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Galleria melonella L.

Protection of honey combs from moth damage

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Protection of honey combs from moth damage

THE FOLLOWING MOTHS ARE REGARDED AS PESTS OF BEE PRODUCTS:

Class:	Insects	*Insecta*
Order:	Butterflies	*Lepidoptera*
Family:	Pyralids	*Pyralidae*
Species:	Greater Wax Moth	*Galleria mellonella L.*
	Lesser Wax Moth	*Achroia grisella*
	Fruit (pollen) Moth	*Vitula edmansae*
	Mediterranean Flour Moth	*Esphestia kuehniella*

Of all moths, the Greater Wax Moth causes the greatest damage in apiaries which lead to material and financial losses every year. For this reason, we propose to study only the biology of the Greater Wax Moth more closely.

The methods employed in combating *Galleria mellonella* are generally effective against other moths identified as pests of bee products.

BIOLOGY OF THE GREATER WAX MOTH

Geographical distribution

The geographical distribution corresponds reasonably with that of the bee. Distribution is limited by the inability of the pest to withstand prolonged periods of cold. This explains why Wax Moth problems are less acute in higher locations or do not occur at all [1].

Pathology

Adult Wax Moths cause no damage because their mouthparts are atrophied. They do not feed during their adult life. Only larvae feed and destroy combs. However, adult Wax Moths and larvae can transfer pathogens of serious bee diseases (e.g. foulbrood). In colonies infested with foulbrood, the faeces of Wax Moths contain large amounts of *Paenibacillus larvae* spores [2].

Development stages

Galleria development goes through 3 consecutive stages: egg, larva and pupa. This sequence is only interrupted if the temperature is too low or when there is no food. Therefore, the cycle can last between 6 weeks and 6 months depending on temperature and food. According to the literature, over-wintering can take place as egg larva or pupa.

The egg.

Normally, females lay their eggs by means of their ovipositor into crevasses and gaps. This puts them out of reach of the bees and prevents their destruction.

The larva.

After hatching, the young larva immediately searches for a comb in order to feed and to build the silk-lined feeding tunnels. Speed of growth is directly dependent on temperature and food supply. Under ideal conditions the larval weight can double daily during the first 10 days [4].

The metabolic warmth, which is created by this rapid growth, can increase the temperature in the spun silk nests far beyond the environmental temperature. The larva feed in particular on impurities occurring in wax, such as faeces and the cocoon of bee larvae as well as pollen. The larva eats also wax. Larvae, which have been reared exclusively on pure wax (foundation, fresh comb), do not complete their development [4; 13]. Dark, old combs that contained many broods are most at risk.

At the end of the larval stage, the larva spins a very resistant silk cocoon on a firm support, such as wooden frames, hive walls or in the comb storage chest. Frequently the larva spins its cocoon in a hollow it had bored into the wood.

The pupa.

In the cocoon, the larva changes into a pupa and then into the adult moth. These metamorphoses last from one to 9 weeks.

The adult Insect (imago).

Size and colour of the imago vary considerably depending on food composition at the larval stage and on the duration of the various developmental stages. Females are larger than males [5].

The females start laying eggs between day 4 and 10 after emergence from the cocoon [5]. At dusk, the females attempt to enter the beehive to lay their eggs. If the colony is strong enough to repel the Wax Moth, they lay their eggs outside in cracks in the wood.

The development of the greater wax moth

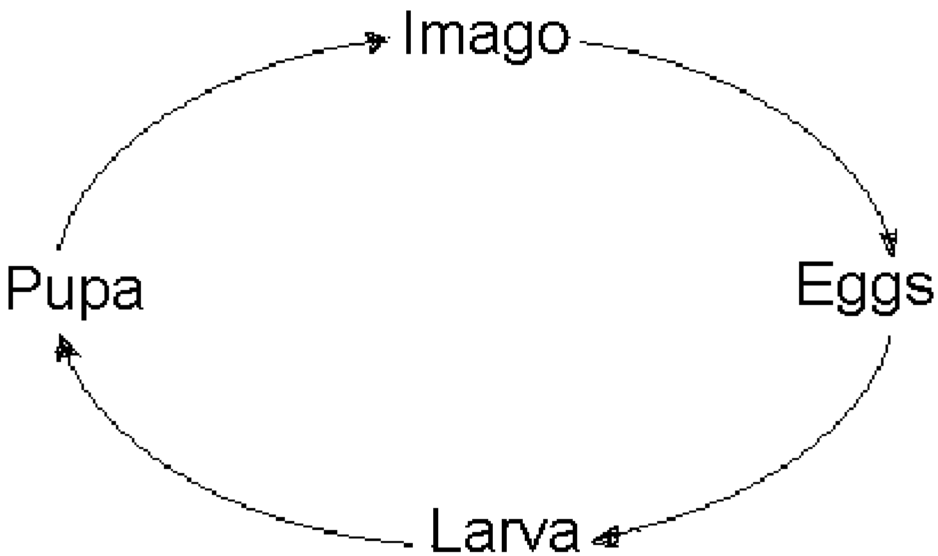
- night active moth
- wing-span 14-38mm
- does not feed
- survival 1-3 weeks [5]
- female lays 300-1000 eggs [3;4]

