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STUDIES ON THE POMEGRANATE BUTTERFLY.
Virachola livia (KLUG)

[Leptocera - Rhopalocera : Lycaenidae]

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INTRODUCTION

The pomegranate butterfly, Virachola livia (KLug), is a serious pest on pomegranate fruits in the U.A.R. The larvae bore into the fruits to feed on the pulp surrounding the seeds or on the soft undeveloped seeds themselves. Sometimes, the damage is so severe that the whole fruit may be ruined and becomes unsuitable for consumption. It is due to this pest that the area under pomegranate-in the U.A.R. has decreased from 2319 feddans in 1952 to 1806 feddans in 1962 and, accordingly, the yield has decreased from 14500 tons in 1952 to 5-97 tons in 1961. Any efforts to check this pest would undoubtedly help in reviving the cultivation of this popular fruit in the country.

The present paper deals with some biological aspects of this pest, which might help in planning a successful control program. It also includes studies on its distribution in the country, its host plants, lifehistory, the number of generations per annum, the description and behaviour of the different instars, estimation of damage and the natural enemies.

Statistical analysis of the data collected this season indicated significant difference between lower, upper as well as both surfaces of leaves.

**SUMMARY**

Need for additional information based on the results obtained by other workers on egg-laying habits of the cotton leafworm, tests were conducted to determine the characteristic behaviour of egg-laying and to estimate the population density of egg-masses, of this pest on different host plants. For this purpose, field experiments were carried out on Dokki Farm during 1966 and 1967 seasons.

From the present data it appears that there is a real preference in some hosts than others. It seems also that the moths have the ability to choose the suitable sites for oviposition. Moreover, it is obvious that the lower surfaces of leaves of mulberry, cotton, castor oil, sweet potato, okra and soybeans were preferred for egg-laying though egg-masses were also laid on upper and very few ones on both surfaces. It is believed that this preference is related to their wide, flat and hand shaped blades.

Observations also revealed that the upper surfaces of hemp mallow and jew's mallow leaves were the desired locations for egg-laying and this may be due to their narrow, convex and boat shaped blades. Investigations throughout the two years experiment showed that no egg-masses were ever found at one time on both surfaces of sweet potato leaves under these conditions.

Although the results of this research are encouraging, it is suggested that further work is also needed to determine the role of other factors involving in egg-laying behaviour on different host plants.

**REFERENCES**


Distribution

Hanna (1939) stated that this pest occurs all over the Nile Valley and in Dakhla, Kharga and Baharia oases, but not in Siwa oasis.

During 1963, the present authors have collected it on futna pods (Acacia farnesiana), sunt (Acacia nilotica), pomegranate (Punica granatum) and on few other minor hosts from the following regions: Bourg El-Arna, Belbia, Inshas, Zagazig, Kallub, Ismailia, Barrage, Gabal El-Aasfar, Dokki, Giza, Embaba, Kirdasa, Saff, Fuyooum, Kom-Oshim, Sids, Minia, Beny Ahmed, Mallawi, Mansfautout, Souhag, Garga, Nag-Hamadi, Kous, Kom-Ombo and Siwa oasis.

Host plants

The main host plants of Virachola livia (Klug) are pomegranate fruits (Punica granatum), dates (Phoenix dactylifera) and green pods of futna (Acacia farnesiana) and sunt (Acacia nilotica). However, it was recorded on Acacia edgeworthii by Gough (1913) in Aden, on Inga dulcis by Andres (1916) in U.A.R. and on tomatoes (Lycopersicum esculentum) by Buxton (1913) in Palestine. Hanna (1939) in U.A.R., recorded it on the following hosts: Acacia farnesiana, Acacia baileyana, Acacia mellifica, Acacia modesta, Acacia nilotica, Acacia mules, Acacia horrida, Acacia catechu, Acacia spalvigera, Onagia bicepularis, Dicksonia antarsoras, Eriobotrya japonia, Phoenix dactylifera, Psidium guava, Prosopis spiralis, Punica granatum and Punica vulgaris.

To the above mentioned list has to be added three more host-plant noticed by the present authors: green pods of Cuscuta chinensis pucherrima and carob (Ceratonia siligica), and also the green pod of broad beans (Vicia faba) at Embaba in March 1964. All these were successfully reared till the emergence of the butterflies.

