

## Small hive beetle (*Aethina tumida*) threat on the horizon

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### Abstract

Beekeeping is an agricultural industry that deals with breeding bees, obtaining honey, wax, and other products. Bees are used for pollination of many types of crops to increase their harvest. Beekeeping products are also used in medicine, pharmacology, chemical, and food industries. One of the essential aspects of successful beekeeping development is ensuring sustainable epizootic well-being from infectious and invasive bee diseases in Ukraine. About 3 million bee colonies are owned by private farms and amateur beekeepers, which give approximately 50–60 thousand tons of commercial honey and 1.2–1.4 thousand tons of wax per year at the current stage of beekeeping development in Ukraine. Honey and bee products from Ukraine received 15 prestigious awards in various categories at the 77th National Honey Show, held in London among many countries in 2008. In recent years, there has been a constant increase in the threat of new little-known invasive and infectious diseases that pose a significant danger to beekeeping worldwide. The invasion of the small hive beetle *Aethina tumida* belongs to quarantine and hazardous invasive diseases, which have destroyed many bee colonies in several countries worldwide (USA, Canada, African countries, Australia, some European countries – Italy, and Portugal). There are no effective methods of preventing and controlling the small hive beetle. The only way to prevent the invasion of the small hive beetle in Ukraine is constant monitoring and control at the state border of the movement of bee packages and bee products, which may pose a threat to introducing this invasive species into Ukraine.

**Keywords:** beekeeping in Ukraine; invasion; quarantine diseases; small hive beetle; differential diagnosis.

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## 1. Introduction

The small beehive beetle (*Aethina tumida*) is a species from the Nitidulidae family of glossy beetles. It is a beekeeping pest associated with honey bees in Africa, North America, and Australia. A hazardous quarantine facility (Jamal et al., 2021; Hall et al., 2021; Toledo-Hernandez et al., 2023).

The small hive beetle is one of the most dangerous bee parasites, as a mass infestation can destroy an entire colony quickly. Unlike the African honey bee subspecies, which can effectively defend itself against the small beetle, the European bee subspecies are less able to do so. Currently, available chemical means of control contain the risk of developing resistance, contamination of beekeeping products, and harmful effects on bees, animals, and humans. Alternative control measures are being developed (Eyer et al., 2009; Panel on Animal Health and Welfare, 2015; Biolley et al., 2018). Beetle infestation is notifiable in Germany. It is also

classified as a notifiable animal disease in other EU countries and Switzerland.

## 2. Results and discussion

### Historical reference

The small beehive beetle (*Aethina tumida*) was first described in 1861 by the Scottish entomologist Andrew Murray (1812–1878), and its biology was first described in more detail in 1940 by the researcher Lundy A. E. in South Africa (Lundie, 1940).

### Distribution and economic losses

*Aethina tumida* (small beehive beetle) was previously known only in Tropical Africa (south of the Sahara desert). However, it has recently been imported to the USA (where it was first discovered in 1996), Canada (2002), Australia (since 2002), and Europe (2003). In Australia, it was found in bees in New South Wales and Queensland. In Canada, it was found in bees in the following provinces: Manitoba

(2002 and 2006), Alberta (2006), Quebec (2008, 2009), and Ontario (2010). The combination of the import of queen bees from other countries and bee families (packets) caused a significant spread of *Aethina tumida* (Hood, 2004; Neumann & Elzen, 2004).

In 1998, approximately 5,000 families of honey bees died from the small hive beetle in Florida (USA) (Toledo-Hernandez et al., 2021).

