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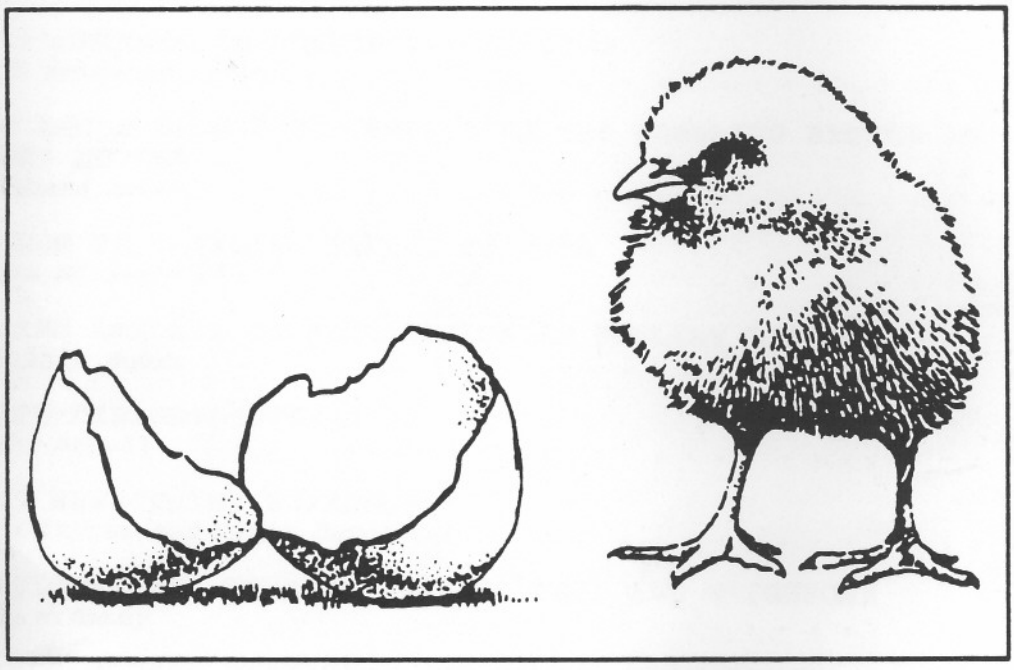

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BIOLOGY AND ECONOMIC IMPORTANCE OF THE DARKLING BEETLE IN POULTRY HOUSES[1]

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In modern commercial poultry houses the major premise pest, other than flies, is the darkling beetle, *Alphitobius diaperinus* Panzer. This beetle, a member of the family Tenebrionidae, may also be called the "lesser mealworm" and the "litter beetle". Poultry producers sometimes call the adult beetle "black bugs" and the larval stage "worms". This beetle is a worldwide problem in poultry houses. It is a reservoir and vector for many poultry diseases, and it destroys the insulation in poultry houses.

BIOLOGY AND BEHAVIOR

LIFE CYCLE (see diagram, Figure 1)

The darkling beetle (lesser mealworm) adult is a dark brown to black beetle about 1/4 inch long with fine longitudinal grooves on the back. When the adult beetle is newly formed it is nearly white but rapidly darkens to reddish brown, dark brown, and finally to black. The male and female beetles look alike although there are differences which may be detected under a microscope. After mating, the female begins to lay eggs (in clusters) in the litter and manure within 6-10 days. Each oval light color egg is about 1/32 inch long. The adults live for many months (up to a year) and continue to produce eggs for most of their lifetime.

[1] Presented at the 1994 Poultry Supervisors Short Course, North Carolina State University, Raleigh, NC.

