The Behavior of Resting, Sleeping, Moulting and Spinning of the Wild Silkworm *Epiphora bauhiniae* (Guerin Meneville) Lepidoptera: Saturniidae during Larval Period

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Abstract—The study was conducted under laboratory condition, to determine whether the wild silkworm *Epiphora bauhiniae* (Guerin Meneville) has similar behaviour in cocoon processing and building corresponding to domesticate and semi domesticated silk moth. Forty mature larvae were used, divided into four replicates (of ten larvae each) they were fed on the leaves of *Ziziphus spinichristi* for 19–20 days, each replicates involves ten larvae. Comparative studies, of the average weight of larvae prior to and after excretion of fecal pellets and urine were obtained, in addition to that after completed building of cocoon and the mean were attained and recorded the mean larval period ranged between 19–20 days from egg to mounting, one day was spent for construction of cocoon shell (spinning period) and five days (pre pupal period) being in active inside cocoon shell before shedding its exuvia. The larvae lost 24% of its weight for building cocoon shell, 21% lost as urine and feces, 22% lost of larval weight inside cocoon and 33% weight of larvae inside cocoon before moulting i.e. immediate pre-metamorphosis to pupa. The results showed similar behaviour to that of domesticated and semi domesticated silk worms, beside that it shows high capability to be reared in and out door, which reflect the importance of findings in emboldening or furtherance others to study more in this field.

Index Terms—*Epiphora bauhiniae*, larvae, Behaviour, resting, spinning, moulting, silkworm

INTRODUCTION

The wild silk worm *Epiphora bauhiniae* is an important African silk worm, belong to family Saturniidae, with a wide range of distribution in Sudan and produce cocoon of commercial value [1] *E. bauhiniae* hosted on the leaves of *Ziziphus spinichristi* consumed 25 g of fresh leaves during larval period [2] African wild silk moths were previously reported by [3] namely *Anaphe panda*, *Genometo postica* and *Epiphora bauhiniae*, he study their mechanical properties and thermal behaviors. *Epiphora*, are known as Emperor moths.

They are classified under the sub order Ditrydia and the family saturniidae [4,5]. Untill now the species under *Epiphora* are *E. bauhiniae* (Gurin Meneville), *E. mythiminia* (West Wood), *E. albida* (Cameron Lanne), *E. rectifascia* (Cameron Lanne), *E. ploetzii* (Cameron Lanne), [5,6] Eri silk worm cocoon weight 2.6 g. Scientists enumerated numerous silk moths only from which 70 species were of economical value and from these only four species were of commercial value such as mulberry silk, tassar or tusah silk, Muga silk, and Eri silk [7] *Epiphora bauhiniae* was found and known in South and Central Africa [8] while [9] reported *E. bauhiniae* as an African wild silk moths with other namely *Anaphe panda*, *Genometo postica*.

Insects behavior in spinning process was observed and studied in the first time by [10,11,12] *Bombyx mori* a domesticated silk worm [13] giant silk worm [14,15,16]and Chinese oak silk worm *Antheraea pernyi* [17,18]. These studies of insect behaviors were based on experimental results obtained by visual observations, chemical, and surgical treatments. Recently simple methods were advised for measuring the spinning behavior of silk worm *Bombyx mori* using two video cameras and a personal computer [19] or by using 3 DAGS computer program which graphically analyze the successive process of larval body movement, spinning area and speed [20,21,22,23,24]. *Bombyx mori* spin cocoons of various shapes some are of globular cocoons and other ellipsoidal or pea nut shaped [25,26] the main behavioral feature effecting cocoon shape formation, spinning posture and the cocoons expansion behaviour during spinning cocoon is related to both length and girth of the larval body with coefficient of correlation between body width/length and cocoon width/length of 0.79 ± 0.11. [26] reported on silkworm *Bombyx mori* tree strains that had studied for their behavior, a significant differences in spinning behaviors were found, the body shape (spinning posture) has an effect on the shape of cocoon formation.
The silk handicrafts sector employs a large number of people, many of whom work with traditional materials and locally process to produce final products, usually in remote and backward areas. The economic importance of silk handicrafts is enhanced by the fact that cottage industries offer high employment potential and require only low capital investment with high value addition rates. The use of silk and the customs it has stirred have constantly been linked with status and prestige, with nobility and royalty. Silk textile traditions have been incessant by the continuing demand for prestigious, culturally momentous cloths, such as those worn at wedding ceremony in North Africa [27, 28].

