different plant species. This feeding occurs at night, so it may not be apparent that AGB is responsible for defoliation, unless plants or soil are moved to see if beetles are hiding nearby.

AGB grubs also have a wide host range, but their feeding preference can differ from adults. For example, grubs feed readily on corn and soybean roots, but we have not observed leaf feeding in the field on these crops by adults.

The table on page 12 shows selected host plants of AGB published previously or noted in recent field work. Significant damage has been observed to plants in bold text.

SELECTED AGB HOST PLANTS

| PLANT TYPE | ADULT HOST | GRUB HOST |
|-------------|---|---|
| CROPS | basil beets bell pepper carrot eggplant turnips | alfalfa blueberry cabbage corn mint potato soybean |
| ORNAMENTALS | aster chrysanthemum dahlia hosta lavender rose sunflower | turf |
| WEEDS | goldenrod lambsquarters maretail Palmer amaranth ragweed wild carrot | hawkweed maretail |

AGB INFESTATIONS AND SOIL TYPE

The key risk factor for AGB in field crops in the Great Lakes region is coarse-textured soil. AGB populations tend to be greater, and significant damage more frequent, in sandy fields or parts of fields, as in this 'beachy' looking section of a field in Ohio in the image below.

For thousands of years, glaciers moved and ancient lake levels rose and fell across the region. This history results in complicated soil maps, even at the individual field level, which include areas of sand from glacial outwash or old shorelines.



A. Raudenbush, The Ohio State University

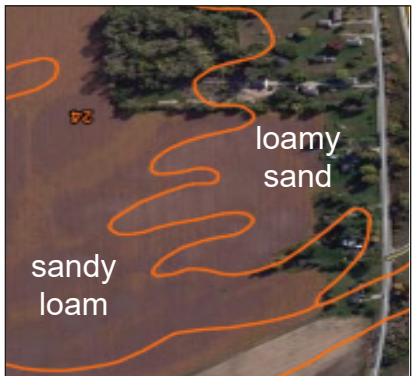
AGB INFESTATIONS AND SOIL TYPE

Many fields in Michigan, northern Indiana, and northern Ohio have sandy hills or ridges that are AGB hot spots year-after-year.



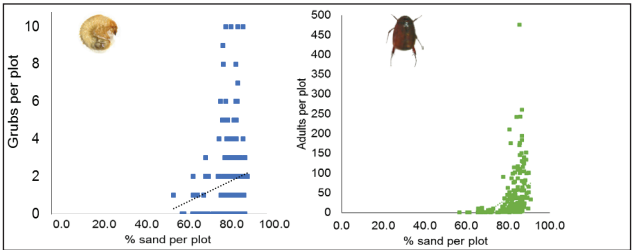
R. Costa, Michigan State University Extension

For example, stand loss in a field in Southern Michigan (above) occurred on sand ridge 'fingers' visible on the USDA-NRCS soil map (right), where AGB numbers were very high.



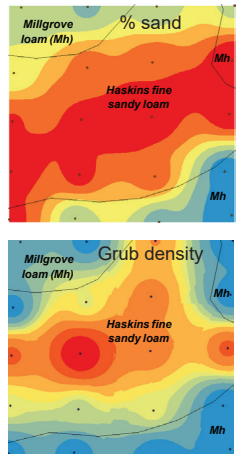
AGB INFESTATIONS AND SOIL TYPE

Grid sampling of fields in Ohio and Michigan with a history of AGB infestation showed that higher grub numbers occur in areas with more sand (below, left). Adult emergence follows the same trend (below, right). Risk increases greatly when sand content is $>75\%$.



A. Pekarcik, USDAARS

Another way to visualize the relationship between AGB and soil sand content is with heat maps. The images on the right show a field in Henry County, Ohio, that was sampled for AGB grubs. On the top is a heat map showing areas of the field with low (blue) and high (red) amounts of sand. On the bottom is a heat map showing areas of the same field with few (blue) and many (red) grubs sampled. The AGB hot spot, where grub numbers are highest, coincides with the sandy ridge.



A. Pekarcik, USDAARS

SIGNS AND SYMPTOMS OF AGB IN CORN: ROOT INJURY

AGB grubs eat residue and organic matter in the soil, but they also feed on the radicles and coleoptiles of germinating seeds underground (left). This can kill plants before they emerge. If seedlings do emerge in infested fields, their roots continue to be eaten. Grubs prefer to feed on fine peripheral roots away from the central root mass (right) but in severe cases, the entire root system is gone.