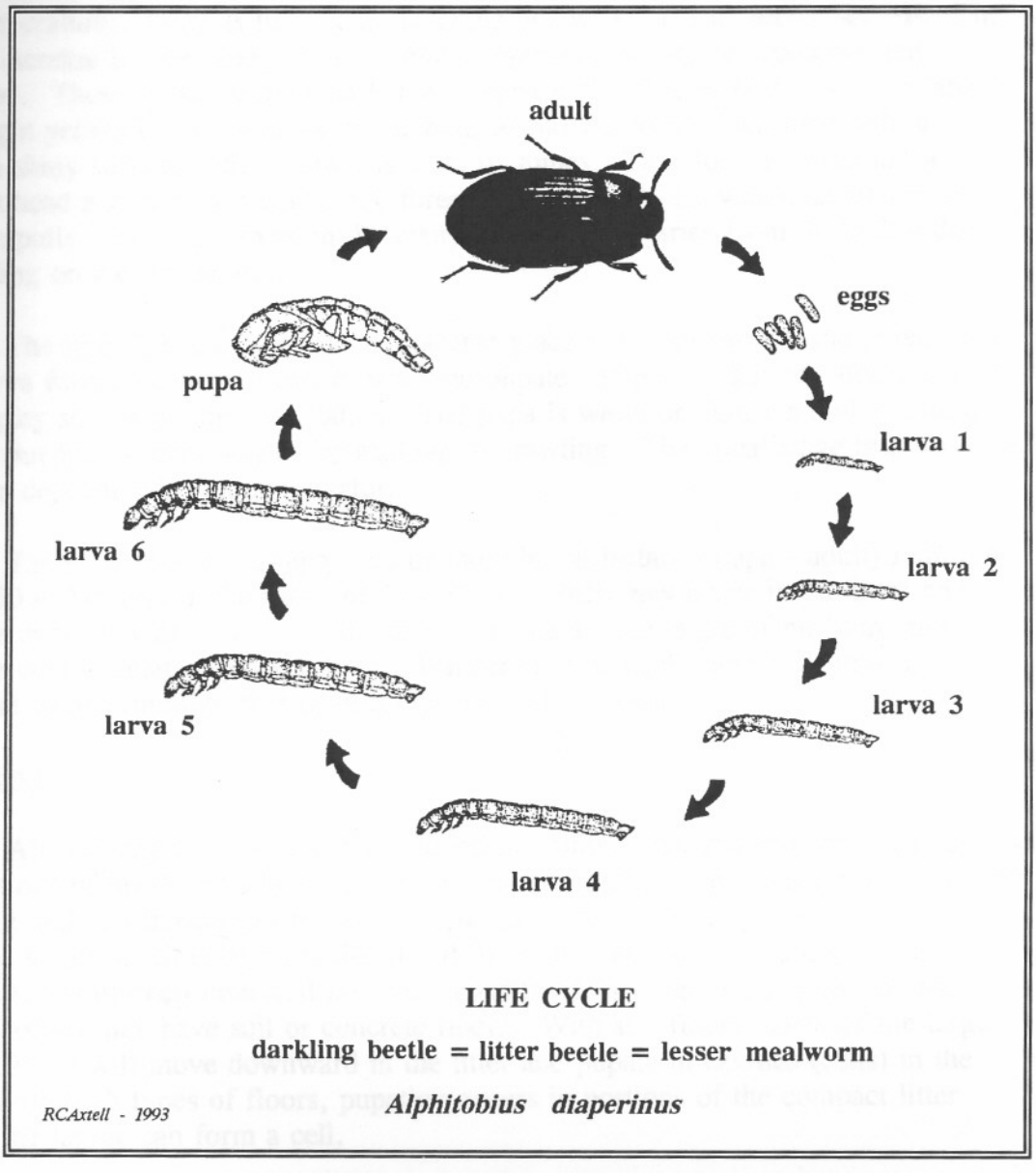

adult
eggs
larva 1
larva 2
larva 3
larva 4
larva 5
larva 6
pupa
LIFE CYCLE
darkling beetle = litter beetle = lesser mealworm
Alphitobius diaperinus
RCAxtell - 1993

Figure 1.

Larvae hatch from the beetle eggs in 3 to 10 days (95 to 70 °F) depending on the temperature. There is little or no hatching below 60 °F and above 100 °F. The larvae increase in size though 6 to 10 molts depending on the environment and nutrition. These larvae become darker with each molt. The largest larvae are brown with light yellow-brown areas on the underside and 1/2 to 3/4 inch long with a smooth shiny surface with no obvious hairs or spines. The elongate larva has a distinct head and body segments, and three pairs of small legs which enables it to move rapidly. The time spent in the many larval stages varies from 30 to 200 days depending on the temperature.

