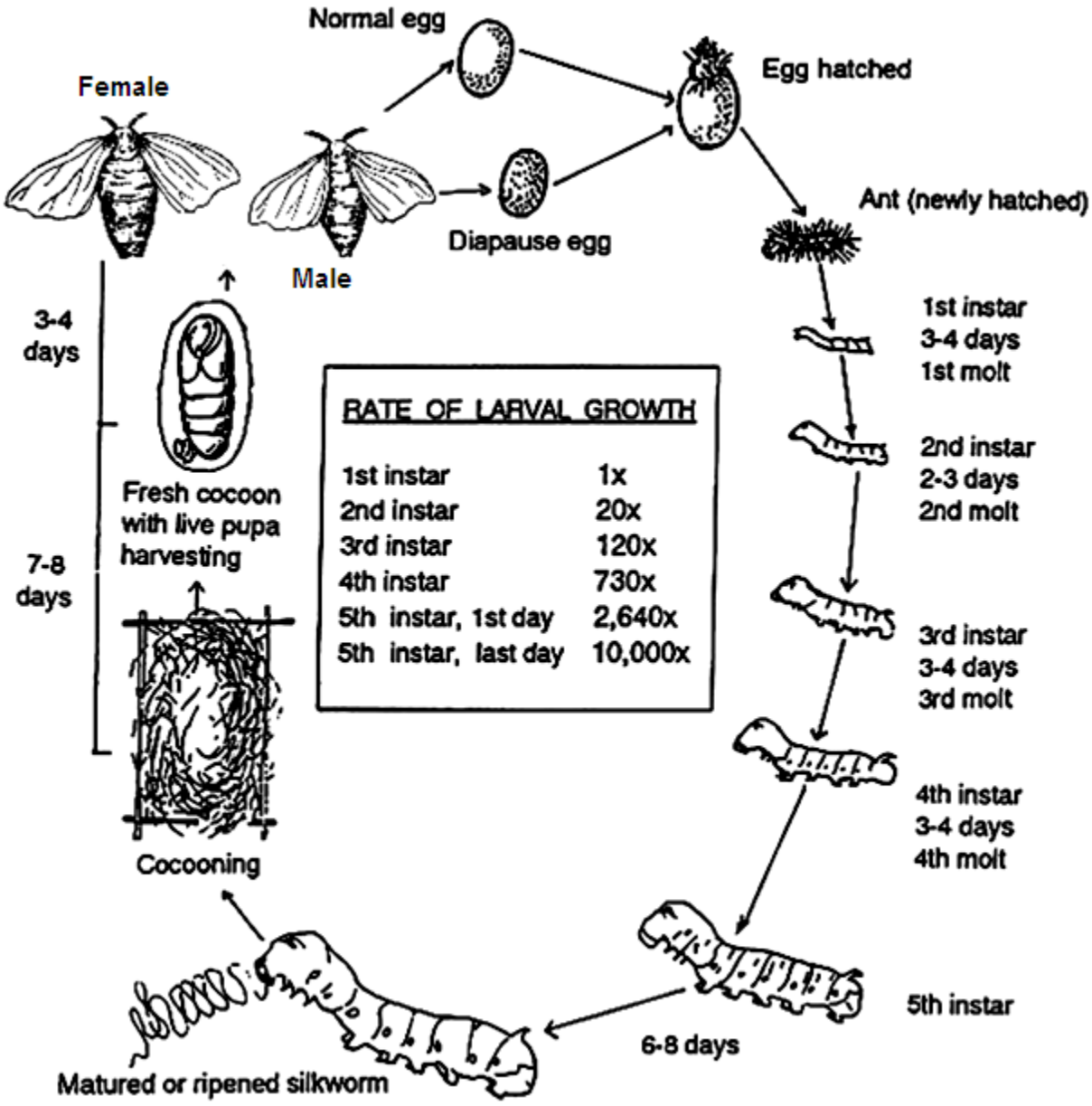
Life Cycle of silkworm *Bombyx mori*

Dr.H.B.Mahesha, Yuvaraja's College, University of Mysore, Mysuru.



