

BIOLOGY OF SILKWORM (*BOMBYX MORI*) IN TURKEYO. Yilmaz^{1*}, Y.E. Erturk², F. Coskun³, M. Ertugrul⁴¹Vocational High School of Technical Sciences, Ardahan University, Ardahan, Turkey.²Faculty of Agriculture, Department of Agricultural Economics, Iğdir University, Iğdir, Turkey.³Faculty of Agriculture, Department of Animal Science, Ahi Evran University, Kirsehir, Turkey⁴Faculty of Agriculture, Department of Animal Science, Ankara University, Ankara, Turkey.

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Abstract

According to oldest records the first time silkworm was cultivated and silk was obtained from cocoon at China. Silkworm eggs and mulberry seeds were brought to Istanbul illegally the year 552 at the age of Byzantine Empire although China kept it as a secret. It started to spread in the Marmara region especially in Bursa and its neighbourhood. Then it was spreaded to all over the world. Sericulture has been economical, cultural and traditional cultivating sector in Turkey for 1500 years. Silkworm is cultivated in about 30 countries that include Turkey. Silk fiber is superior to other fibers in terms of stability, flexibility and brightness. Amount of need is approximately twice the amount of cultivating. In the whole world Turkish silk fiber quality is at second rank after Japanese silk. Silkworm is a general term that includes a range from worm to the butterfly. Silkworm is a kind of night butterfly. Butterflies are light cream colour, have chubby bodies and have soft feathers. Wingspan is about 4-5 cm. Butterflies have lost flying ability because of domestication also have 2 or 3 days life and at that period doesn't feed and doesn't fly. Silkworm is fed with mulberry leaves. One cocoon is made from a single silk fiber its length is 800 meters. Real silkworm named "*Bombyx Mori L*" is bred at mulberry tree which is cultivated in China is white breed. *Bombyx Mori L* silkworm produces best silk fiber among other genus and it is most special genus cultivated.

Key words: Sericulture, native breed, genetic resource, Silk Road, cocoon.**Introduction**

Some animal species and breeds had an important place in the history of some countries such as Merino sheep in Spain, Angora Goat in Turkey and sericulture in China (Ertugrul et al. 2010). Sericulture in the World is

generally made in Asian countries. In the World production percentages of China and India are 80% and 15% respectively (Kaya and Tutkun 2012). The production of fresh cocoon is about 134 in 2012 (Table 1). Silk has some unique characteristics in kinds

of fabric. It is shiny, soft, strong, and has a fabric can be dyed. It is so sensitive, therefore it is effected by noise, smell, wind, temperature change, even carers hygiene (Imer 2005). Generally four kinds of silkworm which are Mulberry, Eri, Tasar and Muga are reared in the World. Mulberry silkworm (*Bombyx mori*) (Table 2) has the majority in them which percentage is about 95%

(Akbay 1981). In Turkish society silkworm seem cute. A survey study was realized in primary school students. According to study between 9 and 40% of students in different levels rear insects. Students rear silkworm, ant, ladybug and grasshopper which showed that silkworm was one the loveable insect in insect groups (Tezcan et al. 2010).

Table 1. Production of apiculture and sericulture (Anon 2010, Anon 2013).

Year	Number of Villages Engaged in Sericulture	Number of Families Engaged in Sericulture	Number of Egg Boxes Produced	Production of Fresh Cocoons (tonnes)
1936	2.201	49.338	56.278	2.135
1940	2.422	63.498	73.045	3.014
1950	3.013	69.354	62.927	2.501
1960	2.530	60.370	50.865	2.444
1970	1.559	43.589	64.340	1.461
1980	1.601	43.025	66.042	1.707
1990	1.916	44.541	80.544	2.171
2000	230	2.210	3.147	60
2012	342	2.572	5.576	134

Table 2. Scientific classification of the silkworm (Akbay 1981).

