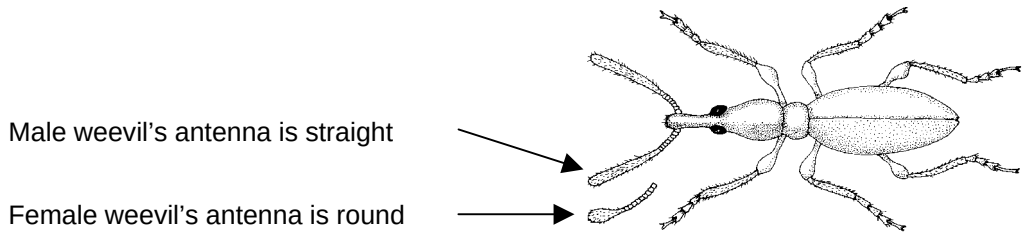
- How they may be controlled, how difficult this is and what it costs relative to the loss they are likely to cause?

We can classify sweetpotato pests into three major groups as follows: (1) root, leaf and stem damaging insect pests, (2) diseases, and (3) weeds. Each of these groups will be discussed in sections 4.5-4.7.

4.5.1 Sweet potato weevils (Cylas puncticollis and Cylas brunneus)

A. Biology and lifecycle

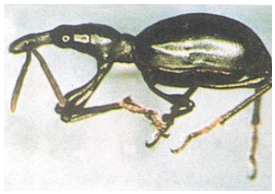
The sweetpotato weevil is a type of beetle; the adult stage is a black beetle that looks like a large ant. There are a number of species of sweet potato weevil; *Cylas puncticollis* and *Cylas bruneus* are the most common species in East Africa, while *Cylas formicarius* is the most abundant in North America and the Far East. *Cylas brunneus* is brown and smaller than the larger, black *Cylas puncticollis*, while *Cylas formicarius* is as small as *Cylas brunneus* but has a bluish-black abdomen and a red thorax. The male and female adult sweetpotato weevils can be told apart by the shape of their antennae. The antennae of the males are straight while those of the female are round or club-shaped (see diagram below). When an adult weevil is disturbed, it plays dead.



