Chapter 2 General aspects of the life cycle stages of the silkworm *(Bombyx mori)*

Capítulo 2 Aspectos generales de las etapas del ciclo de vida del gusano de seda *(Bombyx mori)*

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Abstract

The objective of this work is to present the main morphological characteristics of the different stages of the life cycle of the silkworm *Bombyx mori*, developed at the Universidad Politécnica de Francisco I. Madero, located in Tepatepec, Hidalgo. Every year, silkworm populations are raised in which Agrotechnology Engineering students are involved to reinforce theoretical-practical knowledge of Entomology. It is concluded that the life cycle of the silkworm is approximately 45 days, passing through egg, larva, pupa and adult.

Larva, Mulberry, Sericulture, Cocoon, Insect

Resumen

El objetivo de este trabajo es dar a conocer las principales características morfológicas de los diferentes estados del ciclo de vida del gusano de seda *Bombyx mori*, desarrollado en la Universidad Politécnica de Francisco I. Madero, ubicada en Tepatepec, Hidalgo. Cada año se realizan crianza de poblaciones de gusano de seda en donde se involucran alumnos de la Ingeniería en Agrotecnología para reforzar conocimientos teórico-prácticos de Entomología. Se concluye que el ciclo de vida del gusano de seda es de aproximadamente 45 días, pasando por huevo, larva, pupa y adulto.

Larva, Morera, Sericultura, Capullo, Insecto

2 Introduction

In Mexico, particularly in the state of Hidalgo, due to its economic importance, silkworm cultivation is being promoted to obtain silk thread and to evaluate the nutritional value of the worm (larva) and pupa, in comparison with some edible insects (Rodríguez et al., 2012). The silkworm is the larva of the moth *B. mori* Linnaeus (Lepidoptera: Bombycidae), which produces silk by feeding on the mulberry plant (*Morus alba* L.) of the Moraceae family. It is an insect of the Lepidoptera order, to which belong the so-called "moths" (of nocturnal habits, including the silkworm) and the "butterflies" (of diurnal habits). It is a domesticated insect, which means that it is fully adapted to commercial breeding. In fact, it does not exist in the wild because it has lost the ability to fly and to survive in extreme environmental conditions. It is a species of complete metamorphosis, which means that during its life it goes through the stages of egg, larva or worm, chrysalis or pupa and butterfly. While all stages are very important, particular attention will be paid to the larval and pupal stages. Breeding consists of feeding the worms, which upon entering the chrysalis stage will build a cocoon, with a single silk thread, which is the productive unit (Pescio et al., 2008). It is a domesticated species that has been exploited for more than 5,000 years, the breeds currently reared have been derived from a wild worm B. mandarina Moore, 1872 originating in China, India and Korea. The insect ingests approximately 20-22 g of fresh mulberry or 5-5.5 g of dried mulberry for growth, 40% of the consumption is assimilated and the remaining 60% is eliminated through excrement, and only 25% of the digested food is transformed into raw silk for cocoon formation. The food and its nutritional quality have a great influence on the development of the silkworm, in the larval stage and in cocooning. In order to carry out its morphological development and metabolic functions, the silkworm needs two important nutrients, crude protein and carbohydrates, which are concentrated in high percentages in the young leaves of mulberry trees. The amount of macro- and micronutrients in mulberry leaves influences the content of protein, lipids, carbohydrates, vitamins, minerals and water, and varies according to variety, soil fertility, climate, time of year, age and leaf position (Rodríguez et al., 2016). The purpose of this work is to present the main morphological characteristics of the different stages of the life cycle of the silkworm developed at the Universidad Politécnica Francisco I. Madero.

2.1 Methodology to be developed

The academic project financed by the "FOMIX CONACYT 131264" concerning "Mulberry plantations and silkworm populations" has been developed for fourteen years in the Agrotechnology Engineering of the Universidad Politécnica Francisco I. Madero, located in Tepatepec, state of Hidalgo, Mexico. To date, there is a plantation of three mulberry varieties and two silkworm breeds. Every year, rearing of this insect is carried out in which the students of UPFIM and especially those of Agrotechnology carry out practices related to the Entomology and Phytosanitary of the crop, taking data of all the biological stages of the *Bombyx mori* such as egg, larva, pupa and adult, the observations are captured and analysed in the Excel programme.