The aim was to support sericulture and silk industry in Sudan. The studies were conducted to determine the time of moulting, sleeping of larva during different instars and the percentage loss of larval weights during cocoon processing.

**MATERIALS AND METHODS**

**Location and description of the study area**

This study was conducted under laboratory conditions in the area of Gedarif State, eastern Sudan which lies between latitudes 12° 45’ N, and 14° 15’ N, longitudes 34° E and 37° E, (altitude 600m above sea level). During the rainy season, period (july-August) in 2006.

**Feeding**

During the experimental periods larvae were fed on leaves of *Ziziphus spini Christi* [2]

**Climatic conditions of the study area**

Data concerning rain fall and relative humidity were obtained from Gedarif meteorological office 2006. The rainfall varies from north to south. The average annual rainfall in Gerba (143 km from Gedarif), is 175 mm to 570 mm at Galabat (150 km South Gedarif). It is markedly seasonal in character. The length of the rainy season fluctuates during July to October, and reaches peak in August. Records on relative humidity, and temperature during the studies were recorded. This is the area in which the insect naturally present, with high population [1].

**Larval behavior during different instar**

The hatched 100 larvae were transferred to a feeding tray (50 x 40cm) made of plastic and fed on the leaves of *Ziziphus spini Christi*, three times a day. The observed behavior, of the larvae i.e. sleeping, moulting, resting, eating, beginning and ending of moulting, rest before and after moulting of each larval instar were recorded; beside the mean time of moulting and resting of larva during the whole larval period.

**Percentage of larval weight loss during cocoon processing**

Forty fully developed 5th instar larvae were separated after last 8 days of feeding, during larval period (20 days). The larvae were divided into 4 groups, each group of 10 larvae and each larva was put singly into a container (20x20cm) made of plastic. Four weights were taken for each larva in each container using sensitive electronic balance that usually used for gold weighing. The first weight was before larva drops feces i.e. before placing into container. The second weight, was obtained for each larva after excretion of urine and feces (during this time the larva was ready to spin cocoon). When larva started spinning cocoon shell, it was left for one day, then pulled out from the cocoon shell and weighed again. The fourth and the last weight were done after the larva spent five days inside the cocoon shell and before they are transformed to pupa. The % weights were obtained for each group, included percentage of weight lost for building cocoon shell, for urine, feces excreted and data were recorded, also close observations concerning cocoon building behaviour were done on final stages of larvae on natural *Ziziphus* trees and plates of constructed cocoons were taken.

**III. RESULTS AND DISCUSSION**

**Spinning process**

Cocoons were formed in layers. The fully developed worm builds an outer leathery layer first, white in color followed by a second layer by moving its head in areas of circles, and the process of building continued without rest till the last six layers were completed (Plate 1) these layers actually represent cocoon shell. The larva spun a silken or fibrous cocoon (Plate 2 left) with one continuous lustrous fiber around itself within which it under goes pupation. The larvae remained inactive inside the cocoon as a worm for five days, pre-pupal period (Plate 2 middle) in the first two days, the larva being in motionless (inactive) and vibrated in the third day, the vibration occurred from time to time and during this time the larva lost 40% of its weight inside the cocoon, representing 22% of its original weight before shedding its exuvia or skin and transformed into a violet brown pupae (Plate 2 right) (its final stage of development before becoming an adult). The larva completed spinning up elongated shaped cocoon in one day, left one end open in upper part of the cocoon for adult to emerge. The spinning usually started at 5 p.m. before sun set and continued during the night of the same day till 5 pm next day. The larvae reared under temperature 32 -36 °C and relative humidity (RH) 65 - 88%.