As in the case of a typical Lepidopteran insect, the silkworm passes through four distinct stages, *i.e.*, egg, larva, pupa and adult during its life cycle, the duration of which may last for six to eight weeks depending upon racial characteristics and climatic conditions. Multivoltine races found in tropical areas have the shortest life cycle with the egg, larval, pupal and adult stages lasting for 9-12 days, 20-24 days, 10-12 days and 3-6 days respectively. In uni/bivoltine races, the egg period of the activated egg may last for 11-14 days, the larval period 24-28 days, the pupal period 12-15 days and the adult stage 6-10 days.

In nature the univoltine races produce only one generation during the spring, and the second generation egg goes through a period of rest or hibernation till the next spring. In the case of the bivoltine races, however, the second generation egg does not hibernate and hatches within 11-12 days and produces the second generation normally during summer. But it is the third generation egg which undergoes hibernation and hatches only the next spring, thus producing only two generations in a year (bivoltine). In multivoltine races, the life cycle is the shortest because of the warmer ecological conditions where they are reared, and so they may yield as many as seven to eight generations in a year in tropical sericultural areas such as India, Thailand, etc., silkworm rearing is, therefore, continuous in tropical areas whereas in sub-tropical and temperate zones it is mostly seasonal lasting from spring to early autum.

Larval life

In sericulture it is the larval life that is of direct importance to the rearer since he has to take care of the worms very carefully. The larval life may last from 20-24 days in the case of the multivoltine species in tropical areas or 24-28 days in the case of uni and bivoltine races in temperate areas, being shorter under warmer summer and autumn conditions, and some what longer under cooler spring conditions. During the larval life the worm moults or casts off its skin four times to be able so as to grow. There are also varieties of worms which moult three and five times but they are not of importance economically.

In view of the four intervening moults, the larval life is divided into five distinct stages or instars which are referred to popularly as five different ages. The first three instars are referred to as "young ages" and the fourth and fifth instars as "late ages". The duration of the different instars and moulting periods for the different races is as follows:

Duration of different instars and moulting periods

		Multivoltine races		Uni and bivoltine races	
		Duration	Temperature and humidity conditions	Duration	Temperature and humidity conditions
I	instar	3 days	27°C 80-85% R.H.	3 days	27ºC and 85% R.H.
I	moult	20 hours		20 hours	
II	instar	2 days		2 days	
II	moult	20 hours		20 hours	
III	instar	3 days		3 days	25ºC and 30% R.H.
III	moult	1 day		1 day	
IV	instar	4 days	25-26°C 70-80% R.H.	5 days	22-24ºCand 75% R.H.
IV	moult	1 day		1 day	
V	instar	6-7 days		9-10 days	20-23°Cand 70%
Total Duration		22-23 days		26-27 days	

Moulting

Each larval instar can be broadly divided into two phases i.e., the feeding phase and the moulting phase. After feeding voraciously and having attained full growth for the particular instar the worm loses its appetite and the larva prepares to moult and cast off its old skin. Prior to each moulting, the larva stops feeding and rests with its head held up. The lustrous body skin gradually becomes translucent, loose and wrinkled and the worm becomes dull in appearance and wanders about in search of a resting place. It emits a silky substance with which it fixes itself to dry leaves.

The moulting periods last for 20 hours being shortest in the second moult, followed by the first, third and fourth. This resting for moulting is often referred to as "going to sleep" and the coming out of the worm from moult as "waking up". During the moulting period the worms should not be disturbed so that the process of moulting is not interfered with and uniform moulting is ensured.

Mature worms

After the silkworm passes through four moults, it reaches the fifth and final instar when it attains its maximum weight a day prior to maturity and before it stops feeding. At its maximum weight it is about 10000 times its own weight at the time of hatching and this phenomenal growth takes place within the short span of 20-25 days. When the worm is fully mature for mounting, it loses it appetite, stops feeding, and excretes soft faeces with high moisture content. At this stage because of its voluminous increase in size, the silk gland is visible through the body integument and, therefore, the thorax and body segments of the mature larva appear translucent. In fact the silk glands are so enlarged as to account for nearly 40 per cent of the body itself. This is characteristic of the ripened worm and serves as guidance for picking the mature worms for mounting. The mature worms become very restless and raise their heads in search of support so as to be able to start spinning.