- duration of cycle under ideal conditions; About 6 weeks

- 4-6 generations per year [3]

Duration: 1 - 9 weeks [5]

- in cocoon
- immobile phase
- does not feed



- clutch of 50 – 150 eggs [4]
- olive shaped. ½mm
- white – reddish

Temp. °C	Duration (days) [5]
24-27°	5 – 8
10-16°	>35
>9°	Development stopped

- grows from 1 to >23mm
- 8 – 10 stages (skin shedding)
- last stage spins cocoon
- duration: 28 days – 6 months depending on temperature and food [5]
- ideal temperature: 29 – 35°C [5]
- development stops at <15°C [6]

POSSIBILITIES FOR CONTROLLING WAX MOTH

In beehives.

- Allow only strong colonies in an apiary. (The bee itself is the most dangerous enemy of the Wax Moth).
- Never leave comb or wax in an unoccupied hive.
- Periodically clean the Varroa inserts.
- Replace combs regularly.
- After mass invasion of Wax Moths, destroy their eggs on combs, frames and hives (e.g. sulphur vapour).

In comb storage chests: (see tables pages 6 and 7)

Main rule: For all control strategies, it is necessary to inspect stored material regularly during the warm season.

Technical methods

Physical methods

Biological methods

- *Bacillus thuringiensis spores*

The bacterium *Bacillus thuringiensis* was discovered in 1911 and has been successfully used for plant protection for several years. The bacterial strain of the product B-401 was selected in particular for its activity against the Wax Moth. The bacterium produces spores containing a toxin. When the larvae ingest the spores, the toxin is freed and damages the intestinal walls. This results in the death of the larvae. Adult Wax Moths do not feed and are therefore not endangered by this product.

The bacterium *Bacillus thuringiensis* was is harmless for vertebrates (man, livestock) and bees and leaves no residues in wax or honey.

Chemical methods.

- *Sulphur (sulphur dioxide, SO_2)*

Burning of sulphur strips or spraying of SO_2 from a pressurized vessel are the two main control methods using sulphur. This is still one of the most effective means against Wax Moths. It is highly volatile, not fat-soluble and therefore poses only a slight danger to bees, wax, and honey.

After removing comb from the colonies, it is advisable to wait one or two weeks before treatment (SO_2 is ineffective against eggs). For more safety, the treatment can be repeated after 2 weeks.

- *Acetic acid*

Acetic acid vapour instantly kills eggs and moths. The larva, especially in the cocoon, is more resistant and must be exposed to the vapours for longer [3]. For this reason, the combs must be treated immediately after removal from the colonies, before eggs can develop into larvae.

- *Formic acid*

Professional beekeepers successfully use formic acid against Wax Moths. The effects are comparable to that of acetic acid.

Substance witch has no more to be used

- *Paradichlorbenzole (PDCB)*

(e.g.: Anti-Teigne, Waxviva, Antimotta, Imker-Globol, Styx)

There is an important risk for building of residues in honey and wax. The limit of tolerance in Switzerland, fixed at 0.01 mg/kg, might be exceeded, thus making honey unsuitable for sale.

In high concentrations, PDCB can be toxic to bees. If several combs are put directly into the colony from a storage chest without airing heavy damage may occur and can result in the death of the colony.

Due to the above findings, the application of PDCB is not Good Apicultural Practice and the substance should be banned.

Control possibilities against Wax Moths in stored combs

Method		Advantages (+) / Disadvantages (-)	Procedure / Remarks
Technical		+ no residues	
	- Sorting comb		- supplementary measure separate dangerous old comb from foundation and new comb
	- immediately melt old wax		- supplementary measure
	- storage in a cool, light and airy place	+ simple	- Moths fear light and draughts; e.g. shed, porch - Protect against weather, rodents and insects
Physical		+ no residue	
	- cool storage (<15°C)	+ effective - infrastructure, long term method	- cellar, cool place - good air circulation in comb stack
	- frost treatment	+ effective + kills all stages - expensive infrastructure	- 2 hours at –15°C or 3 hours at –12°C or 4.5 hours at –7°C [5] - strict period of frost
	- heat treatment	+ effective + kills all stages infrastructure (warm air blower) - risk of wax melting	- 80 minutes at 46°C or 40 minutes at 49°C - good air circulation - accurate temperature control
Biological	- spores of *Bacillus thuringiensis* (B-401)	+ no residues + long-term effect (2-3 months) - average effect against the Lesser wax moth - labour intensive	- observe instructions - ensure good distribution on the combs - observe sell-by-date and storage conditions (living organisms) - if combs already infested, 1 x sulphur then B-401 - ideal for the beekeeper with a few colonies