The larva lost 24% of its weight for building cocoon shell, 21% as urine and feces, 22% inside cocoon and only 33% of its original weight remained inside the cocoon before being transformed into pupa (Table 1-2). The result revealed that, the average time of sleeping of larva before moulting is 20:43:52 hours and that required for larva to complete moulting is 10 minutes, then larva rest for a period of 2:47:35 hours after moulting, so the total time required for sleeping, moulting and resting is 23:35:31 hours (Table2). The cocoons were elongated cocoons build with open mouth and strong peduncle while the total period from hatching to mounting was range between 19-20days. The constructed cocoon shell was perforated in the first day after spinning the cocoon shell, the motionless larvae is activated again and spun silk closed the opening or pierced part of the cocoon shell or enclosed...
itself in a thin layer cocoon shell inside the main constructed one. This behavior confirmed that the period in which the larva remained inside the cocoon shell (five days after spun cocoon shell) was a part of larval period.

Plate (1): Shows six layers of *E. bauhiniae*’s cocoon

Plate (2): Cocoons (left), Pre pupal (middle) and pupal (right) stages of *E. bauhiniae*

### Table (1)

<table>
<thead>
<tr>
<th>Group number</th>
<th>Mean weight of ripe larva (g)</th>
<th>Mean weight of excreted urine and feces (g)</th>
<th>Mean weight of ripe larva ready to spin (g)</th>
<th>Loss of larva weight for building cocoon shell (g)</th>
<th>Loss of larva weight inside cocoon (g)</th>
<th>Weight of larva inside cocoon before moulting four days (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>1.06</td>
<td>4.21</td>
<td>1.13</td>
<td>1.20</td>
<td>1.80</td>
</tr>
<tr>
<td>2</td>
<td>5.77</td>
<td>1.17</td>
<td>4.61</td>
<td>1.41</td>
<td>1.31</td>
<td>1.88</td>
</tr>
<tr>
<td>3</td>
<td>5.63</td>
<td>1.16</td>
<td>4.46</td>
<td>1.41</td>
<td>1.22</td>
<td>1.84</td>
</tr>
<tr>
<td>4</td>
<td>4.35</td>
<td>0.93</td>
<td>3.43</td>
<td>1.10</td>
<td>0.86</td>
<td>1.46</td>
</tr>
<tr>
<td>Total</td>
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<td>4.32</td>
<td>12.71</td>
<td>5.05</td>
<td>4.59</td>
<td>6.98</td>
</tr>
<tr>
<td>mean</td>
<td>5.24</td>
<td>1.08</td>
<td>3.18</td>
<td>1.26</td>
<td>1.15</td>
<td>1.75</td>
</tr>
<tr>
<td>SD</td>
<td>0.639661</td>
<td>0.111654</td>
<td>0.524937</td>
<td>0.170758</td>
<td>0.197547</td>
<td>0.192787</td>
</tr>
<tr>
<td>%</td>
<td>100%</td>
<td>21%</td>
<td>-</td>
<td>24%</td>
<td>22%</td>
<td>33%</td>
</tr>
</tbody>
</table>

* Each group means of ten larvae and reared under Temp. & RH range, between 32-36 °C and 65-88 % respectively.
Table (2)
Time of moulting and sleeping of larvae of E. bauhiniae during larval instars.