The large larva moves into a protected place to transform into the pupal stage. The larva forms a cavity or cell in which to pupate. Pupation is in the litter, manure, underlying soil or building insulation. The pupa is white or light tan and is able to wiggle but has no appendages for walking or crawling. The pupal stage lasts for 4 to 14 days depending on the temperature.

The entire life cycle (egg - six or more larval instars - pupa - adult) requires about 30 to 80 days in the range of 95 - 70 °F. which may occur in the litter and manure in poultry houses. The life stages tolerate a wide range of moisture and survive well in relatively dry habitats. Temperature is much more important than moisture in determining rates of development and survival.

HABITAT

All life stages of the beetle are found in poultry litter and manure. The largest populations of beetles and hence the most serious problems are usually associated with growout and brooder houses for broilers and turkeys. In these houses it is common practice to till the litter and add additional litter between flocks resulting in the accumulation of deep litter and favorable conditions for large beetle populations. These houses may have soil or concrete floors. With soil floors, some of the large beetle larvae will move downward in the litter and pupate in cavities (cells) in the soil. With both types of floors, pupation occurs in portions of the compact litter where the larvae can form a cell.

Manure-inhabiting populations of beetles are most likely to be a problem in deep pit (high rise) caged layer houses where the manure is allowed to accumulate for many months before removal. The drier portions of the manure piles are most suitable for the beetles. These houses may have either soil or concrete floors.

In broiler-breeder houses, the feeders and waters are usually on slats raised about 3 feet above the floor and the drier portions of the manure under the slats may support large populations of beetles. The slats typically cover about one-third of the house along each side while the center one-third of the house has litter which may be infested with beetles. The floor of broiler breeder houses is usually soil but may be concrete.

BEHAVIOR

Both adults and larvae of darkling beetles are capable of rapid movement. When disturbed they will quickly run downward in the litter or manure. If removed from the habitat they will stop movement for a while and appear to be dead; movement will suddenly occur after a few minutes.

The adults and larvae tend to aggregate so that large numbers will be found in certain areas in the poultry litter or manure. They will accumulate under boards, feeders, or waterers set on the litter. There is a considerable amount of cannibalism by large larvae and adults on the small larvae and eggs, if the population is crowded.

Beetle adults and larvae aggregate under dead or dying birds on the litter and will feed on the carcasses. The beetles do not attack healthy birds, however.

Dispersal of large larvae and adults may be observed in poultry houses. Both life stages crawl upward on the walls and posts. Nearly all of the larval dispersal takes place at night. The larvae are seeking pupation sites and the amount of upward movement is related to the density of the population in the litter and the limited suitable sites for pupation in the litter, manure, or soil beneath. These larvae invade all kinds of building insulation and make tunnels as sites for pupation. The pupae complete development and the resulting adults in the tunnels leave and return to the litter or manure for feeding and oviposition. Some of the dispersing adults may enter these tunnels but the insulation damage is initiated by the larvae.

Adults disperse at any time but more at night than in the daytime. Some of the dispersing adults congregate on the walls around exhaust fans and other opening to the outside and probably leave the house. The adults are capable of flying although this is usually not observed because flight is at night, especially between 2000 and 2400 hours.

BEETLE POPULATION MONITORING

To evaluate the consequences of a control program and to improve the methods, the beetle population in a house should be monitored weekly. The direct approach is to walk through the house and look for larvae and adults in the most likely places. Examine the litter around posts and along the walls; look under feeders and waterers situated on the litter. Turn over caked litter and dead birds to look for beetles. Pieces of boards may be left on the litter and overturned during inspections to look for beetles beneath. Although seldom done, it would be useful to enter the houses in the evening after dark and look for climbing larvae and adults.