Spinning of the cocoon

The spinning of the cocoon starts almost immediately after mounting and in 48-72 hours spinning is completed by the mature worm. In another day or two the worm transforms itself into the pupa within the cocoon.

The pupal period may last for 8-14 days after which the adult moth emerges slitting through the pupal skin, and piercing the fibrous cocoon shell with the aid of the alkaline secretion (cocoonase- a protease enzyme) that softens the tough cocoon shell.

The adult moths are ready to copulate immediately after emerging from the pupa and the female then lays the eggs. Adult life is short, lasting from 3-10 days depending upon races and seasons. The adults do

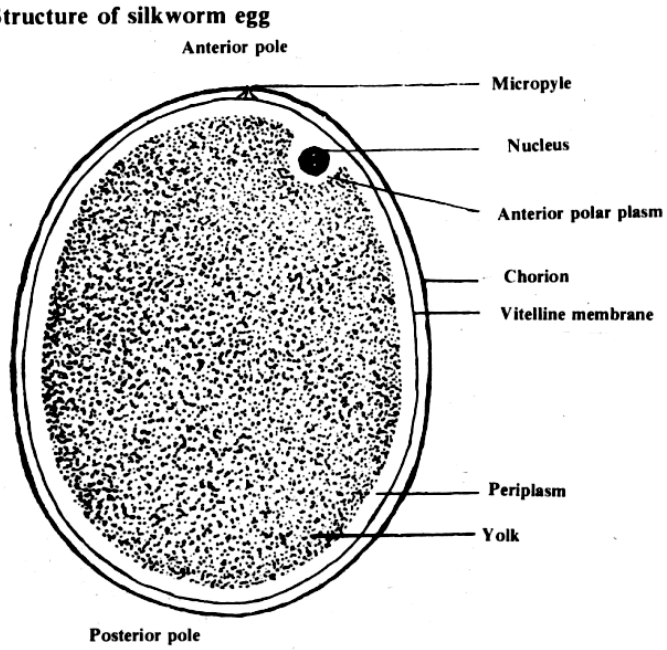
not feed and are also incapable of flight due to domestication over thousands of years. The females are larger in size and generally sluggish while the males are somewhat smaller and more active. A female of the multivoltine variety may lay an average approximately 400 eggs while the average number for the uni-and bivoltine varieties of silkworm moths is from 500-600.

Morphology *Bombyx mori*

Silkworms pass through a complete metamorphosis (Holometabola) from egg to the adult stage through two intermediate stages of larva (caterpillar) and pupa (cocoon).

The morphology of the *Bombyx mori* in its different life-cycle stages are discussed below:

Egg



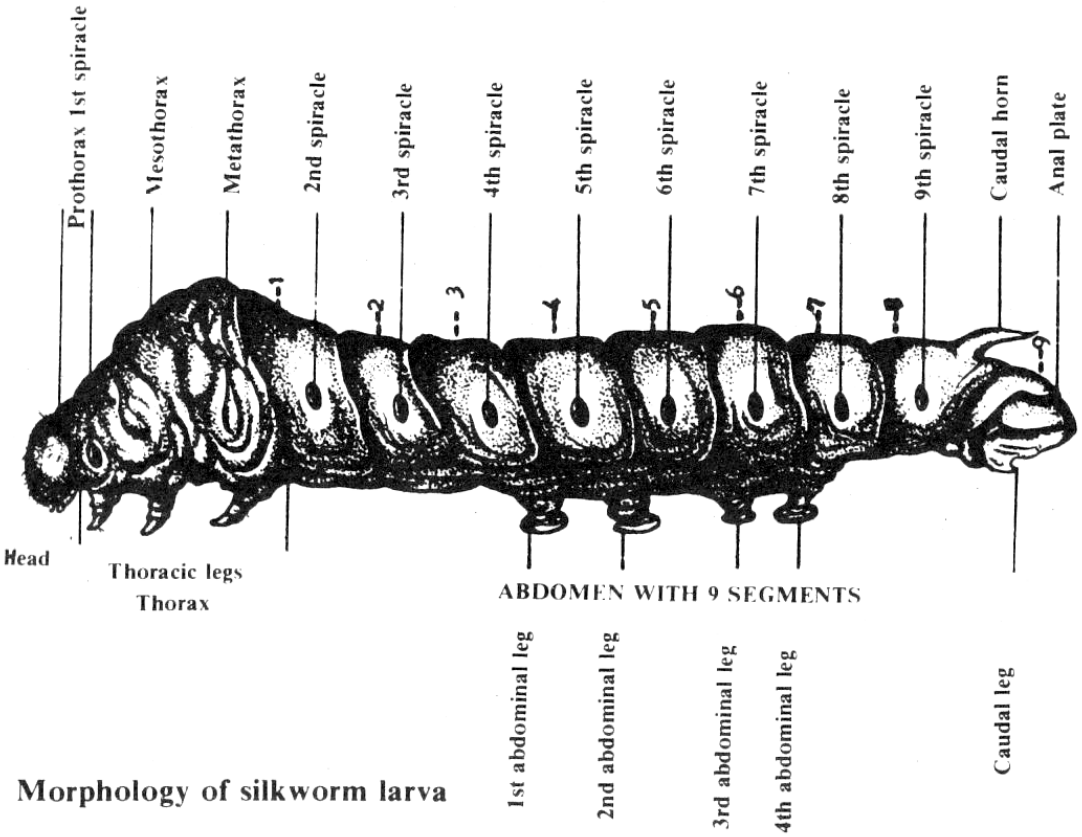
Structure of silkworm egg

The size, weight, shape, colour of the egg as well as number per laying vary among different strains. The silkworm eggs are tiny and weight of a single egg is about 0.55 to 0.6 mg, so that there are 2000 eggs per gram. The silkworm eggs measure 1 to 1.3 mm in length and 0.9 to 1.2 mm in width. They may be ovoid, flat, ellipsoid or oval and flat at the ventral side. The protective covering of the egg is chorion with a micropyle at the anterior pole and slightly off-centre. The sperm enters through this opening for fertilization. The respiratory canals are distributed in large numbers over the entire surface of the egg and these are funnel shaped. The air necessary for respiration enters through these respiratory canals. The colour of the egg is also a racial character. Races producing white cocoons lay pale yellow eggs, while races producing yellow

cocoons lay deep yellow eggs. In both cases the Japanese races lay slightly darker eggs than the Chinese races. In the case of the hibernating eggs laid by bivoltine and univoltine races, the egg colour changes and becomes dark brown or purple with the deepening on the colour of the serosal pigments.

Larva:

The silkworm larva when newly hatched is black or dark brown. It has a large head and the body is densely covered with bristles so that it looks like a hairy caterpillar. There are four pairs of tubercles; the subdorsal, supra spiracular, infra spiracular and basal tubercle each of which carries three to six setae. As the larva grows, it becomes smoother and lighter in colour due to the rapid stretching of the cuticular skin during the different instars of the larval stage. The larval body is composed of the same segments as any insect: head, thorax and abdomen. The entire body is covered with a thin and elastic chitinous cuticle which is capable of being extended considerably to permit rapid growth of the larva during any instar. The integument consists of the epidermis and the cuticle over it.

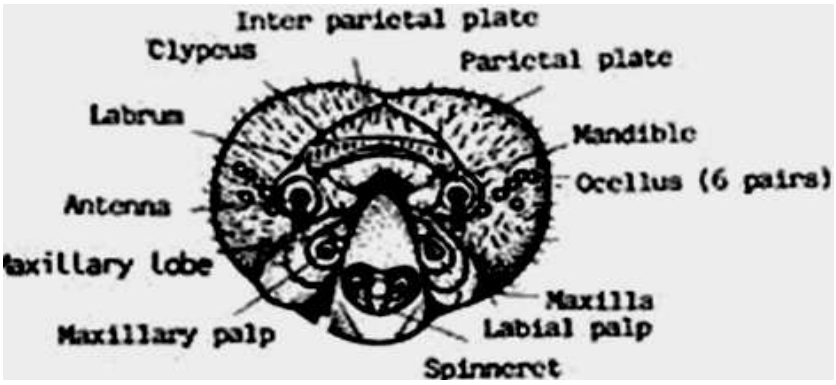


Morphology of silkworm larva

Head: The head consist of six body segments fused together with a cranium. The second, fourth, fifth and sixth segments carry appendages which are modified into antennae, mandibles, maxillae and labium respectively. Median epicranial suture is well developed and prominent. Similarly on the outer side, the