C. DiFonzo, Michigan State University



C. DiFonzo, Michigan State University

SIGNS AND SYMPTOMS OF AGB IN CORN: DEFICIENCIES

Deficiency symptoms are often visible in AGB infested fields, especially on sandy hills.

Root pruning from AGB feeding results in yellowing (below) due to nitrogen deficiency.



C. DiFonzo, Michigan State University

Purpling (right) results from phosphorus deficiency or the build-up of sugars in the leaves due to poor root growth.

Deficiency symptoms disappear if the roots outgrow larval pruning, or once the grubs stop feeding and pupate in June.



A. Pekarcik, USDAARS

SIGNS AND SYMPTOMS OF AGB IN CORN: STAND LOSS

AGB grubs consume plants before they emerge from the ground or kill seedling by repeatedly pruning off roots. This can result in scattered missing plants (below, left) or small patches of loss (below, right).



C. DiFonzo, Michigan State University



C. DiFonzo, Michigan State University

Widespread stand loss from AGB is uncommon, but can occur under heavy grub pressure. The field below (in southeast Michigan) suffered significant stand loss in sandy areas which had over 20 grubs per ft².



R. Costa, Michigan State University Extension

SIGNS AND SYMPTOMS OF AGB IN CORN: STAND VARIABILITY

A very common symptom of AGB infestation is stand variability, which can occur even under moderate grub numbers. A field may be at its target plant population, but differential patterns of root feeding result in uneven emergence and growth. Adjacent plants can differ greatly in height and maturity (below).



C. DiFonzo, Michigan State University



C. DiFonzo, Michigan State University

During vegetative growth, injured plants can be up to four stages behind in maturity of surrounding plants and show deficiency symptoms.



C. DiFonzo, Michigan State University

SIGNS AND SYMPTOMS OF AGB IN CORN: 'HIDDEN' YIELD LOSS

Maturity differences resulting from AGB root feeding early in the season continue into later stages and eventually affect yield. Plants behind by several vegetative stages remain behind in the reproductive stages, pollinating out-of-synch of the surrounding crop.



C. DiFonzo, Michigan State University

This type of yield loss is not very apparent, since there is no actual stand loss, simply unevenness that is hard to pick out through scouting later in the season. The image to the left shows three plants in mid-June. Below are the ears from the same plants in mid-August.



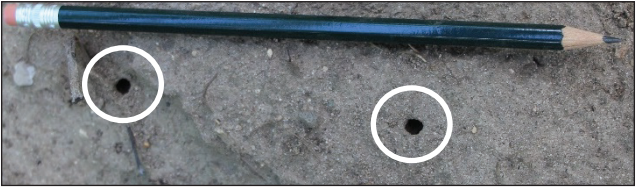
C. DiFonzo, Michigan State University



C. DiFonzo, Michigan State University

SIGNS AND SYMPTOMS OF AGB IN CORN: DEAD BEETLES

In field with heavy AGB infestations, emergence holes (the diameter of a #2 pencil) are often numerous in June (circled in white, below).



C. DiFonzo, Michigan State University

Dead beetles may also be present and litter the ground.



C. DiFonzo, Michigan State University

SIGNS AND SYMPTOMS OF AGB IN CORN: DEFOLIATION OF WEEDS

AGB adults emerging from infested fields do not feed on corn. They move to field edges and feed on many weeds including ragweed, lambsquarters, and wild carrot.

Noticeable stripping of leaves (shown below) gives plants a ragged appearance and may be a sign that the AGB population is heavy in adjacent fields.



C. DiFonzo, Michigan State University



C. DiFonzo, Michigan State University



Beetles hide during the day under weed hosts. Notice the many beetles in the soil under this giant ragweed plant.