An indirect approach to measuring the beetle population is using a "tube trap". This trap is a 10 in. long piece of 1.5 in. diameter PVC pipe with an insert of rolled corrugated cardboard (such as used for brooder guard). Holes near the end of the pipe allow staking with gutter nails to prevent the birds from moving the tube. After the tube trap is on the litter for one week, the cardboard insert is removed and the beetles (larvae and adults) counted. A new cardboard insert should be used each week. At least 10 of these traps should be used per house.

ECONOMIC IMPORTANCE

STRUCTURAL DAMAGE

Modern poultry houses are designed to maintain the temperature within a narrow range as far as possible to maximize the efficiency of production. Insulation is placed beneath the roof and in the walls according to the climate in an area. Polystyrene insulation is widely used but other types such as polyisocyanurate, polyurethane, and fiberglass may be found in poultry houses. The beetle larvae tunnel the insulation panels so extensively that the insulating value may be reduced by 30% or more in only a few years. The resulting poor temperature control results in greater production costs due to reduced feeding efficiency. The cost of replacing the insulation is many thousands of dollars per house and the time the house is out of production is costly. There may be some tunneling into the wood structure by the larvae but this is minor compared to the damage to the insulation.

NUISANCE COMPLAINTS

When infested litter or manure is removed from houses and spread on fields the adult beetles rapidly disperse and invade nearby houses and businesses. This often results in legal actions and a significant public relations problem.

DISEASE ASSOCIATIONS

The darkling beetles are reservoirs for a wide variety of pathogens including several that are threats to poultry production. They harbor fungi (*Aspergillus*), bacteria (*Escherichia*, *Salmonella*, *Bacillus*, *Streptococcus*) and viruses causing leukosis (Marek's disease) and infectious bursitis (Gumboro disease). A variety of other viruses, including the agents causing fowlpox, Newcastle disease and avian influenza have been recovered from the beetles although other arthropods are considered to be more important vectors. Avian coccidiosis, a major disease of poultry caused by protozoans (*Eimeria* spp.) survives as oocysts ingested by beetles which may be eaten by the birds resulting in transmission of the disease. The cystericercoids of worms (*Choanotaenia* and *Raillietina*) which infect poultry have been recovered from *A. diaperinus* demonstrating its role as an intermediate host for those internal parasites.

The bacteria *Salmonella typhimurium* causes gastroenteritis in humans and poultry products may be a source of the food-borne infection. Darkling beetle larvae and adults harbor *S. typhimurium*; adult beetles have been shown to pass the bacteria in the feces for at least 28 days after the beetle ingested contaminated feed and the larvae after being infected with the bacteria carry the infection from one larval stage to the next. *Salmonella* infection of broiler chicks by ingesting an infected beetle adult or larva has been demonstrated.

In recent research at NCSU we have demonstrated transmission of enteric pathogens of turkeys by means of darkling beetle larvae (**see Figure 2**). Larvae were exposed to turkey feces from an enteritis-affected flock and determined to contain turkey enterovirus and rotavirus. Growth depression and increased mortality were observed in the turkey poults which fed on the exposed larvae. Exposed larvae which had been surface-sterilized also produced clinical signs of enteritis after the poults consumed them, indicating that pathogens were able to survive within the larvae. This experiment demonstrated the capacity of larva of the darkling beetle to serve as a mechanical vector of enteric pathogens of turkeys.