Method		Advantages (+) / Disadvantages (-)	Procedure / Remarks
Chemical	- Sulphur	+ effective + good pollen conservation against moulds - regular repeats - ineffective against eggs - fire danger	- treatment from above (SO_2 heavier than air) - do not breathe in vapours (respiratory and eye irritant) - burn in a small sulphur stove - treat every four weeks (in summer) - 1 strip per 100 litres (about 3 DB supers) - SO_2 in spray can - 1 second (=2.5g SO_2) per honey super or - 3-4 seconds per 100 litres hive volume - no fire danger
	- Acetic acid	+ effective + no problem residues + kills all stages + kills Nosema spores [10] - attacks metal parts - regular repeats - caution when handling	- treatment from above (vapours heavier than air) - do not breathe in vapours, avoid contact with skin - 200ml acetic acid (60-80%) per 100 litres per hive volume [6;7; 10; 11] - in summer, treatment repeated 1-2 times with an interval of 2 weeks [3]
	- Formic acid	+ effective + no problem residues + kills all stages - attacks metal parts - regular repeats - caution when handling	- treatment from above - do not breathe in vapours, avoid contact with skin - 80ml formic acid (85%) per 100 litres hive volume [12] - in summer, treatment repeated 1-2 times with an interval of 2 weeks

CONTAMINATION OF WAX AND HONEY BY PARADICHLORBENZOLE (PDCB)

PDCB is a highly volatile and lipophilic (easily soluble in fat and wax) substance. Beeswax can take up this material and a part of it may later migrate into honey. Honey analyses from Germany and Austria show that PDCB residues in honey are not rare. This applies to native as well as imported honeys.

Even when measured values pose no problems as far as human toxicology is concerned (an experiment on carcinogenic effects is ongoing), the reputation of honey as one of the last natural products may be damaged in the eyes of the public. PDCB should not be used in beekeeping because there is an important risk of building of residues higher than the Swiss tolerance limit of 0.01 mg/kg. A honey with such high residues can not be sold in Switzerland. Every beekeepers, caring for the quality of his bee products should not use PDCB. Such an application is not Good Apicultural Practice.

PDCB residues in Swiss honeys

	1997	1998	2000	2001	2002	2003
Number of samples	28	13	23	16	93	315
Number of positive samples	4	6	6	5	32	129
% positive samples	14	46	26	31	34	41
% above TL (> 10 µg/kg)	11	15	9	12	18	24
Maximum value µg/kg	35	112	56	37	112	300

limit of detection at 3 microgrammes per kilogram honey

1 µg/kg corresponds with 1 millionth of a gram in 1 kilogram honey or 1 ppb.

TL – Swiss Tolerance Limit

-Para-dichlorbenzene accumulation in wax

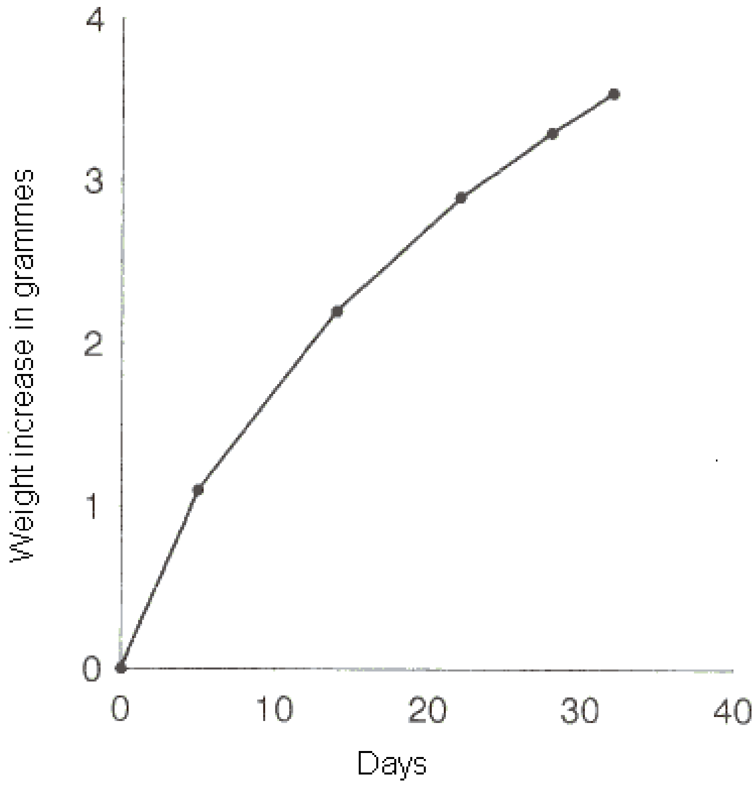
The amount of PDCB stored in wax depends on the duration of exposure and the wax surface area. Foundation takes up PDCB more quickly than wax as a block (table 1).