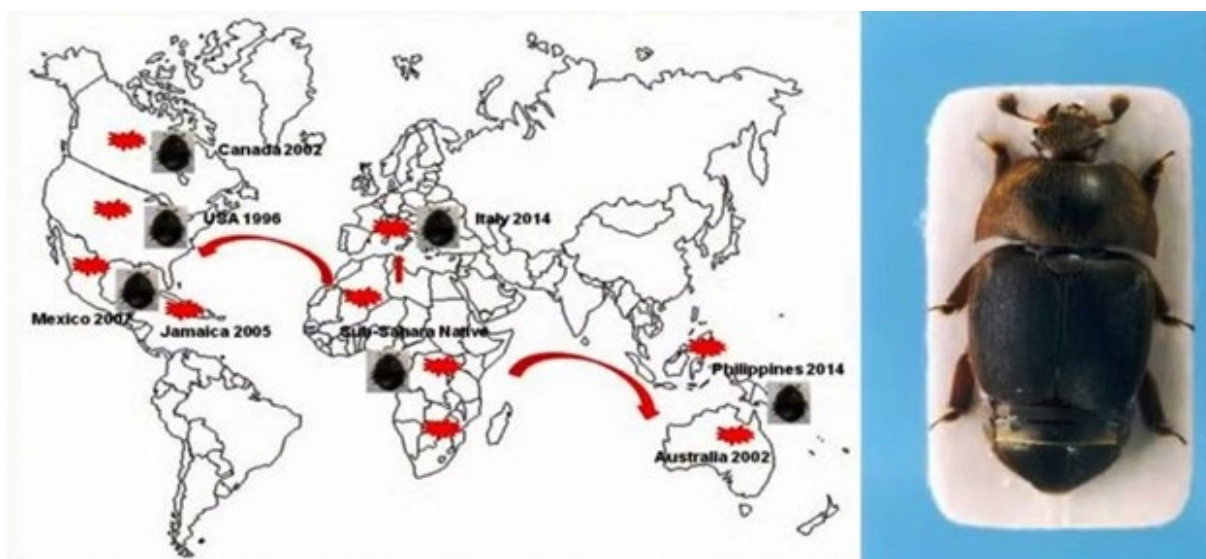


Fig. 1. Map of the distribution of the small beehive beetle in the world

In 2014, the small beehive beetle was discovered in Italy (Calabria), and 2019 – in Sicily. The small beehive beetle appeared in the southeast of North America in 1996 and spread rapidly to the United States. Since 2002, the beetle has also been observed in the northern parts of the United States and Canada, where it is likely to be less of a problem for climatic reasons and may not be able to become established permanently. To the west, he reached North Dakota. In 2000, it was registered in Egypt, and 2001, in Australia. The spread has been limited to small areas in New South Wales, where it has not yet caused significant economic losses.

The SBB likely got to these countries on ships with fruit or bee colonies. The first cases in the USA (Charleston, Savannah) and Australia (Sydney, Brisbane) come from port cities. After long expectations that it would eventually reach Europe, it happened in 2004, when the larvae and beetles were first detected in Portugal, but only in the cages of imported queen bees, which made it possible to quickly stop the spread of the infestation (attack, invasion). In North America, the beetle has spread to California and Mexico (Hernandez et al., 2023), and in Australia – from New South Wales to Townsville (Nanetti et al., 2021).

In September 2014, beetles and larvae of the small hive beetle were found in three locations near the Italian port of Gioia Tauro in the northwestern province of Reggio Calabria. By mid-December 2014, more than 50 infected bee colonies were found in this area, the infected colonies were destroyed by burning, and the soil was treated with chemicals (pyrethroids, coumaphos). Another infection was diagnosed in an apiary in Sicily. The authorities delineated two exclusion zones (with a radius of 20 km and 100 km) around the infected beehives. It is forbidden to export bees from these quarantine zones.

In 2015, beetles and larvae were again detected to a lesser extent in Calabria's 20 km exclusion zone. Infections with small beehive beetles have yet to be registered in Germany, other European countries, and Ukraine.

### Etiology

The causative agent of the disease is *Aethina tumida*. The small beehive beetle (Fig. 2) is a brown-black insect, about 5 mm long. Adults live up to 6 months and can be found in any part of the beehive (often in the lower part), are photophobic (photophobia), do not like light, and hide in dark corners. Females lay eggs in cracks and crevices of the hive. The whitish larvae are up to 1 cm long and omnivorous: they feed on pollen, wax, bee brood, and honey, and after 10–16 days, they pupate outside the hive (in the soil) (Idrissou et al., 2019).

The beetle is flattened, with oval body outlines; immediately after hatching, it is reddish-brown, then its color varies from dark brown to black. The head and pronotum are more comprehensive than their length; the pronotum reaches the width of the elytra. The pronotum is widest at the base with pointed, slightly protruding rear corners (Cornelissen & Neumann, 2018).



Fig. 2. Small hive beetle *Aethina tumida*  
a – Dorsal part; b – Ventral part  
(pict. James D. Ellis, University of Florida)

The elytra are slightly shortened posteriorly, leaving the last tergites of the abdomen free and the last (pygidium) wholly uncovered. However, the transverse hindwings are expected, and the beetle can fly very well. Excellent three-segmented antennae are typical of the entire family. The shape of the tibia of the hind limbs is also essential for identification. They are broadly flattened and have parallel sides in the posterior two-thirds.