Phyluym	Artropoda
Class	Insecta/Hexapoda
Ordo	Lepidoptera
Subordo	Macro Lepidoptera-Heterocera
Super Family	Bomycoiden
Family	Bomycidae
Genus	Bombyx
Species	B. mori

Genetic Resources

There are three registered silkworm breed by Turkish Standard Institution called as White of Bursa (Bursa Beyazi) (Figure 1 and 4), Piebald White of Bursa (Bursa Beyazi Alaca) (Figure 2 and 5), and Yellow of Hatay (Hatay Sarisi) (Table 3) (Figure 3 and 6) (Anon 2004). In a

study genetic variation was searched those three breeds by using method of RAPD based on PCR. According to results 68 of RAPD band were invastigated and the highest ration of polymorphic locus was 55,9% in Yellow of Hatay. The ratios of White of Bursa and Piebald White of Bursa were 44,1%. Nei's genetic distance

for White of Bursa-Piebald White of Bursa, White of Bursa-Yellow of Hatay, and Piebald White of Bursa-

Yellow of Hatay were 0,0637, 0,1012, and 0,0793 respectively (Akkir et al. 2010).

Table 3. Some traits of three silkworm breeds of Turkey (Anon 2004).

Trait	White of Bursa (Bursa Beyazi)	Piebald White of Bursa (Bursa Beyazi Alaca)	Yellow of Hatay (Hatay Sarisi)
Voltinism	Univoltin	Univoltin	Univoltin
Moultinism	4	4	4
Egg shape	Elliptic	Elliptic	Elliptic
Egg colour	Gray	Gray	Gray
Egg yield	390-590	439-656	303-545
Cocoon shape	Elliptic	Elliptic	Groundnut
Cocoon colour	White	White	Orange
Single cocoon weight (gr)	1,25-2,16	1,6-2,1	1,4-2,1
Ratio of Cocoon/Shell	11,9-15,8	13,3-15,7	10,9-13,5



Figure 1. Larvas of White of Bursa (Bursa Beyazi)



Figure 2. Larvas of Piebald White of Bursa (Bursa Beyazi Alaca)



Figure 3. Larvas of Yellow of Hatay (Hatay Sarisi)



Figure 4. Cocoons of White of Bursa (Bursa Beyazi)



Figure 5. Cocoons of Piebald White of Bursa (Bursa Beyazi Alaca)



Figure 6. Cocoons of Yellow of Hatay (Hatay Sarisi)

Morphology

As like other Lepidoptera insects silkworm has four various life cycles (Table 4). It has $2n=56$ chromosomes. Polyvoltine breeds can give 300-400 eggs (Akbay 1981). Silkworm is a monofag creature (Akkaya 2003) and it is only fed by eating mulberry leaves (Akbay 1981, Anon 2014^{a,b}). Apoptosis is a programmed cell death and Lockshin proved in 1964 that

silkworms have apoptosis in their metamorphosis process (Dogan et al. 2010). Pheromone is a secreted or excreted chemical factor that triggers a social response in members of the same species (Anon 2014^c). The first invented pheromone was bombykol in silkworms. Female silkworm excretes bombykol to influence males (Bati 2014).

Table 4. Life cycles of silkworm in polyvoltine breeds (Akbay 1981, Yasayanlar 2013).

Cycle	Duration	Mulberry leaves requirement (kg/per egg box)	Condition of heat and humidity
1 st Age	3 days	1-2	27 ⁰ C heat and 85% humidity
1 st Sleep	20 hours		
2 nd Age	2 days	5-6	
2 nd Sleep	20 hours		
3 rd Age	3 days	20-25	
3 rd Sleep	1 day		22-24 ⁰ C heat and 75% humidity
4 th Age	5 days	80-90	
4 th Sleep	1 day		20-23 ⁰ C heat
5 th Age	9-10 days	450-475	
Total	26-27 days		

Fibre of silk is composed from two fibres of silk made from fibroin protein. Those two fibres are covered by sericin protein. Percentages of fibroins and sericin in silk fibre are 75% and 25% respectively. After silk fibres are woven, layer of sericin should be removed from fibre. This process should be made after silk fibres are woven but before silk fibres are dyed. After sericin removed from silk fibres, the fabric becomes brighter, softer and elastic. For this operation some acid, neutral or basic protease materials are used. In a study those three different materials were investigated and results showed that the best cleaning material is based on basic proteases (Duran et al. 2007).