LIFE HISTORY

All through this work, a continuous supply of the different stages of the insect was made available. At the beginning of March, pods of futna containing eggs or larvae were collected and kept in breeding wooden boxes. When the larvae were full grown, they usually crawled out of the pods to enter the pre-pupal stage. These larvae were collected and confined separately in specimen tubes until the butterflies were released each in a wire gauze sided cage, supplied with pomegranate...
fruits or branches of acacia, with green pods and honey solution as food. These conditions were found to be favorable for copulation and egg-laying as will be shown later.

In some cases, eggs were also collected from fuitsa pods in the field by means of a wet brush or by cutting a small area of the pod-skin carrying the egg by a razor blade. In the latter procedure, the small parts carrying the eggs were put in water in a specimen tube and shaken gently for a while to separate the eggs which then floated on the surface. They were then collected with a brush, transferred on to filter paper in Petri-dishes and left until hatching. Recently hatched larvae were placed separately in small Petri-dishes and provided daily with acacia or pomegranate seeds.

Copulation

In captivity (average temperature about 30°C.) copulation took place after 3 to 10 hours from the emergence of butterflies. In one case, out of 50, it occurred on the second day. The coitus may last from less than one hour up to more than five hours. Out of fifty pairs, 13 pairs took 56-90 minutes with an average of 76 minutes, 18 pairs took 91-125 minutes with an average of 106 minutes, 9 pairs took 130-172 minutes with an average of 146 minutes, 7 pairs took 174-208 minutes with an average of 190 minutes and the last three pairs took 265-328 minutes with an average of 298 minutes. Copulation was observed to occur at any time of the day, mostly after mid-day. Out of fifty pairs, 8 copulations occurred between 10:45 a.m. and 12:00 p.m. and the rest, 42 copulations, took place between 12:15 p.m. and 16:42 p.m. No copulation was observed after sunset.

In order to get information on the effect of cage size on copulation and oviposition, the following experiment was carried out: 1, 4, 6, 8 and 16 cubic feet cages were chosen. Some cages from each size were kept indoors and others were placed outdoors in the field. In each size, 1, 2, 3 and 5 pairs of butterflies were released and supplied with branches of acacia pods or pomegranate fruits and honey solution. In all cases, no copulation was noticed, and all the eggs laid were found to be unfertile. The same results were obtained in five repetitions of each trial. In another experiment, sixty pairs of recently emerged butterflies, were released in a 16 cubic feet cage which was left outdoors, with the usual provision of honey solution and pomegranate fruits. Out of 469 eggs

that were laid. only 106 (22.6%) hatched. In a third trial, the cage was only one cubic foot and the number of butterflies was thirty pairs, from which 368 eggs were obtained, out of which 310 (84.2%) succeeded to hatch.

The results of the last two experiments indicated that crowding of butterflies in the breeding cage has a definite effect on mating, and subsequently on the oviposition of fertile eggs. To ensure such indication, the following trial was made: 7 one cubic foot cages were prepared; one pair of butterflies was put in the first, 2 in the second, 5 in the third, 10 in the fourth, 15 in the fifth, 25 in the sixth and 35 in the seventh. The total number and laid eggs and hatched eggs were counted and the results are shown in Table I, which includes the averages of two experiments.

TABLE I
The effect of crowding of butterflies in breeding cages on the number of eggs deposited per female and on the fertility of eggs

<table>
<thead>
<tr>
<th>Number of cage</th>
<th>Number of pairs of butterflies per cage</th>
<th>Number of eggs deposited by female</th>
<th>Number of hatched eggs/female</th>
<th>Percentage of hatched eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>70.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>51.3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>35.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>28.2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>251.1</td>
<td>7.1</td>
<td>26.2</td>
</tr>
<tr>
<td>6</td>
<td>25</td>
<td>18.7</td>
<td>11.5</td>
<td>62.8</td>
</tr>
<tr>
<td>7</td>
<td>35</td>
<td>19.7</td>
<td>16.9</td>
<td>85.8</td>
</tr>
</tbody>
</table>

In this experiment copulation was observed only in cages which contained 15-35 pairs of butterflies. The results in Table I indicate that the average number of eggs laid by each female decreased, and at the same time the percentage of fertile eggs increased with the increase of the number of butterflies in the cage. It could thus be concluded that the crowding of butterflies in the breeding cage and not its size. is the main factor which stimulates mating.

OVIPOSITION

In nature, the eggs are found singly stuck on the surface of the fruits of pomegranate, almost at any stage of the fruit growth. In few cases, however, eggs were observed on leaves and branches. At the early stages of fruit growth, the eggs are often placed inside and around
the calyx, and rarely on other parts. In more developed fruits, they are preferably deposited on the fruit surface rather than inside the calyx.