Eggs are about 1.4 mm long, oval, and white. Older larvae are about 12 millimeters long and whitish, often with a brown coating. Only the central capsule and bipartite pronotum are more sclerotized. Two distinct rows of spiny setae on the back can identify the larva. Breathers on the sides of the body are also located on slightly raised protrusions. A pair of enlarged hairpins (urogomphs) is also at the rear end (Mustafa et al., 2015).

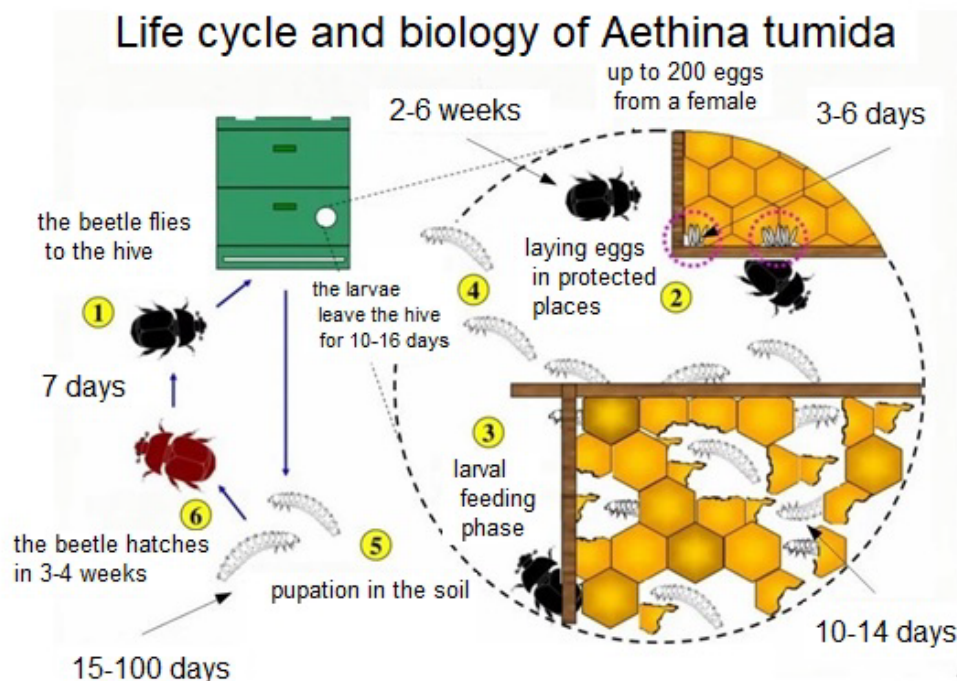


Fig. 3. Life cycle development of *Aethina tumida*

The beetle lays its eggs in cracks and crevices in bee colonies and closed brood cells. They lay clutches of up to 210 eggs in crevices, and only one female lays from 1000 to 2000 eggs during her lifetime. They feed on honey, pollen, and bee droppings and prefer brood, sometimes wholly destroying honeycombs. Larvae feed in a bee colony for an average of 3 to 13 days, but in particularly favorable conditions, only 5–6 days are needed (Stuhl, 2023).

Moisture is essential for beetle larvae. They are highly encouraged by moist conditions. Then they leave the hive to pupate in the ground; they can cover long distances ("wandering larvae"). Larvae leave the hive in the evening hours (peak around 9:00 p.m.). The pupal phase in a self-dug hole in the ground lasts about eight days, under unfavorable conditions, up to three weeks. Like larvae, pupae need moisture and are severely damaged by low soil moisture. Beetles reach sexual maturity about a week after hatching from the pupal chamber. Then they visit hives, where smell plays a significant role, but perhaps also previously unknown insect pheromones (Fig. 3) (Van Gent-Pelzer & Cornelissen, 2021).

Adult beetles feed on pollen and nectar. They survived up to 188 days in the laboratory with good feeding but only 19 days on a diet of only water and wax. The newly hatched beetles survived without food for seven days. Beetles and larvae can be supported experimentally with food substitutes such as fruit, although with less success.

After 2–6 days, *Aethina tumida* larvae hatch from the eggs and begin to eat or destroy almost everything in their

path (pollen, honey, brood, combs). The phase of feeding and growth of immature larvae takes 10–14 days. Mature larvae (about 1 cm long) leave the hive and pupate in the soil at a 1 to 30 cm depth. Looking for a suitable substrate, the larvae can crawl up to about 20 m, but in some cases, even up to 200 m (Roth et al., 2023).