In a study six days application of Juvenile Hormone Analogue Fenoxycarb (JHAF) was searched on major hemolymph proteins of silkworm during last larval instar. According to observed results JHAF application extended the last larval instar in first five days. There was no difference in 6th day application for last larval instar (Uranli et al. 2011). Tufan et al. (2009) investigated brains at developmental stages of silkworms

histologically. The study showed that there were three different kinds of cells types (NSH-1, NSH-2, NSH-3) in pars intercerebralis but one kind of cell type (NSH-L) in pars lateralis. Malay et al. (2006) analyzed different forms of silk fibroin films for iontophoretic medicines by using methods of high temperature, dehydration by freezing, metanol and glutaraldehyt. According to results using glutaraldehyt extended durability of iontophoretic medicines. Izzetoglu et al. (2009) carried out a study to define effect of juvenile and ecdysone hormones treatments in growing stages of silkworms. Those two different hormones applied to silkworms by ugiving two different doses. The results showed that juvenile and ecdysone hormones treatments caused different cocoon weight, diameter and length. It could be said that silk and cocoon structures were affected by juvenile hormones, but weight of pupa was affected by ecdysone hormones. Izzetoglu and Karacali (2012) studied out to determine salic acids in hematopoietic organ of silkworm. It was clear that hematopoietic organ of

silkworm had of N-acetylneuraminic acid (Neu5Ac) and N-glycolyl neuramic acid (Neu5Gc) types of sialic acids. Falakali and Turgay (1999) searched role of rectal sac for going out silkworm mots from cocoons. According to results place, shape and content of the rectal sac affected the puncture of cocoon. Batir et al. (2012) carried out a project to define expression pattern of ecdysone receptor B1 (EcR-B1) in prothoracic glands of silkworm during last larval instar and early pupal stage. The results proved that ecdysone application reduced immunoreactivity in silkworms. In a study development differences in the first (feeding 20 gr) and second groups (feeding 10 gr) were studied by designating the development of control group feeding normal nutrition quantity (30 gr). According to results the second group opposite of first group appears to extend of larval period and to knit the behavior of late cocoon. It could be said that the difference of among groups can bind up nutrition-hormone relation (Akalin et al. 2009).

Pathology

Some diseases of silkworm can be grouped under four titles (Table 5). In middle of 19th century diseases of Pebrine and Flacherie emerged first

in France and then in Italy. Those diseases destroyed sericulture in Europe (Tasligil 1996, Dortok-Abaci 2006, Tas 2013, Ciftci 2013, Yasayanlar 2013, Yildirim 2013^a). Fresh cocoon production decreased from 26.000 tonnes to 8.000 tonnes between 1853-1856 in France (Dortok-Abaci 2006). After several years those diseases spread to Bursa region (Ciftci 2013, Yildirim 2013^a). Cocoon production decreased from 4.000 tonnes to 400 tonnes in 10 years which causes silk production decreased from 600 tonnes to 100 tonnes (Yildirim 2013^a). Louis Pasteur invented the cure in 1867 (Ciftci 2013, Yildirim 2013^a). The cure way was to examine silkworm butterflies in microscope and define healthy silkworm butterflies and use them their eggs for next generation (Ersevinc 2013, Yildirim 2013^b). A study showed that silkworm pupas can cause disease of *Hypersensitivity pneumonitis* in human lungs (Kupeli and Karnak 2011). In silkworms *Nosema bombycis* (Naegeli, 1857) causes disease of Pebrine. A survey study carried out to define spread of *N. bombycis* in provinces of Bilecik, Bursa, and Hatay. According to results *N. bombycis* were found in those regions (Aydin et al. 2007).