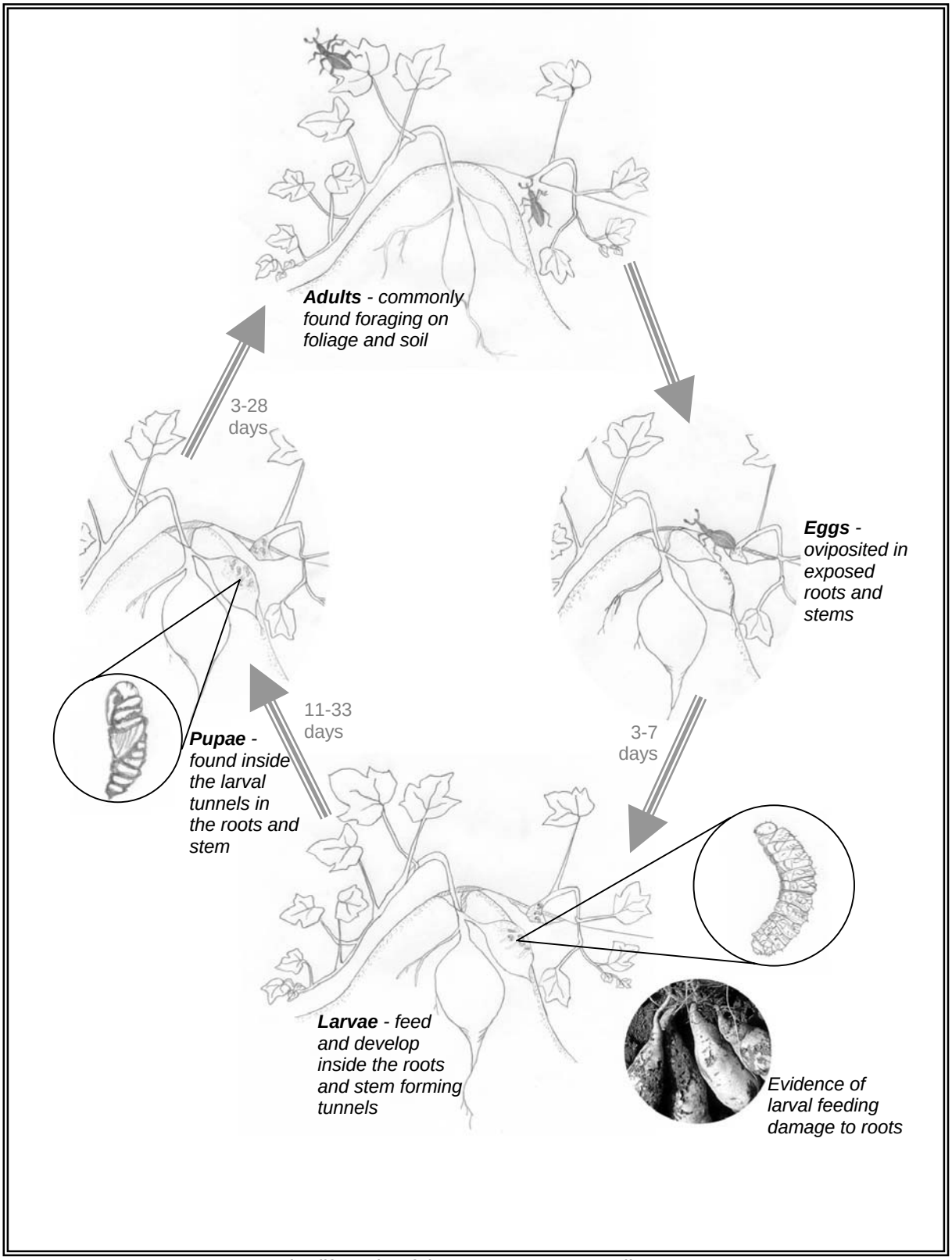

Sweetpotato weevil egg


Sweetpotato weevil larva


Sweetpotato weevil pupa


Adult sweetpotato weevil

The weevil has a life cycle of four stages: egg, larva, pupa and adult. The duration of each stage in the life cycle of the weevil depends mainly on temperature: the higher the temperature, the faster the development. After mating, the female sweet potato weevil lays eggs singly in holes that she has chewed in either the vines or exposed/ easily accessible roots of sweet potato. The female adult weevil can survive for 140 days, although most of her eggs are laid in the first 50 days of the adult stage, a female can produce 50-250 eggs. Eggs will hatch after 3-7 days (depending on the environmental conditions). The developing larvae which are legless, curved and white, tunnel while feeding within the vine or root and are the most destructive stage, larvae live for 11-33 days before pupating. Pupation takes place within the larval tunnels and adults emerge after 3-28 days. The development of the weevil from egg to adult takes 32 days on average. When the adult beetle emerges from the pupa, initially it is light brown in colour. It takes 6-8 days for the outer surface of the weevil to harden and become dark brown. Once this has occurred, the adult leaves the root zone in search of mates. High numbers of weevils in the foliage usually indicates that there is a high number in the root zone.



The lifecycle of the sweetpotato weevil

The female adult weevil produces a pheromone that attracts the male for mating. Male weevils are active at night; they move around on the foliage to search for females. During the day the weevils hide under leaves or in soil cracks. Although the females mate at night, they feed and lay eggs during the day. Their egg-laying behaviour depends on the growth stage of the sweetpotato crop.

B. Damage

The sweetpotato storage root is the preferred site for feeding and egg-laying. However, at the beginning of the growing season, when the plants have not yet produced any storage roots, the adult weevils live on the stem and leaves. The adult will feed on foliage, lay its eggs on the vines and leaves, and the larvae will feed in the stem or the leaf and pupate inside the vines. Plants may wilt or even die as a result of extensive stem damage, and damage to the vascular system can reduce the size and number of future storage roots.