Adult beetles hatch after about 3–4 weeks and begin to fly again actively. The flight radius of the beetles is up to 10 km from where the bee colonies are. A small hive beetle can produce up to 6 generations each year, and a fertilized female can eventually lay up to 2,000 eggs in her lifetime. The larvae of the small hive beetle can coexist with the larvae of the wax moth (giant wax moth, *Galleria mellonella*, trim wax moth, *Achroia grisella*), and they can be confused. However, there are apparent distinguishing features between their caterpillars. Thus, unlike butterfly caterpillars, beetle larvae, in addition, have three pairs of legs in front of the chest and no other pairs of legs on the abdomen. In addition, the larvae of *Aethina tumida* do not form a wax moth membrane (web), typical of wax moth caterpillars.

A small hive beetle hibernates only in the imaginal stage. They sneak into hibernating bee colonies in more excellent areas to benefit from their warmth. A temperature of -12 °C within 24 hours killed all stages of the species' development by 100 % (Wu et al., 2023).

Honey becomes contaminated with larval feces and begins to ferment, and the characteristic smell of rotten oranges appears. Leaked honey from destroyed combs flows to the bottom of the hive so that the infection of the hive is

noticeable by the characteristic rotten smell. Even healthy colonies can be destroyed entirely within a few weeks, weakened colonies – in two weeks.

Countermeasures taken by the bee colony include: blocking the access of adult beetles to the hives by guarding bees and sealing the beetles in the crevices and cavities of the hive with propolis. African bees use four times more propolis than European bees, making them more invasion-resistant. Sometimes beetles can use the feeding reflex of bees for their feeding. Beetles can survive in cells under a layer of propolis for up to two months (Kleckner et al., 2022).

Bees exhibit varying degrees of direct aggressive behavior toward beetles, but this is ineffective due to their defensive body shape and defensive posture with raised heads, folded legs, and antennae. They destroy discovered egg clutches and may transfer or destroy larval broods if they notice an infestation. It is still being determined which of these strategies will ultimately lead to the more tremendous success of African bees than European bees in controlling the small hive beetle. In Africa, beetles usually succeed in breeding only in abandoned or significantly weakened nests.

The small beehive beetle infestation diagnosis is based on characteristic clinical and epizootological indicators.

Disease-free certificates for the sale of bee packages are issued based on a thorough inspection of bee colonies. Conduct a visual inspection of the entire bee colony to detect *Aethina tumida* (larvae, beetles, traces of damage) (Amos et al., 2022).

### Differential diagnosis

Adult beetles can easily mix with other species of beetles, especially in central Europe; the brown spotted beetle *Cychramus luteus* is expected, as this beetle, although it is an inhabitant of plant flowers when found in large numbers, can also be found in the bee family. Another similar species, *Cychramus variegatus*, lives in mushroom colonies.

It is necessary to differentiate the small beehive beetle from *Cychramus luteus*, a widespread beetle from the family of glossy beetles, which is very common on the inflorescences of plants in Central Europe. It feeds on the nectar of plants and fruits and does not threaten beekeeping. A differentiating feature is the size and shape of the pronotum, antennae, elytra, and leg of SBB. It is also necessary to differentiate the larvae of *Aethina tumida* from the larvae of the giant wax moth *Galleria melonella* by the characteristic double row of bristles on the back of the beetle larva, which are absent in the moth (Cersini et al., 2021; Liu et al., 2021; Ponting et al., 2021; Muturi et al., 2022).

Important differential features of the imago of a small hive beetle from similar beetles of the Glossy beetle family (Fig. 4):

- 1) The pronotum of a small beehive beetle is wider and protrudes beyond the edges of the abdomen and elytra;
- 2) Wider and larger antennae tips of the small beehive beetle;
- 3) The size of the mammary elytra is smaller, and they do not cover the last segment of the abdominal tergite (pygidium);
- 4) Wider leg of a small beehive beetle.