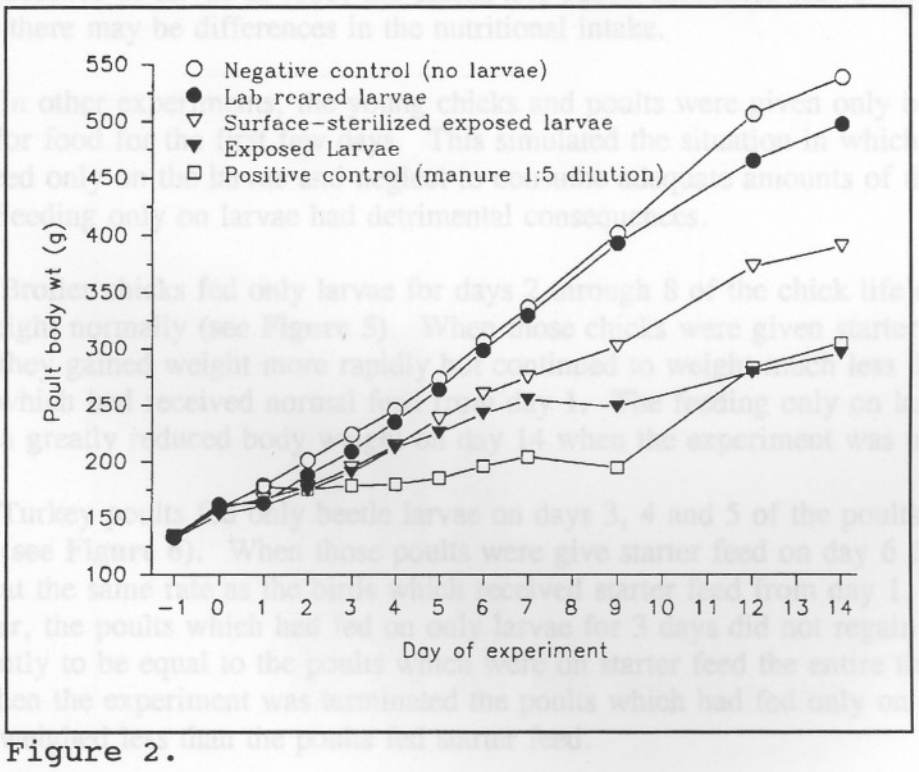


Figure 2.

BIRD CONSUMPTION OF BEETLES

Broiler chicks and turkey poults actively pursue and feed on beetle larvae and adults in the litter; consequently the passage of pathogenic organisms is common. In recent research at NCSU we have documented the extent of feeding by chicks and poults on darkling beetle larvae and the subsequent effects on bird weight gains and feed consumption.

Broiler chicks consume about 450 beetle larvae per chick per day and turkey poults consume about 200 beetle larvae per poult per day by foraging for the larvae in the litter even though poultry feed is available (**see Figure 3 and Figure 4**). Feeding on the larvae by the chicks was at a high level during the nine days of the experiment although there was a decline at the end of that period. Feeding by the turkey poults on the larvae was very high during the first 10 days and then declined drastically. These results demonstrated under simulated field conditions that the young chicks and poults very actively feed on the beetle larvae in the litter even though there is ample starter feed available. In these "free choice" experiments the body weights of the broiler chicks and the turkey poults which fed on both starter feed and beetle larvae were not significantly different from those birds which fed only on the starter feed. In the presence of larvae as food, the chicks and poults consumed less of the starter feed so there may be differences in the nutritional intake.

In other experiments, the young chicks and poults were given only beetle larvae for food for the first few days. This simulated the situation in which some birds feed only on the larvae and neglect to consume adequate amounts of the starter feed. Feeding only on larvae had detrimental consequences.

Broiler chicks fed only larvae for days 2 through 8 of the chick life did not gain weight normally (**see Figure 5**). When those chicks were given starter feed on day 9, they gained weight more rapidly but continued to weight much less than the chicks which had received normal feed from day 1. The feeding only on larvae caused a greatly reduced body weight on day 14 when the experiment was terminated.

Turkey poults fed only beetle larvae on days 3, 4 and 5 of the poults life lost weight (**see Figure 6**). When those poults were give starter feed on day 6 they gained weight at the same rate as the birds which received starter feed from day 1. However, the poults which had fed on only larvae for 3 days did not regain weight sufficiently to be equal to the poults which were on starter feed the entire time. At 21 days when the experiment was terminated the poults which had fed only on larvae for 3 days weighed less than the poults fed starter feed.