In order to confirm the above observations the following experiments were carried out:

In 1964, eighty pomegranate fruits in the orchard were selected. At ten days intervals the eggs deposited on definite sites on each one of the selected fruits were counted and removed. These sites were: inside calyx, around calyx from outside, fruit easy, receptacle region and base stalk region which is attached to the bract. The results show that the preferred oviposition site varies with the growth of the fruits. On small fruits, 14.6% of the eggs were laid inside the calyx and only 13.5% were laid on the fruit skin. One month later, 19.7% of the eggs were laid inside the calyx whereas 50.3% were laid on the fruit. The distribution of the eggs on the other regions was almost even throughout the whole period of growth, except that the eggs laid on the base stalk region decreased from 5.0 to 2.4%.

In case of lutna, eggs are always observed on the green pods, mainly on their bases. In few cases eggs were seen inside the entrance holes made by other larvae in the pod skin. During March 1964, counts of eggs found on definite regions of the pod were made on 300 lutna pods. Four regions of the pod were considered, i.e. calyx, lower region, middle region and upper region of the pod. It was found that most of the eggs (71.9%) are found on the calyx region (including the base of the pod), and the few eggs found on the other regions of the pod are distributed more or less evenly (middle region 16.5%, and upper region 12.4%).

In Acacia spadicea, the eggs are observed on the soft fleshy parts of the stem; in date palms (Phoenix dactylifera) they are observed on the fruits.

It should be also mentioned here that in winter, the eastern and southern branches of the lutna tree carry most of the eggs, mainly around the bases of the pods, whereas in spring, the eggs are deposited equally on the pods on all sides of the tree.

In captivity and in the presence of the host plant, eggs are laid anywhere in the cage (on the wire walls and on the wooden top and bottom).

Number of eggs laid on each futna pod or pomegranate fruit:

On January 25th., March 24th. and June 2nd. (1964), a random sample of about 300-400 futna pods bearing eggs were collected from Belbis district, and for each sample all the pods bearing a similar number of eggs, starting from one egg onwards, were separated and counted. The summary of these counts are as follows:

Light infestation (January, 25th.) : pods carrying 1-3 eggs, 94.8%; 4-6 eggs, 5.2%.

Moderate infestation (March, 24th.) : pods carrying 1-3 eggs, 89.9%; 4-6 eggs, 8.7%; 7-10 eggs, 1.4%.

High infestation (June, 2nd.) : pods carrying 1-3 eggs, 30.8%; 4-6 eggs, 35.9%; 7-10 eggs, 22.8%; 11-21 eggs, 11.5%.

Similar inspection was conducted on pomegranate fruits on three dates, i.e. May 25th., June 2nd. and June 26th. (1964). The data of these inspections indicated the following:

Light infestation (May, 25th.) : pods carrying 1-3 eggs, 99.3%; 4-6 eggs, 0.7%.

Moderate infestation (June, 22nd.) : pods carrying 1-3 eggs, 81.4%; 4-6 eggs, 15.9%; 7-10 eggs, 2.7%.

High infestation (June 26th.) : pods carrying 1-3 eggs, 60.8%; 4-6 eggs, 26.4%; 7-10 eggs, 12.8%.

Incubation period

Hanna (1939) found that the incubation period under laboratory conditions ranged from 3 to 4 days in July and about 10 days in November and December.

In the present work the incubation period was determined at different temperatures ranging from 10 to 30°C. The following technique was followed: Females were left in a cage to deposit their eggs on futna pods, and the pods were checked every three hours during daytime to collect the eggs laid on them. Patches of 100 eggs were prepared each in a Petri-dish, and 6 of these dishes were kept in a desiccator under 65-70% R.H. The desiccators containing the Petri-dishes were kept in incubators under constant temperatures of 10, 15, 20, 25, 30 and 35°C, and checking for hatching was carried out every six hours. The results showed that the optimum temperature for hatching was 30°C, at which the incubation period was only 4 days, whereas it was
6 days at 25°C, 18.7 days at 20°C, and 25.2 days at 15°C. Also, the highest percentage of hatching (98%) occurred at 30°C, whereas 95% hatched at 20 and 25°C, and 87% at 15°C. At 10 or 35°C, all eggs failed to hatch.