clypeus and the labrum are also prominent. There are six pairs of ocelli or larval eyes which are located behind and a little above the base of the antennae. There is a pair of antennae formed of five jointed segments and these are used as sensory organs (feelers). The mandibles are well developed and powerful and are adapted for mastication.

The maxillae on the ventral side of the mouth consist of cardo, stipes, maxillary lobe and maxillary palpi. Maxillary lobe and maxillary palpi discriminate the taste of food. The labium is located ventrally carrying a big-sized, lightly chitinized mentum. The prementum is chitinized and black. Distally the prementum carries a median process or spinneret through which silk is expelled from the silk gland to form the silk bave or thread. The sensory labial palpi are found on both sides of the spinneret.



Magnified Head od the silkworm

Coloured scanning electron micrograph (SEM) of the head of a silkworm

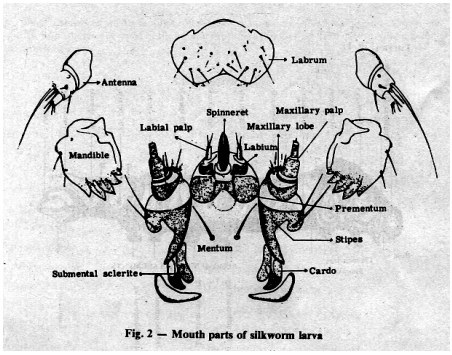


Fig. 2 — Mouth parts of silkworm larva

Thorax: The thorax consists of three body segments called the pro, meso and metathorax. Each of the three thoracic segments carries ventrally a pair of legs each comprising in turn three jointed segments. These are the true legs which are conical in shape and carry sharp distal claws. These claws are not used

for crawling but for holding mulberry leaves while feeding. All the silkworm larvae that show body larval markings carry the so-called eye spot on the dorsal side of the mesothorax.

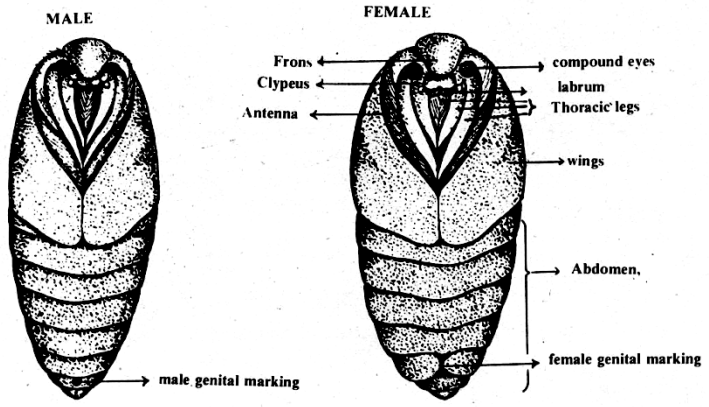
Abdomen: The abdomen is comprised of eleven body segments although only nine can be distinguished as the last three are fused together to form the apparent ninth segment, the anal plate and the caudal legs. The third to sixth and the last abdominal segments each bear a pair of abdominal legs which are fleshy, unjointed muscular protuberances. At the extremity they form a sort of disc with a series of hooks inwardly curved and arranged in a semicircle. On the dorsal side of the eighth abdominal segment, the larva carries the caudal horn. The abdominal segments carry the sexual markings which develop distinctly in the fourth and fifth instars in the eighth and ninth segments on the ventral side. In the female the sexual markings appear as a pair of milky white spots in each of the eighth and ninth segments. The pair of spots on the eight segments is known as Ishiwata's fore glands and the pair on the ninth segment is referred as Ishiwata's hind glands. In the male a small milky white body (Herold's gland) appears at the centre of the ventral side between the eighth and ninth segments. There are nine pairs of spiracles placed laterally on either side of the body. They are found on the first thoracic segment and the first eight abdominal segments. These are the breathing or respiration pores.