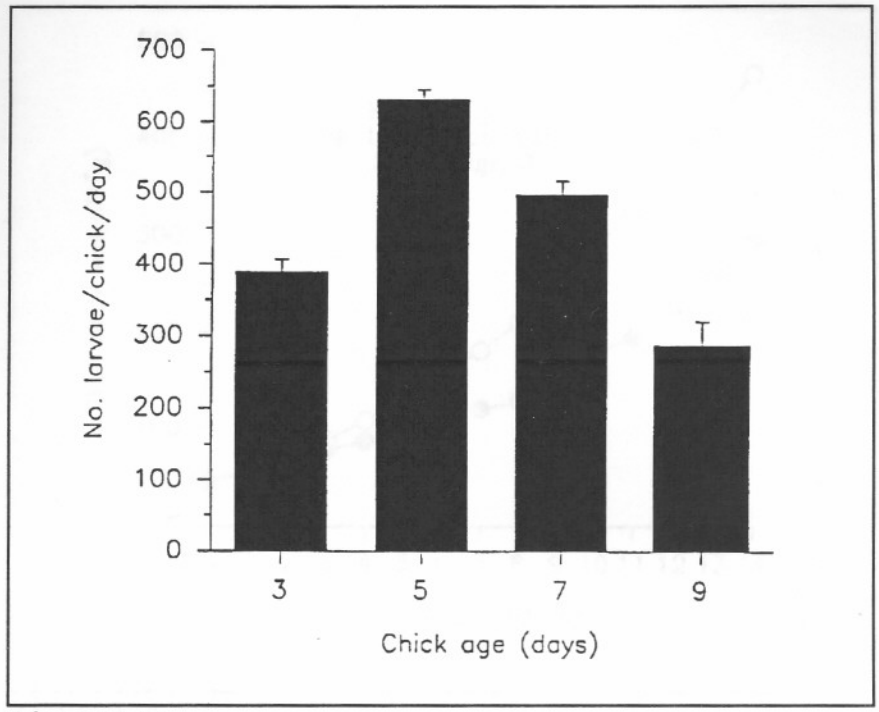
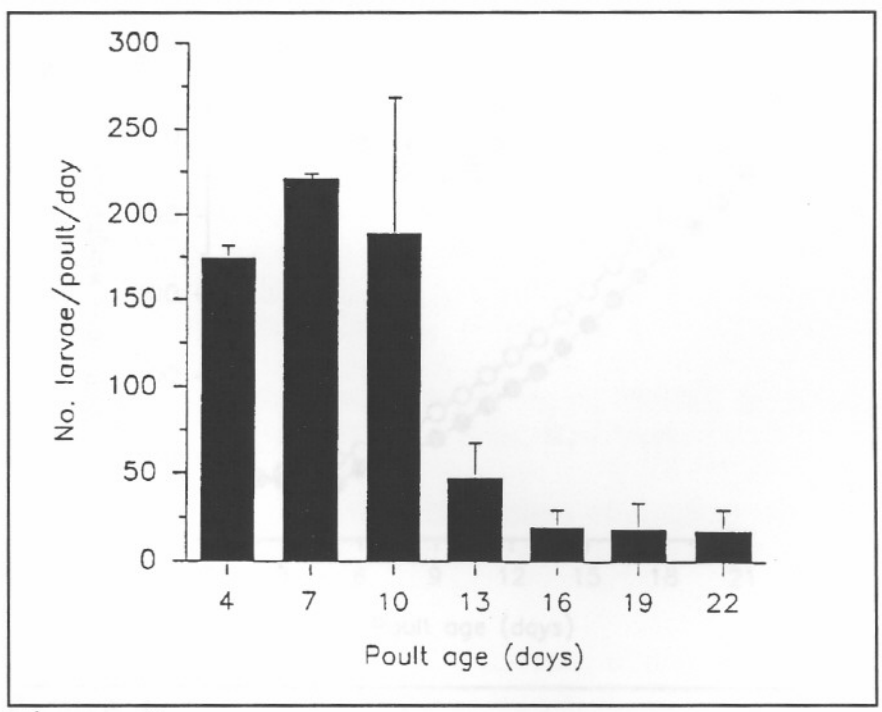


Figure 3.