The larva

Newly hatched larvae were kept individually until maturity in small Petri-dishes containing fresh seeds of pomegranate, futna, sun, Catealanina, broad bean and green dates. These seeds were changed daily to prevent fermentation or fungal infection. For each food 50 dishes were prepared, and the dishes were searched twice daily for the larval exuvia. In all cases, the larva moulted only three times during its larval duration.

Assessment of each larval instar was carried out by measuring the width of head-capsule and the length and width of the body at fixed intervals during the larval duration. Forty anaesthetised larvae were used for each measurement shortly (3-6 hours) after the expected moult time of each instar. The dimensions were found to run around four average during the whole larval duration, indicating the existence of four larval instars. These averages were 0.35, 0.61, 1.03 and 1.63 mm. for the width of head-capsule; 1.40, 4.39, 6.87 and 13.47 mm. for the length of larva; and 0.40, 0.91, 1.16 and 3.17 mm., for the width of larva.

Factors affecting the duration of the larval instars

Host plant

Newly hatched larvae were reared on six different host plants, 50 on each, till maturity, and the duration of the four larval instars in each host was determined as recorded in Table II.

<table>
<thead>
<tr>
<th>Host plant</th>
<th>1st. instar</th>
<th>2nd. instar</th>
<th>3rd. instar</th>
<th>4th. instar</th>
<th>Larval duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pomegranate</td>
<td>Range Mean</td>
<td>Range Mean</td>
<td>Range Mean</td>
<td>Range Mean</td>
<td>Mean duration</td>
</tr>
<tr>
<td>Futna</td>
<td>4-7</td>
<td>3-4</td>
<td>2.8</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Green dates</td>
<td>3-4</td>
<td>3-5</td>
<td>3.2</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Date</td>
<td>3-4</td>
<td>3-5</td>
<td>2.8</td>
<td>2.6</td>
<td>2.5</td>
</tr>
<tr>
<td>Catealanina</td>
<td>3-4</td>
<td>3-5</td>
<td>2.7</td>
<td>2.6</td>
<td>2.4</td>
</tr>
</tbody>
</table>

These records indicate that the hosts, arranged in descending order according to their effect on the duration of the different instars, are as follows:

1st. instar: Pomegranate, futna, green dates, sunt, Ceasalpina and broad bean.

2nd. instar: Pomegranate, green dates, broad bean, Ceasalpina, futna and sunt.

3rd. instar: Pomegranate, green dates, futna, sunt, Ceasalpina and broad bean.

4th. instar: Pomegranate, broad bean, green dates, futna, Ceasalpina and sunt.

Considering the whole duration of the larval instar the descending arrangement of the hosts is as follows: pomegranate (26.9 days), green dates (18.2), futna (16.5), broad bean (16.1), Ceasalpina (15.2) and sunt (14.4).

**Temperature**

Fourty larvae were reared on futna pods from hatching to full maturity at each 15, 20, 25 and 30°C of temperature. The duration of each larval instar in all cases, was determined (Table III).

<table>
<thead>
<tr>
<th>Temperatures</th>
<th>Duration of larval instars in days</th>
<th>Mean larval duration in days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st. instar</td>
<td>2nd. instar</td>
</tr>
<tr>
<td>15°C</td>
<td>11-17</td>
<td>10-12</td>
</tr>
<tr>
<td>20°C</td>
<td>7-9</td>
<td>5-8</td>
</tr>
<tr>
<td>25°C</td>
<td>3-3</td>
<td>2-4</td>
</tr>
<tr>
<td>30°C</td>
<td>2-3</td>
<td>1-2</td>
</tr>
</tbody>
</table>

These results indicate that at 15°C, all the larvae died during the fourth instar and the durations of the first 3 instars were extended to 4-5 times their equivalents at 30°C. As the temperature increased from 20 to 30°C, the duration of the larval instar became shorter, being 32.7 days at 20°C, 16.5 days at 25°C and 13.1 days at 30°C.
The results also indicate that:

(1) The effect of temperature was more obvious on the periods of the first and fourth instars than on the second and third.

(2) The duration of the fourth larval instar is the longest duration when compared with the other three instars under the four temperatures, and the duration of the second larval instar was the shortest.

(3) At 20°C the duration of the larval instars was extended by 2-3 times their equivalent at 30°C, and all of them succeeded to pupate.

Prepupal stage

The duration of the prepupal stage was found to vary according to host plant and temperature.