Table 1: Uptake capacity of a 1kg wax block (Wallner, [8])

After 1 Month	27.3g	paradichlorbenzole
″ 2.5 Months	38.5g	″
″ 9 Months	83.5g	″

- Wax takes up PDCB like a sponge. The more PDCB crystals are added to combs and the longer PDCB acts on the combs, the higher the substance stored in the wax.

Fig.1: 2 sheets of foundation were placed in an airtight glass vessel with 50g PDCB crystals for 30 days. Weight increase corresponds with the stored amounts of PDCB



Source: Wallner K. 1991

- Evaporation of PDCB from beeswax.

• *Airing*

Airing of combs over 1-2 days before insertion into the colony avoids visible damage to bees. Despite this, considerable amounts of PDCB may be present in wax. Airing over several weeks is not enough to remove PDCB from wax completely (fig.2). [seite 13 in Brochure]

The amount and speed of removal are above all temperature-dependent. Thus, the considerably higher temperature in the colony causes PDCB evaporation from combs not previously aired enough. If these cells are now filled with honey, PDCB migrates slowly into the honey.

• *Melting old wax.*

When old comb is melted, the residues persist in the new wax. Examinations of wax carried out here have shown that the majority of commercial wax in Switzerland contains PDCB residues of 5-10 mg/kg

- Stability of PDCB in honey.

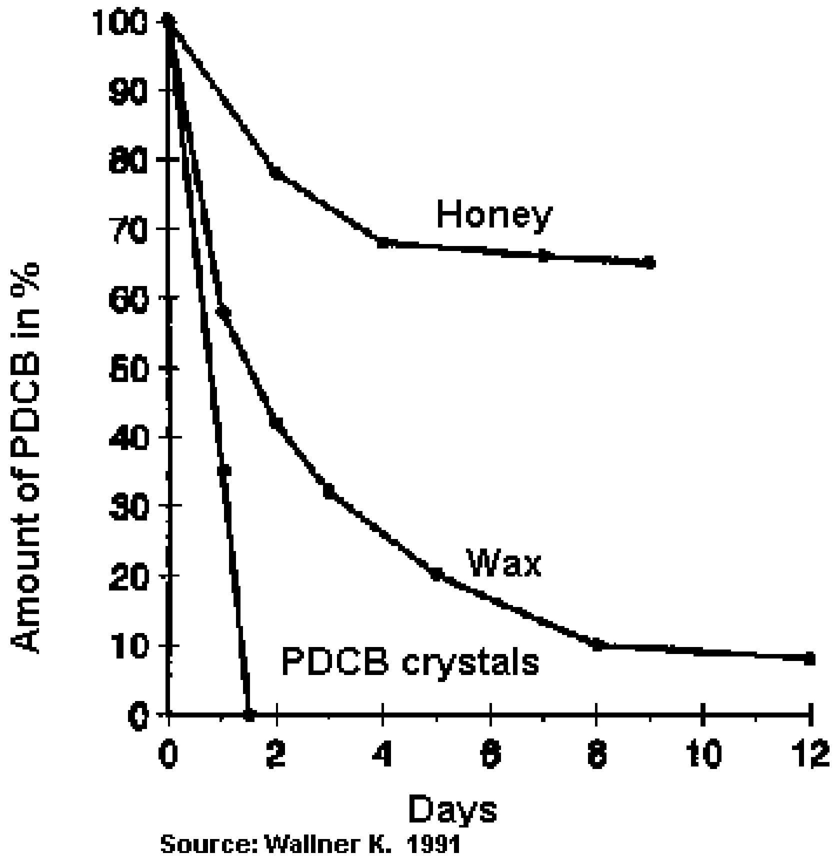
-PDCB evaporates reluctantly from honey and only from the topmost layer.

-Honey cannot be aired as long as needed, since it attracts water and odours.

- There is no possibility of significantly reducing paradichlorbenzole content of honey later.

- Residues of PDCB in honey higher then 0.01 mg/kg are not permitted in Switzerland. Honeys with such residues are rejected by the Cantonal chemists.

Figure 2: Evaporation of PDCB from honey, Wax, and PDCB crystals.



PDCB crystals: freely distributed crystals at room temperature

Wax: foundation gassed with PDCB for 12 days, Aerated at room temperature.

Honey: glass bowls with 10g contaminated blossom honey (28 µg PDCB per kg honey) Aerated at room temperature.

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Table of content