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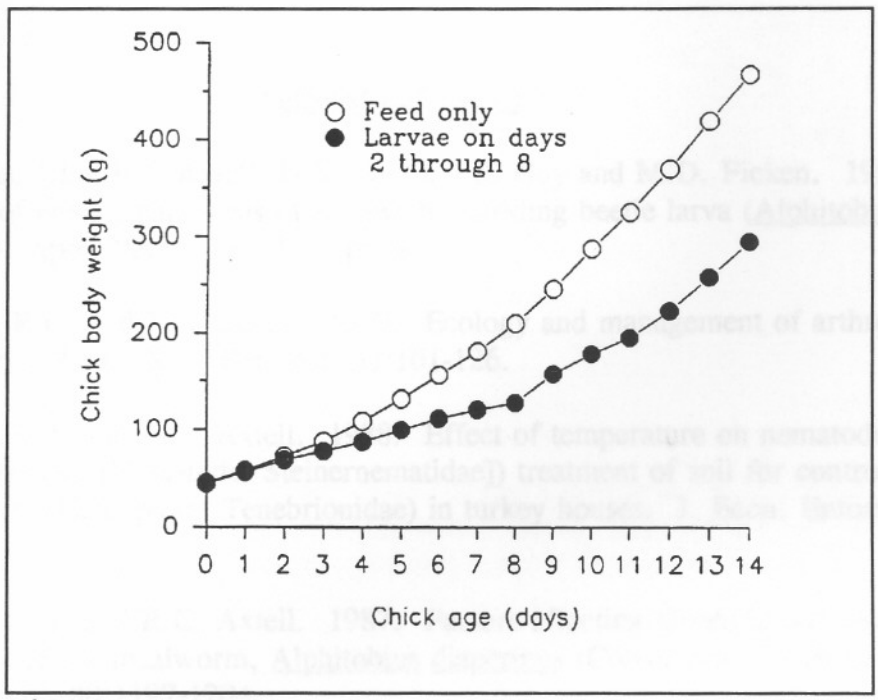

Figure 5.

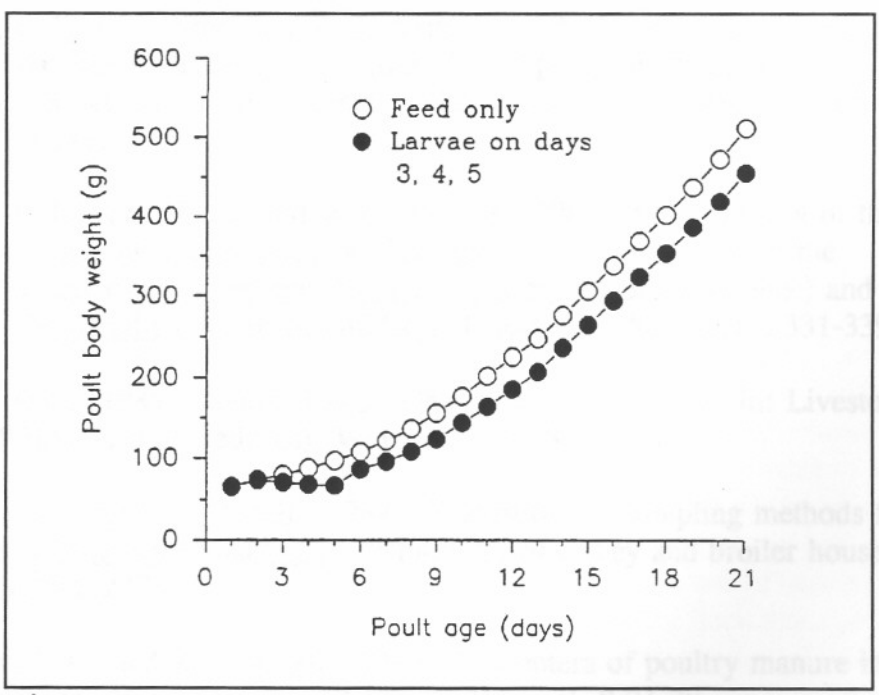

Figure 6.

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