Effect of host plant

Six patches of 50 full-grown larvae that were fed on different hosts: Futna, sunt, Caesalpinia, broad bean, green dates and pomegranate, were confined individually in glass vials at 25°C and 65-70%, till pupation. Inspection was carried out every six hours and the duration of the prepupal stage of each individual was determined. The results are recorded in Table IV, which indicate that the hosts arranged in a descending order according to their effect on the duration of the prepupal period are as follows: pomegranate (4.3 days), green dates (4.0 days), Caesalpinia (3.5 days), broad bean (3.2 days), futna (2.9 days) and sunt (2.6 days).

<table>
<thead>
<tr>
<th>Host plant</th>
<th>Number of larvae and prepupal</th>
<th>Mean duration in days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sunt</td>
<td>8</td>
<td>22</td>
</tr>
<tr>
<td>Futna</td>
<td>12</td>
<td>22</td>
</tr>
<tr>
<td>Broad beans</td>
<td>22</td>
<td>39</td>
</tr>
<tr>
<td>Caesalpinia</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>Green dates</td>
<td>12</td>
<td>22</td>
</tr>
<tr>
<td>Pomegranate</td>
<td>12</td>
<td>22</td>
</tr>
</tbody>
</table>

Table IV

Duration of prepupal stage bred on different hosts
(Temperature 25°C and R.H. 65-70%)

Effect of temperature

A group of 250 full-grown larvae which had been fed on futna, pods, were separated individually in vials, divided into five patches of 50, and placed in incubators running at 65-70 % R.H. and 15, 20, 25, 30 and 35°C. They were inspected every six hours until pupation occurred and pupae were then classified into males and females. The results are recorded in Table V.

These results show that the duration of the prepupal period decreased from 16.85 days at 15°C. to 6.8 days at 20°C. to 2.55 days at 25°C., to 2.15 days at 30°C., and then decreased slightly to 2.35 days at 35°C. No appreciable difference was found between males and females.

TABLE V
Duration of the prepupal stage under different temperatures and 65-70 % R.H.

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Males Minimum</th>
<th>Males Maximum</th>
<th>Males Average</th>
<th>Females Minimum</th>
<th>Females Maximum</th>
<th>Females Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>11</td>
<td>29</td>
<td>16.9</td>
<td>12</td>
<td>21</td>
<td>16.8</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>9</td>
<td>6.7</td>
<td>5</td>
<td>9</td>
<td>6.9</td>
</tr>
<tr>
<td>25</td>
<td>2</td>
<td>4</td>
<td>2.8</td>
<td>2</td>
<td>1.9</td>
<td>2.9</td>
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<td>30</td>
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<td>3</td>
<td>2.2</td>
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<td>3</td>
<td>2.1</td>
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<tr>
<td>35</td>
<td>2</td>
<td>3</td>
<td>2.3</td>
<td>2</td>
<td>3</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Throughout 1963 and 1964, several collections of full grown larvae were obtained from futna pods, separated in vials, left to pupate under laboratory conditions and the duration of the prepupal stage was determined for each. The means of the four seasons were found to be 12.3 to 17.2 days in winter, 3.1 to 5.9 days in autumn, 3.6 to 7.7 days in spring and 2.4 to 2.7 days in summer.

The pupa

The female pupa, beside being stouter than the male, can be easily determined by the presence of an invagination on the ventral median line of the 4th. apparent abdominal segment. Such invagination is lacking in the male pupa.
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Effect of host plant on the size of the pupa

One hundred full-grown larvae that had been fed on futna and sunt, were left to pupate. Pupae developed from each host were classified into males and females and such one was weighed and measured for length and width. The results, summarized in Table VI, indicate that the male and female pupae resulting from larvae fed on futna pods are longer, wider and heavier than those from larvae fed on sunt pods.

<table>
<thead>
<tr>
<th>Values</th>
<th>Male pupae bred on</th>
<th>Female pupae bred on</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sunt</td>
<td>Futna</td>
</tr>
<tr>
<td>Mean length mm.</td>
<td>10.01±0.12</td>
<td>11.05±0.12</td>
</tr>
<tr>
<td>Mean width mm.</td>
<td>4.18±0.05</td>
<td>4.50±0.04</td>
</tr>
<tr>
<td>Mean weight gr.</td>
<td>0.09±0.00</td>
<td>0.10±0.01</td>
</tr>
</tbody>
</table>

The effect of host on the size of the pupa is also observed in nature and in laboratory mass rearing; the pupa emerging from larvae fed on futna, *Coasalpinia* and broad bean pods, were always larger in size than those emerging from larvae fed on sunt, pomegranate and green dates.