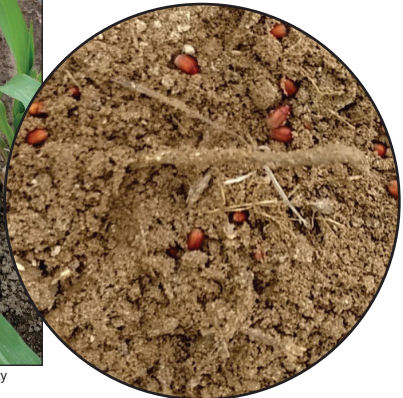
SIGNS AND SYMPTOMS OF AGB IN CORN: INFESTATION OF MARESTAIL

Marestail (horseweed) is a particular favorite for AGB adult feeding. Beetles defoliate entire stems, unfortunately leaving the seed head.



An easy way to confirm AGB in a field is simply to pull up marestail plants and look for beetles. The plant on the left had dozens of beetles hiding under it during the day (below).

AGB grubs have also been found under marestail in the fall and spring, and pupae have been found in the summer.

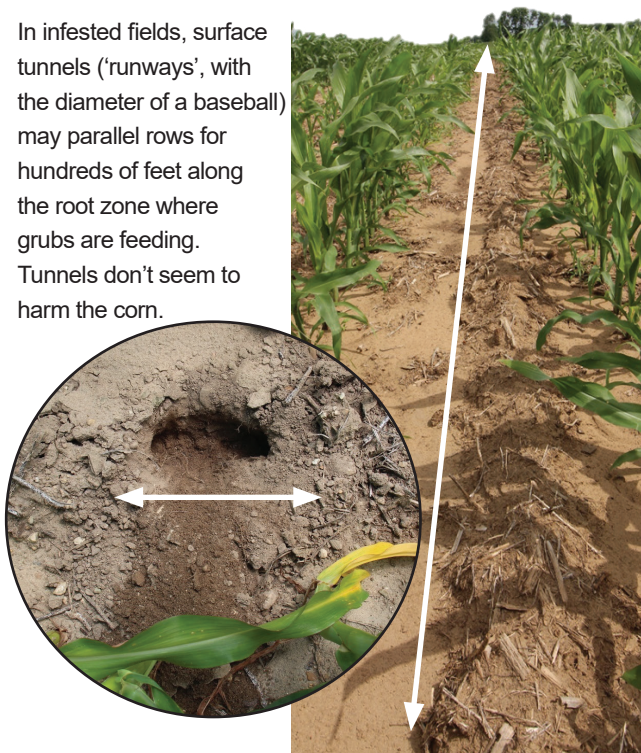


B. MacKellar, Michigan State University
Extension

SIGNS AND SYMPTOMS OF AGB IN CORN: MOLES

AGB infested corn fields often have signs of moles, which eat their weight in worms and insect larvae each day. The sandy locations favored by AGB also make it easy for moles to move through the soil.

In infested fields, surface tunnels ('runways', with the diameter of a baseball) may parallel rows for hundreds of feet along the root zone where grubs are feeding. Tunnels don't seem to harm the corn.



C. DiFonzo, Michigan State University

AGB GRUB SAMPLING

An effective way to sample for AGB grubs is using a golf course hole cutter (right). It takes a soil core that is $1/10^{\text{th}}$ of a square foot, allowing for comparison of grub densities in different fields or plots. However, a cup cutter is expensive and may be hard to find, so most of the time, scouting will be done with a shovel.



C. DiFonzo, Michigan State University

To sample, go to an area in the field where you suspect AGB grubs to be present. Take a core using the golf hole cutter (or shovel). Empty the sample onto a tray where the core can be deconstructed and number of grubs can be counted.



A. Raudenbush, The Ohio State University

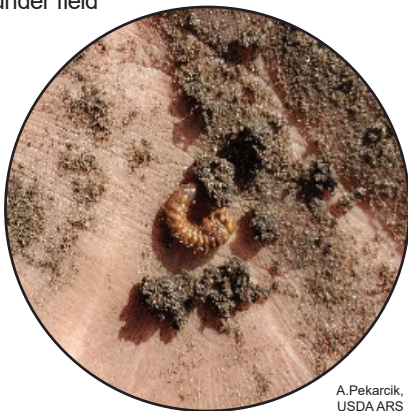
AGB NATURAL ENEMIES

No natural enemies specific to AGB grubs have been found in field crops to date, but many generalist species attack them. Besides vertebrates like moles, skunks, and sandhill cranes, predatory insects in the soil, like ground beetles (right), rove beetles, and ants, likely eat AGB eggs and grubs under field conditions.