<table>
<thead>
<tr>
<th>Replicates number</th>
<th>Time of sleeping before moulting (h)</th>
<th>Time of moulting (h)</th>
<th>Time of rest after moulting (h)</th>
<th>Total time of rest or sleeping (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>00:10:00</td>
<td>2:20:00</td>
<td>22:30:00</td>
</tr>
<tr>
<td>2</td>
<td>20:12:00</td>
<td>00:11:00</td>
<td>2:06:00</td>
<td>23:29:00</td>
</tr>
<tr>
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<td>20:15:00</td>
<td>00:10:00</td>
<td>3:05:00</td>
<td>23:30:00</td>
</tr>
<tr>
<td>4</td>
<td>20:00:00</td>
<td>00:10:00</td>
<td>3:00:00</td>
<td>23:10:00</td>
</tr>
<tr>
<td>5</td>
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<td>00:10:00</td>
<td>2:44:00</td>
<td>23:44:00</td>
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<tr>
<td>6</td>
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<td>2:40:00</td>
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<td>3:10:00</td>
<td>24:20:00</td>
</tr>
<tr>
<td>8</td>
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<td>00:10:00</td>
<td>2:40:00</td>
<td>24:20:00</td>
</tr>
<tr>
<td>9</td>
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<td>00:09:00</td>
<td>2:51:00</td>
<td>24:00:00</td>
</tr>
<tr>
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<td>22:02:00</td>
<td>00:10:00</td>
<td>2:20:00</td>
<td>24:32:00</td>
</tr>
<tr>
<td>Total</td>
<td>205:139:00</td>
<td>00:100:00</td>
<td>22:236:00</td>
<td>232:235:00</td>
</tr>
<tr>
<td>Mean</td>
<td>20:43:52</td>
<td>00:10:00</td>
<td>2:47:35</td>
<td>23:35:31</td>
</tr>
</tbody>
</table>

* Larvae reared under Temp. & RH range between 32-36°C and 65-88% respectively.

[29] stated that 43% of larval weight of Bombyx mori lost as liquid and faeces i.e. similar to the weight lost by larva of E. bauhiniae as urine faeces 21% plus liquid evaporated from the body of larva inside cocoon 22%. [29] Also reported that in Bombyx mori 36% of larval weight was lost for building cocoon shell and 21% its weight inside cocoon shell. [30] Reported that larval of mealworm Tenebrio molitor lose 25.6% of their body weight. However, [31] reported for tussah larval period 45 days, also he reported 37-41 days feeding period, 10 – 14 days sleeping i.e. 2-3days sleeping in each instar. The results revealed that larvae spent ten minutes to complete moulting which is in line with [29] findings in Bombyx mori. But E.bauhiniae required (19 -20 days) feeding which represent the period of larva, this coincided with that reported by [1] and [2], one day sleeping in each instar which better than tussah larvae in term of rearing cost. The results obtained in these studies showed that the silk worm E. bauhiniae spun cocoon longer elliptical in shape with open mouth and 1.5 cm silken peduncle (plate 3 & 4). The behaviour of spinning process for building cocoon with open mouth, and silken peduncle is similar to that reported by [32] for tussah silk worm behaviour in building cocoon. And it is similar to European cocoon shape as reported by [32]. He stated that European cocoon shape assists in evaluating reeling practices. Also the result showed that cocoon of E. buahiniae consists of six layers which in contrast to that reported by [3] on cocoon layers whose reported only three layer of E.bauhiniae.

VI. CONCLUSION
From the results of these studies, the insect Epiphora bauhiniae showed similar behaviour of moulting, constructions and building of cocoons ,to domesticated silkworm Bombyx mori and Eri moth which reflect the importance of the subject insect, for silk production as semi
domesticated silkworm because of its high potential to be reared in and out door. Meanwhile it is expected to be a qualitative addition to the economy as it supports rural livelihood by improving their income.

Studies on silk production in Sudan are very scanty and research to deal with this gap should have a top precedence from the research and academic institutions. This research will serve as a foundation for additional work, towards the development of workable sustainable agroforestry systems for Sudan (Entomo forestry).

REFERENCES