Table 5. Some diseases of silkworm (Akbay 1981, Anon 2014^b).

Protozoon	Bacterial	Virus	Fungal
1. Pebrine	1. Flacherie 2. Septisemi 3. Sotto 4. Court	1. Grasserie 2. Sytoplasma Plihedrozis 3. Spreadable Flacherie 4. Gattine	1. Muscardine (Calcino) 2. White Muscardine 3. Green Muscardine 4. Japanise Green Muscardine 5. Yellow Muscardine 6. Aspergillus 7. Nosema bombycis 8. Botrytis bassiana

Conservation Measures

A project, entitled as “In Vitro Conservation and Preliminary Molecular identification of some Turkish Domestic Animal Genetic Resources (TURKHAYGEN-I)” was prepared by Genetic Engineering and Biotechnical Institute (GEBI), Marmara Research Centre (MRC) Gebze, Kocaeli. Consequent on several iterations the project was approved by Scientific and Technological Research Council of Turkey (STRCT) in 2007 with a budget of 9.1 million Turkish Lira (about US\$ 4.2 million). The implementation period was 4.5 years with the project and it was completed at the end of 2011. The breeds of White of Bursa (Bursa Beyazi), Piebald White of Bursa (Bursa Beyazi Alaca), and Yellow of Hatay (Hatay Sarisi) were covered by the project. Those breeds were started to be conserved in Province Directorate of Ministry of Food, Agriculture and Livestock (MFAL) (Ertugrul et al. 2010, Arat, 2011). Also sericulture is supported by the government. Silkworm producers get 30 TL/per egg box and 20 TL/per kg of 1st class fresh cocoon (Anon 2014^d). Also Silk Cocoon Sales Cooperatives Union pays extra 4,5 TL/ per kg of 1st class fresh cocoon (Baysal 2013)

Conclusions

Silk have protected it's importance and actuality among textile raw materials because of being natural, soft, bright and beautiful since early ages of civilization. Fabrics that is woven from silk is used as clothes besides scarf, handkerchief, tie,

foulard, bundle, curtain fabric, furnishing fabric, carpet (Soylemezoglu, 1995). Although a lot of insects that produce secretion are used to obtain fiber, few of them economically productive. Although *Bombyx mori* that is fed with mulberry can domesticate, other species which living as colonies, feeding with leaves of some forest trees are hard to domesticate (Atav ve Demir, 2009). Silkworm is belong to Arthropoda filum insect class. Insect class have two subclasses including Apteriygota and Pterygota. *Bombyx mori* is in Pterygota subclass. All day and night butterflies beside *bombyx mori* are in Lepidoptera ordo. Lepidoptera ordo have Bombycidae and Saturnidae family that produce silk. Bombycidae family have *Bombyx mori* and *Bombyx mandarina* species. *Bombyx mori* is domesticated. *Bombyx mandarina* is undomesticated species (Parlak, 2001; Soya, 2013). Although there are silk fiber that obtained from undomesticated silkworm such as Tasar, Muga, Eri, Anaphe, today silk fiber that obtained from *Bombyx mori* is important for production and consumption worldwide (Atav ve Namırtı, 2011).

There are 3 native breeds in Turkey. These are Alaca, Bursa White, Hatay Yellow. These breeds are purebreeding and they are conserving as native gene sources at hard conditions by Bursa Provincial Directorate of Agriculture. Also small family enterprices breed silkworm for economical purpose especially at province of Bursa. Producing raw silk is less than the other countries and

experimental datas needed to improve sericulture. Some morphological, molecular and biological studies about sericulture have done so far in Turkey (Aslani,1993; Yumuşak, 2001). But these studies was not on native breeds. For this reason native silkworm breeds are endangered although still didn't characterized completely (Eroglu Akkir, 2010).

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