A. Raudenbush, The Ohio State University

Grubs infected with entomopathogenic (insect-killing) bacteria, fungi, and nematodes occasionally are found during field sampling. These generalist pathogens infect many species of insect larvae in the soil, not just AGB. Nematodes isolated from AGB infested fields caused 30-40% mortality of AGB grubs in controlled studies. They may provide background mortality under field conditions, but do not control heavy AGB infestations.



Right: A diseased grub found during soil sampling in Ohio.

A. Pekarcik,
USDAARS

AGB MANAGEMENT IN CORN

AGB management is difficult and options are not well tested since infestations are sporadic and often limited to sections of a field.

| PRACTICE | IMPACT |
|-------------------|--|
| SEED TREATMENTS | Limited or no impact to date. <ul style="list-style-type: none">• All pictures of damaged corn in this guide were taken in seed-treated fields |
| SOIL INSECTICIDES | Mixed results with products tested to date <ul style="list-style-type: none">• Dead grubs observed in treated areas, but the number of grubs was not reduced compared to untreated strips• Emergence of adult beetles is often reduced in treated areas. This helps only if egg laying is primarily back into the same field (which often isn't the case) |
| ADULT SPRAYS | No evidence that this practice is effective <ul style="list-style-type: none">• Spraying must be done the previous season before corn is planted• Timing would be difficult• Multiple sprays required |

Right: A dead grub near the base of a plant treated with soil insecticide.



C. DiFonzo, Michigan State University

AGB MANAGEMENT IN CORN

| PRACTICE | IMPACT |
|--------------|---|
| TILLAGE | Evidence is mixed <ul style="list-style-type: none">• Tillage disrupts grubs in the soil, but grubs may be below the tillage line in fall and spring• Infestations occur in both tilled and no-till fields |
| WEED CONTROL | Might reduce egg laying in the prior crop <ul style="list-style-type: none">• Particularly important to control marestail which is very attractive for adult feeding |
| COVER CROPS | Some positive observations <ul style="list-style-type: none">• Dense roots may hide germinating plants from grubs; the residue is an alternative food source• Likely fits in cropping systems where cover crop use is routine. |



C. DiFonzo, Michigan State University

SIGNS AND SYMPTOMS OF AGB: IN SOYBEAN

AGB infestations are reported less often in soybean than in corn, but root injury can be severe; cotyledons may be entirely clipped.



C. DiFonzo, Michigan State University

Soybean stands can compensate for damaged plants with additional growth of neighboring plants. Thus, AGB damage may go unnoticed unless there is obvious thinning of stand apparent in scouting or from the roadside, as on this infested sandy hill in northern Indiana (below).



C. DiFonzo, Michigan State University

SIGNS AND SYMPTOMS OF AGB: IN ALFALFA

Alfalfa and mint are at risk for AGB infestation. Signs include thinning stand, especially on sandy knolls, as in this field in southwest Michigan (below).



C. DiFonzo, Michigan State University

Note the increased weediness on top of the hill where the alfalfa died or grew poorly due to root feeding.

SIGNS AND SYMPTOMS OF AGB: IN VEGETABLE PRODUCTION

Grubs feed on vegetables seeded directly or transplanted into raised beds.

Grub activity can start earlier in beds covered with black plastic, which raises the temperature of the soil. Raised beds may also increase grub survival by elevating them above water-logged soil conditions.



C. DiFonzo, Michigan State University

Potatoes are often grown in the same coarse-textured soils favored by AGB, and the dense canopy attracts adults for egg laying. Damage occurs in the weeks after eggs are laid, when grubs chew holes into tubers. Tubers damaged in this way cannot be sold for the fresh market or chipping, resulting in significant culling and economic loss for the grower.



C. DiFonzo, Michigan State University



C. DiFonzo, Michigan State University

SIGNS AND SYMPTOMS OF AGB: ADULT FEEDING

In field crops in the Great Lakes region, damage by grubs early in the season is the primary impact of AGB. But adult damage is still an issue in other crops and regions.

Right: defoliation and stand loss in a North Carolina cotton field.

Below: up close image of AGB adult foliage feeding.



Sent to D. Reisig,
North Carolina State University



Right: Severe feeding on a lavender oil crop in southern Michigan.



Sent to C. DiFonzo, Michigan State University