As the plant gets older and starts to form storage roots, the weevils search for exposed ones. Most weevils (80-90%) can be found in the foliage from 10 cm above the soil surface to 15 cm below the soil. They cannot dig, so their penetration into the soil layer is limited, not allowing them to reach roots that are well buried. The only way for them to get to the roots is through cracks in dry soil. When an adult finds a root, it punctures the surface as it feeds. In addition to feeding punctures the female adults also make egg-laying punctures. The eggs are laid just below the surface of the root. The punctures containing eggs can be distinguished by their dark colour because the eggs are covered with a plug of weevil frass (insect excrement). Both the feeding and egg laying punctures lower the quality of the root, and can reduce the market price. If roots with egg punctures are stored, they will serve as a source of infestation for the clean roots stored beside them.

The larva, after hatching from the egg, will bore into the tissue of the root. While external damage to roots can affect their quality and value, internal damage can lead to complete loss. Even low levels of infestation can reduce root quality and marketable yield because the plants produce a bitter toxin, called a terpenoid, in response to *Cylas* weevil feeding. Sweetpotato weevils are a particularly serious problem under dry conditions, because the insects, which cannot dig, can reach roots more easily through cracks that appear in the soil as it dries out. It is for this reason that during the dry season, unlike cassava, sweetpotato roots cannot be stored in-ground for any significant period of time.

As sweetpotato weevils fly infrequently, and generally only for short distances ranging from 500 m (if there are sweetpotato plants) to 1,000 m (if there are no sweetpotato plants) newly planted fields are most likely to be infested via: planting material infested with eggs or larvae within the vines or adults hiding amongst the leaves; survivors in infested roots and residues from a preceding crop; immigrating *Cylas* spp. weevils from neighbouring fields or alternative host plants. The sweetpotato weevil has several host plants of the same plant family as the sweetpotato, for instance the water spinach plant, *Ipomoea aquatica.* The flowers of these plants resemble the flower of the sweetpotato. These plants can shelter weevils between planting seasons and serve as a source of weevil infestation when a new crop of sweetpotato is planted.

Damage caused by the different species of sweetpotato weevil is similar. More than one species may often be present in the same field or even the same root.

C. Natural Enemies

The natural enemies of the sweetpotato weevil include several kinds of predators, parasites and pathogens. The predators are the most easily observed of these. They include ants, earwigs, ground beetles and spiders. Ant nests from banana fields can be moved to the sweetpotato field to enhance predation.

A fungus (*Beauveria bassiana*) that commonly lives in the soil can infect and kill the weevil fairly effectively. This fungus is easily cultivated by trained individuals on coffee residue,

wheat and rice straw, and is commercially available in some countries. The fungal culture can be used for treating the planting material and the soil to reduce the weevil population.

D. Management

Chemical control is not effective because the weevils are protected for, at least part of their lifecycle by their development within roots or stems, where they are not easily reached by pesticides. Pesticides kill natural enemies that under natural circumstances quite effectively control weevil populations, and can also present health risks for humans and animals. In some countries planting materials are dipped into a synthetic pesticide before planting, which can delay pest infestation for several months, however most pesticides are expensive and highly toxic therefore dipping is only likely to be economical for large scale commercial root production or vine-multiplication nurseries.

Breeders have spent many years trying to develop varieties that are resistant to the weevil. So far they have not been successful. However, varieties that form roots relatively deep in the soil are less attacked because the weevils cannot easily reach the roots to lay eggs. Other varieties escape weevil damage because their storage roots mature quickly and can be harvested early.

Sweetpotato weevil sex pheromone is produced commercially in several countries. It is produced in a laboratory and applied to small rubber capsules that are placed in traps in the field. The rubber capsules should be placed above the foliage and covered to protect them from rain and sunlight. A container of soapy water is usually placed under the capsule. Male adults that are attracted by the sex pheromone fall into the pail of water and can easily be collected and removed from the field. These traps are useful for indicating how large the weevil population is. Unfortunately in Uganda, mass trapping using sex pheromone traps did not lead to a reduction in weevil damage to roots. In other countries where *Cylas formicarius* is the main pest species, mass trapping using sex pheromone traps is used. In Cuba the sex pheromone is often used together with an application of the fungus *Beauveria bassiana*. The fungus is applied on the soil surface beneath the sex pheromone trap or sprayed on the foliage around the trap. Weevils attracted to the sex pheromone will be infected by the fungus and killed after several days.