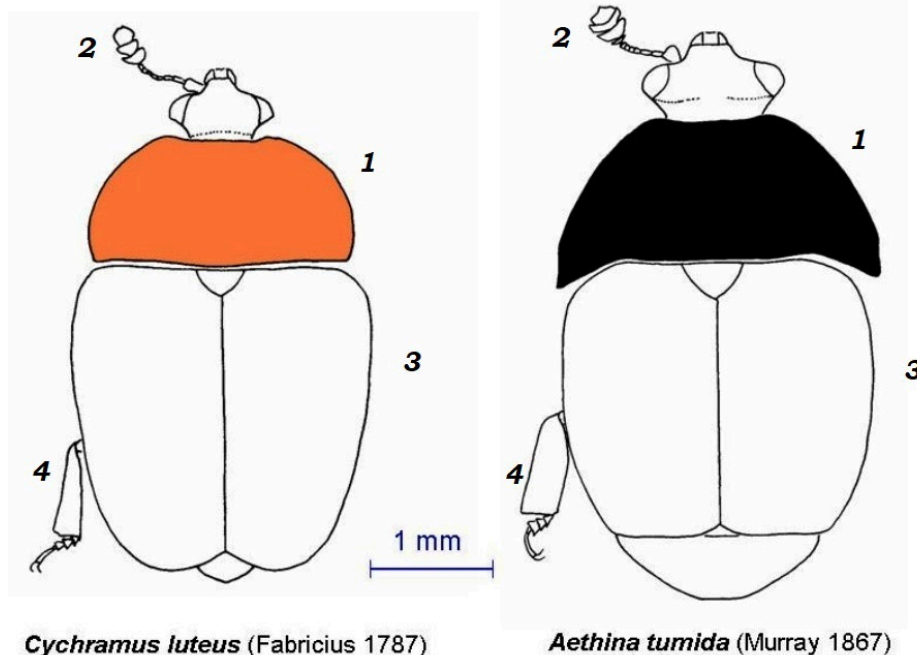


Fig. 4. Morphological signs of differentiation *Aethina tumida* from *Cychramus luteus*

### Treatment

There are no effective means against the small beehive beetle. Bayer AG's *Aethina tumida* control strips "Check-Mite +" (coumaphos) are the only product approved for treating hives against SBB. Still, the drug is highly toxic and banned in several countries. Treatment is carried out in all infected bee colonies. Use one strip for every five frames of bees. To control SBB, use a soil treatment with a permethrin (pyrethroid) solution in addition to CheckMite+. Use one

strip cut in 1/2, then attach it to a 5" by 5" pleated square. Strips are removed after 42–45 days. There are ten strips in the package. It measures 4.75 inches long by 1.5 inches wide. The cost of one package is about 40 USD. Coumaphos – (coral, azuntol) – a pesticide from the FOS group with high toxicity for warm-blooded animals. They are banned in several countries around the world and in Germany. Diazinon, Neotsidol, and Bazudin are similar in chemical structure (Franco et al., 2022).

## Prevention and control measures

The ultimate goal of all preventive measures is to prevent further spread of the beetle. The most reliable way to detect the beetle is by careful, regular visual observation of bee colonies—inspection of colonies for suspicious beetles, larvae, or signs of damage by beetle larvae. However, since the first infestation of an SBB colony can be easily overlooked, it is recommended to use bug traps with the addition of sticky poison for cockroaches and ants.

Based on the experience gained in Calabria since 2014 with the imported beetle, it can be assumed that *Aethina tumida* cannot be eradicated in other regions of Europe once the beetle has established itself in the territory. It is all the more important to introduce quarantine and establish strict compliance with bans on importing bee packages and queen bees and bumblebees into Europe (certificates of well-being!) and trade in wax and bee products, as well as regular monitoring and inspection of bee colonies (Silacci et al., 2018; Huwiler et al., 2020; Hopkins & Keller, 2021; Solomon et al., 2021).

To prevent and control the beetle, it is necessary to maintain strong families and maintain the sanitary condition of beehives and premises for storing honeycombs. Empty combs are treated with paradichlorobenzene; bee colonies are treated with CheckMite+ (Bayer concern), and the soil around the hive at a distance of 4 m is sprayed with a 0.05 % permethrin solution. Attempts are made to use pathogenic nematodes to destroy pupae and adult beetles in the soil. A reduction in the flight opening has a specific effect on preventing the penetration of adult beetles into the hive (Greco et al., 2010; Buchholz et al., 2011; Cornelissen et al., 2019; Bisrat & Jung, 2020; Aydin, 2022).

## Control measures

Infection with *Aethina tumida* is notifiable and quarantined. In the event of the first outbreak, it is recommended to smoke bee colonies and burn them together with hives and apiary equipment with the mandatory treatment of a point in a radius of 100 m around it with a 0.05 % permethrin solution. Extensive soil digging or treatment, such as insecticides, is indicated to eliminate migrating larvae and destroy beetle pupae around infested hives. In Germany, no veterinary medicinal product has yet been approved with a corresponding safety certificate.

## 3. Conclusions

Based on the analysis of literary sources, it can be concluded that the small hive beetle is a considerable problem for beekeeping worldwide and poses a threat to the beekeeping of Ukraine due to close economic ties with the countries of the European Union.

## Conflict of interest

The author declare that there is no conflict of interest.

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