2.2 Results

The mulberry tree is the only plant on which the silkworm feeds, it grows in tropical, subtropical and temperate climates, it can grow in infertile soils, but when grown in rich soils, with regular irrigation, it produces large quantities of high quality leaves, these characteristics are present every year in the UPFIM plantation (figure 1A). Its cultivation has historically been for silkworm rearing, however, mulberry has a variety of uses: as livestock feed, fruit production, medicinal recipes, garden construction, paper products, timber and firewood production. Mora 2010, carried out experiments on the diet of rabbits using mulberry leaves as fodder, obtaining good results.

Silkworm eggs are round, 1 to 1.3 mm long and 0.9 to 1.2 mm wide, they can be oval, flattened or ellipsoidal, at the time of oviposition they have a yellowish-white colouring that will vary in the following hours, until, finally, it turns grey (figure 2). Pescio et al., (2006), report that the egg stage comprises the resting period of their active life and from this several types of races or biological groups of the silkworm can be classified. The races are classified according to the type of diapause: univoltine and polyvoltine. Univoltine silkworms have only one cycle per year; bivoltine silkworms have two cycles per year, while polyvoltine silkworms have a very small diapause and can develop several generations per year. The duration of this state depends on the breed and type of diapause or dormancy. Diapause is the suspension of development. Eggs with diapause are those with two stages of embryonic development. The first stage takes place during the 48 hours, during which embryo development stops, and the second stage, hibernation, of variable duration, and which needs specific environmental conditions to become active.

Álvarez, 1993, reports that they are elliptical in shape with a smooth chorion, and measure 1 mm wide by 1.3 mm long. Freshly laid, they are pale yellow in colour. As the embryo develops, the colour of the eggs varies. At 40 hours of age, the eggs become pinkish in colour, and at 72 hours, their colouring is ochre. He also mentions that the larvae, before hatching, open a hole in the chorion and are black when hatched. The body is covered with long, light brown setae, the setae emerge from warts located on the anterior part of the three thoracic segments and the eight abdominal segments; a caudal horn is observed on the eighth abdominal segment, and as they develop, they change colour until they become white. We report that the worm is the most active, because a series of processes and changes occur, such as feeding, metabolism, skin changes, silk secretion and cocoon development. The larvae (figure 2C) have a rigid cuticle that limits the size of the insect, which is why it can only grow by shedding its old exoskeleton and making a larger one, a process called molting. The larva loses its appetite, raises its head, its body becomes tense and creamy in colour, and it becomes restless as it approaches moulting.

The pupal stage is a dormant stage, when the insect is unable to eat and appears completely still. It is a transient phase during which changes in the shape of the insect are defined. Pupation is important because hysterolysis occurs in some larval organs, such as the sericine gland, abdominal legs and ocelli (figure 2D). Similar observations are reported by Alvarez 1993, the pupae are of the obcta type; newly formed pupae are light green in colour and after 24 hours they turn brown. The average duration of this stage ranges from 15 to 40 days. The pupal stage is generally called the resting, dormant stage and is the stage when the insect is unable to eat and appears completely still. The pupal stage is a transient phase during which changes in the shape of the insect are defined.

The pupal stage is important because hystolysis occurs in some larval organs, such as the sericeous gland, abdominal legs, ocelli, etc. Other organs also change their shape and specific functions in the adult. The duration of this stage is 12 to 15 days, and it is relatively fixed and finished when the butterfly emerges from the cocoon (Pescio *et al*., 2008).

The silk cocoon formed by two proteins is a protective structure that the worms build with a single silk filament, prior to their transformation into a butterfly (figure 2.1). Rodriguez et al., 2013, mention that on average it weighs 1.8 g without chrysalis or pupa (figure 2E). The filament is made up of slime secreted from the serigal glands. Silk filaments are generally 20-30% sericin and 70-80% fibroin. The components of fibroin and sericin are: C, H, O, N and S.