The most effective way to control the weevil is through cultivation practices aimed at preventing infestation, including:

- Sanitation of the field
  - removal and destruction (through burning or feeding to livestock) of infested vine and root residues, if vines are left in the field to help increase soil fertility, care should be taken to ensure they are dead and not able to sprout. If piecemeal harvesting of the crop is practiced care should be taken to remove and destroy any infested roots that are found.
  - removal of volunteer plants and alternative hosts,
  - crop rotation with other crops that are not hosts to sweetpotato weevils for 2-3 seasons if possible.
- Use of clean (uninfested) planting materials, especially vine tips. Weevils tend to lay eggs in the older woodier parts of the vine, so if the tender tips are used for planting they are less likely to be infested by weevils.
- Timely planting and prompt harvesting to avoid the dry period.
- Planting away from weevil-infested fields, and/or using barrier crop such as cassava, maize, bananas or sorghum planted around the perimeter in strips of at least 3-5 m in width between fields to restrict sweetpotato weevil migration.
- Flooding the field for at least 48 hours after completing harvest to drown weevils in the soil.
- Hilling up of soil around the base of plants to prevent or fill soil cracks. This practice not only protects the plants from weevil attack but can also result in increased crop yields.
- Applying sufficient irrigation to reduce/ prevent soil cracks.

- Mulching to keep the soil moist and prevent cracks, and provide a more favourable place for natural enemies. Care should be taken not to use a mulching material that weevils can feed or develop on.
- Piecemeal harvesting to remove the largest storage roots most at risk from weevil attack and subsequently hilling up the soil around the remaining roots to prevent sweetpotato weevils from being able to access the roots through cracks in the soil.

The results of some experiments with cultural practices for weevil control are shown in the table below.

Method	*Where tested*	*Result*
Hilling up	East Africa, Taiwan, Philippines, Vietnam, America, India, Cuba, Indonesia	Works well. Should be implemented before the adult weevil reaches the roots to lay eggs.
Early harvesting	East Africa, Vietnam, Cuba, Philippines, America	In Vietnam, harvesting 2 weeks earlier reduced the loss due to weevils from >30% to < 5%. Also good results in other locations.
Mulching	East Africa, Taiwan India, America	Use of mulches of plastic or rice straw reduced weevil damage. The soil surface should be covered soon after planting and the cover should be maintained until harvest. The mulch not only helps to retain soil moisture, but also prevents the weevils from gaining access to roots through soil cracks.
Intercropping	Philippines, India	In Taiwan, 103 different crops were tested as intercrops for weevil control. The best results were obtained with coriander.
Routine irrigation	Philippines, Taiwan, America, Vietnam, Indonesia	Effective because soil cracking is prevented. Most practical method for farmers with a reliable water supply.
Field sanitation	Taiwan, Philippines	Field sanitation can help to reduce weevil infestation if it is practiced in a larger ecosystem area or community. Infested roots must be buried >15cm underground.
Flooding of the field	Indonesia	Flooding of the field for >48 hours can kill the weevil larvae present in roots that have been left in the field.

4.5.2 Rough sweetpotato weevil (Blosyrus spp.)

A. Biology and lifecycle

Females lay batches of 15-25 pale yellow eggs close to the edge of the sweetpotato leaves, mostly at the tip. The leaf edges are folded around the eggs and attached so they are protected and not visible. Eggs are also found underneath fallen leaves. Development is temperature dependent. Eggs hatch after 7 days. The whitish, c-shaped larvae roll the leaves and drill themselves into the soil, head first and then search for food. After about 30 days pupation occurs in holes in the soil. The pupal stage lasts for about 20 days. Adult rough sweetpotato weevils are difficult to spot, as they are well camouflaged against the soil, they can be found on the ground underneath foliage during the day. The presence of purple to black frass, about 7 mm in diameter, is a sign of an abundance of rough sweetpotato weevils.