The larval skin or integument consists of the cuticle and the hypodermis. The cuticle is made of chitin as well as protein and is covered with a thin layer of wax. Nodules are found all over the body surface of the silkworm larva. The distribution of these nodules differs according to the variety of silkworms, being less in number in varieties having lustrous body surfaces, such as the Chinese bivoltine and the multivoltine varieties. The nodules are found in larger numbers over parts of the body where normally the larval markings are found. The larval markings in silkworms are caused by skin pigment.

Pupa: The pupal stage is generally called the resting, inactive stage of the silkworm when it is incapable of feeding and appears quiescent. This is a misnomer. The pupal stage is a transitional phase during which definite changes take place. During this period of biological activity the larval body and its internal organs undergo a complete change and assume the new form of the adult moth. The mature silkworm larva passes through a short transitory stage of pre-pupa before becoming a pupa. During the pre-pupal stage the dissolution of the larval organs takes place and this is followed by the formation of adult organs during the pupal stage. Soon after pupation the pupa is white in colour and soft but gradually turns brown to dark brown and the pupal skin becomes harder.

The prominent morphological parts visible are a pair of large compound eyes, a pair of large antennae, fore-and hind-wings and the legs. Ten of the abdominal segments can be seen on the ventral side,

but only nine of them are visible on the dorsal side. Seven pairs of spiracles can also be discerned in the abdomen; the last pair is non-functional. Sex markings are prominent and it is much easier to determine sex in the pupal stage than in the larval stage. The female has a fine longitudinal line on the eighth abdominal segment, whereas such a marking is absent in the case of the male.



Drawing of male and female pupa
Bombyx mori

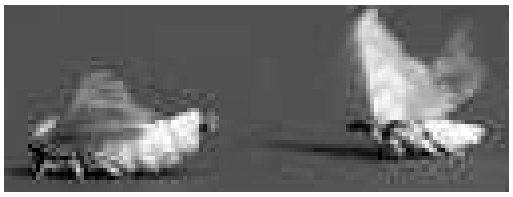
Adult: The adult moth emerging from the pupa is incapable of flight as a result of its domestication for more than four thousand years. It does not feed during its short adult life. The body of the moth like that of the larva is composed of three distinct segments: head, thorax and abdomen. Another important characteristic in common with other moths and butterflies is that the body surface is covered with scales. The compound eyes are situated on either side of the head. The ocelli are absent. The antennae are conspicuous, large and bipectinate.

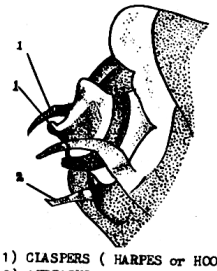
The thorax consists of three segments namely pro, meso and metathorax as in the larva. The meso thorax is the largest and is pentagonal. There are three pairs of thoracic legs, one pair on each of the three thorasic segments. Each of the thorasic legs is composed of five segments. The meso and metathorax bear two pairs of wings, the front pair overlapping the hind pair when the moth is in the resting position.

In the male eight abdominal segments are visible; in the female seven. There are six pairs of spiracles present laterally on either side of the body.

Morphologically the female and male can be easily distinguished in the adult stage. The female has comparatively smaller antennae, its body and the abdomen are fatter and larger and it is generally less active than the male moth. At the caudal end, the male moth has a pair of hooks known as harpes where as the female moth has a knob-like projection with sensory hairs. These differences help to a large extent in separating the sexes for preparation of hybrid eggs.

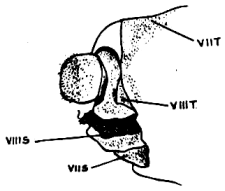
Female and Male Moths





1) CLASPERS (HARPES or HOOKS)
2) AEDEAGUS

Abdominal end of male moth



(lateral view)

VII T & VIII T-7 & 8 Abdominal tergite

VII & VIII S — 7 & 8 Abdominal sternites

Abdominal end of female moth