Figure 1 Biological stages of the silkworm Bombyx mori at the Universidad Politécnica Francisco I. Madero, Tepatepec, Hidalgo. Mulberry crop (A), eggs and hatching larvae (B), last instar larva (C), pupae (D), cocoons (E) and adult or moth (F)

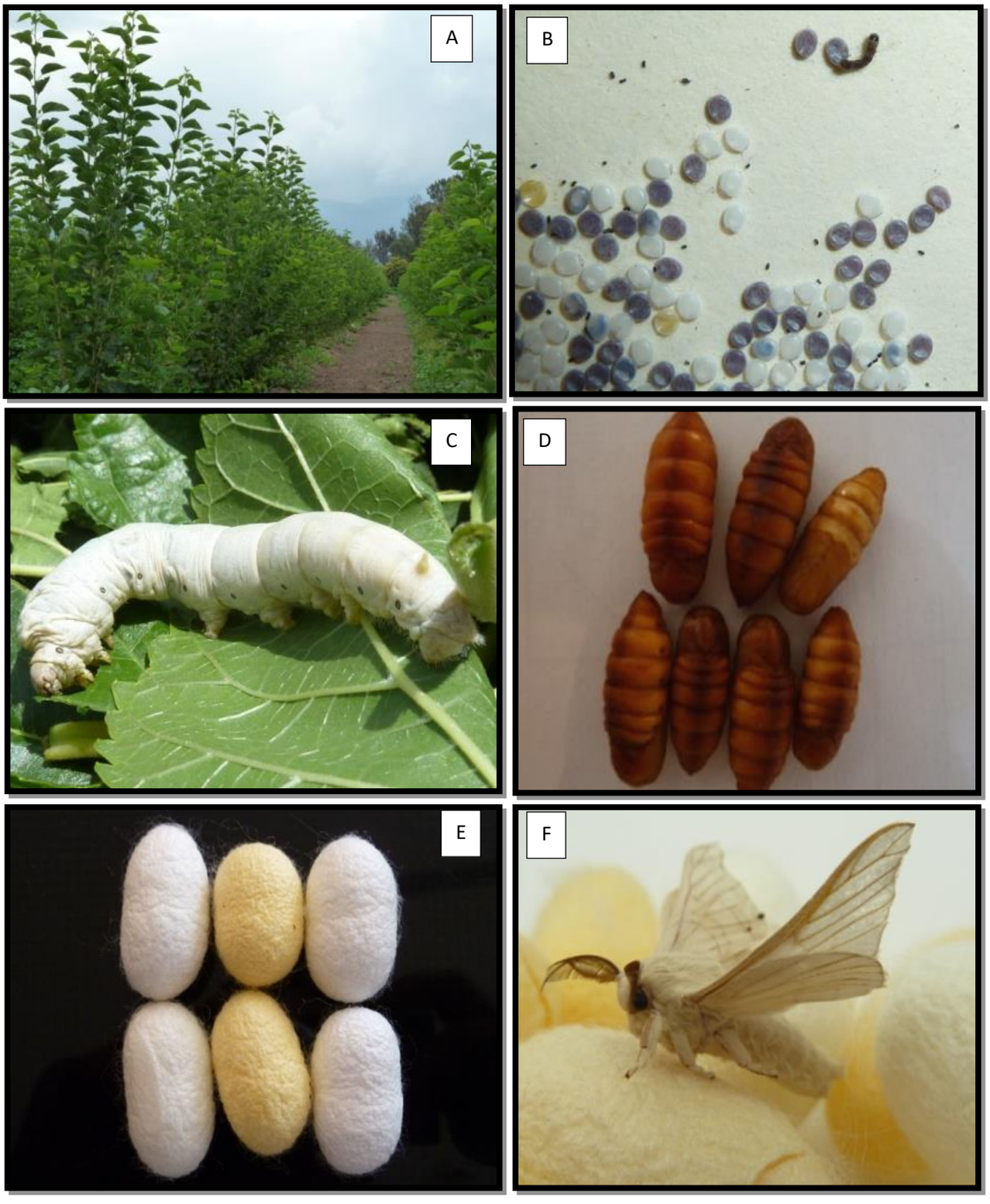
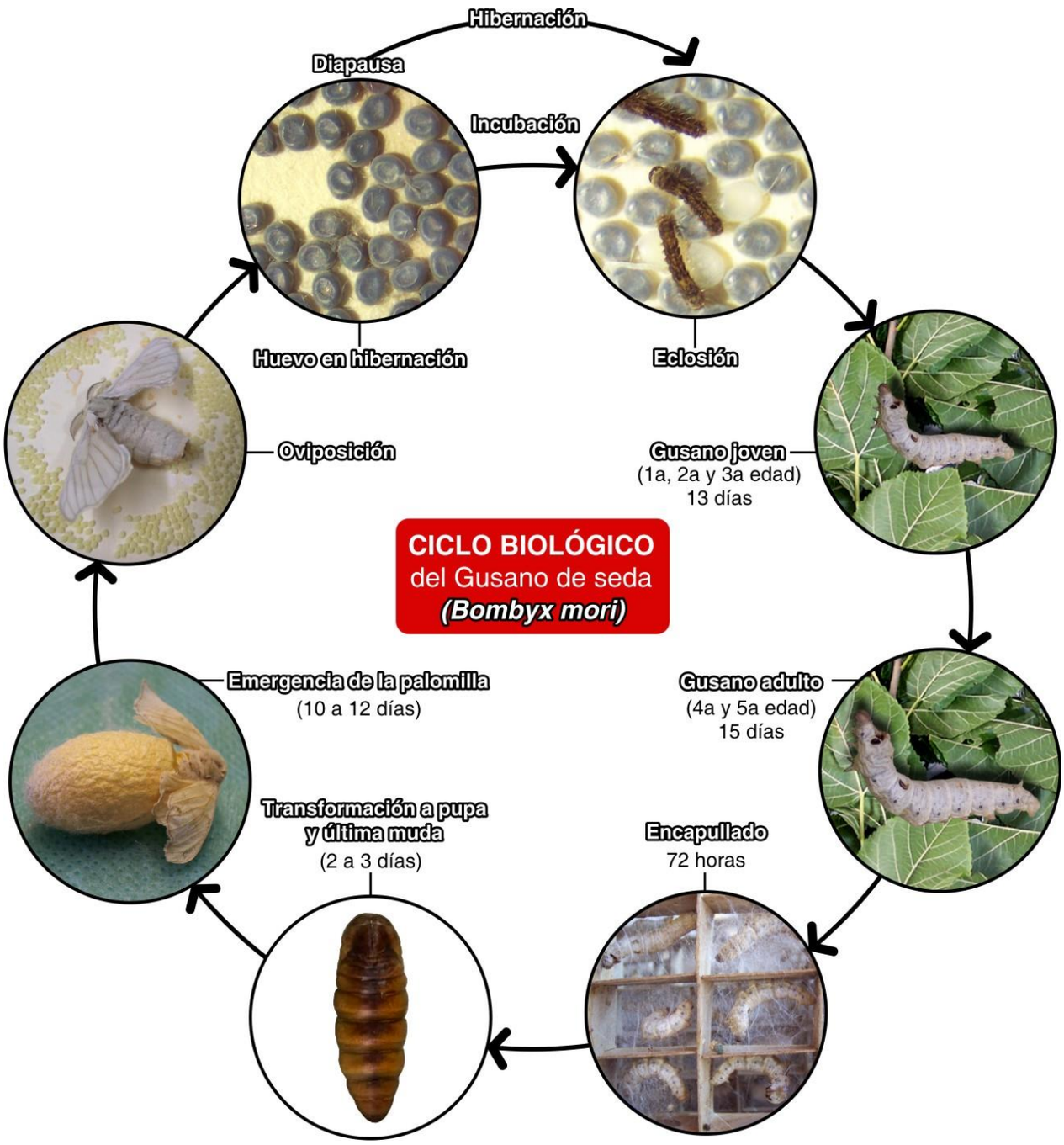


Figure 2.1 Life cycle stages of the silkworm, personal communication with the Centro Nacional de Sericultura de San Luis Potosí



The moth consists of three parts: head, thorax and abdomen (figure 2.1). The body is covered with white scales and there are three pairs of legs and two pairs of wings on the thorax. Their function is exclusively reproductive, they cannot fly or feed. The head of the adult has two feathery antennae which are used to perceive the smell of pheromones, especially those of the larger male (figure 2F). Similar information is reported by Salice *et al*., (2001), who state that the moth consists of three parts: head, thorax and abdomen. The body is covered with white scales and there are three pairs of legs and two pairs of wings on the thorax. Their sole function is reproduction, they cannot fly or feed. The head of the adult has two feathery antennae, which are used to perceive the smell of pheromones, especially in the larger male. Sex can be easily distinguished in this state because the female has a larger body than the male due to the large number of eggs contained in the abdomen.

2.3 Acknowledgement

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2.4 Conclusion

Finally, it is concluded from this work that the life cycle of the silkworm is approximately 45 days, passing through egg, larva, pupa and adult, and that up to four broods can be carried out per year, given suitable climatic and phytosanitary conditions for the insects and the mulberry crop.

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