Factors affecting the pupal period

According to Hanna (1939), the average duration of the male and female pupa under laboratory conditions in July, is seven and eight days, respectively. He also stated that in the laboratory, the duration lasts in January for about 54 days and in February for about 21 days.

**Effect of temperature**

Fifty male and 50 female pupae were kept under each of the following temperatures: 15, 20, 25, 30 and 35°C. and pupal durations were determined as recorded in Table VII, which show that the average duration was 57.7 days at 15°C., 23 days at 20°C., 9.8 days at 25°C., 7 days at 30°C. and 6.6 days at 35°C. There is no significant difference.
between the duration of pupal stages of males and females at any of the above temperatures.

Throughout the four seasons of 1963-1964, several newly formed pupae were left in vials to emerge under room temperature and the duration of the pupal stage was determined for each one. The results revealed that this period was 48.2 days in January (mean temperature 15.9°C), 7.7 days in June (mean temperature 28.6°C), 24.3 days in November (mean temperature 18.7°C), 36.5 days in February (mean temperature 16.9°C), 23.3 days in March (mean temperature 19.2°C), 17.6 days in April (mean temperature 30.9°C), 10.7 days in May (mean temperature 25.1°C) and 8.3 days in July (mean temperature 29°C).

### TABLE VII

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Duration of pupal stage in days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
</tr>
<tr>
<td>15</td>
<td>74</td>
</tr>
<tr>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>25</td>
<td>11</td>
</tr>
<tr>
<td>30</td>
<td>8</td>
</tr>
<tr>
<td>35</td>
<td>7</td>
</tr>
</tbody>
</table>

**Effect of host plant**

Patches of 50 pupae each, whose larvae had been fed on sunn, futn, Ceasalpinia, green dates and pomegranate, were kept at 25°C and R.H. 65-70% till emergence. The durations of the pupal stage in the five cases are recorded in Table VIII.

### TABLE VIII

<table>
<thead>
<tr>
<th>Host plant</th>
<th>Duration of pupal stage in days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
</tr>
<tr>
<td>Sun</td>
<td>10</td>
</tr>
<tr>
<td>Futna</td>
<td>9</td>
</tr>
<tr>
<td>Ceasalpinia</td>
<td>10</td>
</tr>
<tr>
<td>Green dates</td>
<td>10</td>
</tr>
<tr>
<td>Pomegranate</td>
<td>10</td>
</tr>
</tbody>
</table>
The duration period of the pupal stage was almost the same in all cases and it ranged between 9.9 and 10.4 days.

The adult

Time of emergence

A total of 1484 pupae were obtained from futna pods during May 1964, separated in vials after being classified into males and females and left to emerge under room temperature (26.5°C) and natural light. For each one, the time of emergence during day time was recorded, and the results showed that:

1. The majority (71.8%) emerged between 9 a.m. and noon, whereas 17.1% emerged between 7-9 a.m. and 11.1% emerged between 12-14 p.m.

2. The emergence ceased in the afternoon and all through the night till the following morning, i.e. from 14 p.m. to 7 a.m.

3. A higher proportion of males (49.6%) than females (37.2%) emerged between 7 and 10 a.m. Later on in the day, the percentage of the emerging females was 62.8%, as compared with 50.4% of the males.

4. Emergence of male and female becomes equal from 12 to 13 p.m. reaching 7.5% in both sexes.

Percentage of emergence

Collections of pupae obtained from futna pods at different months during 1963 and 1964, were left under room temperature till emergence. The most successful emergence was found to be in July (93.1%), followed by October (96.1%) and then May and April (91.8% and 93.3%, respectively). During December and January, the percentage emergence decreased to 66.1 and 63.3%, respectively.

Sex ratio

A large number of larvae and pupae were collected from futna pods at Belbis, four times a month throughout 1963 and 1964, were bred in the laboratory and the sex of the produced butterflies was determined. The sex ratio, throughout the whole season, was found to be 1:1.
Pre-oviposition period

Twenty five fertilized females were confined separately in cylindrical wire-cages under laboratory conditions (average temperature 28.5°C) and supplied with honey solution and futna pods. In all of them egg laying began on the second day after their emergence.

The pre-oviposition period of unfertilized females was also estimated. Out of twenty-five unfertilized females, which were confined under the same mentioned conditions, twelve started to deposit on the second day after emergence, four on the third day, five on the fourth day, three on the fifth and the last one on the seventh day.

Temperature has a definite effect upon the pre-oviposition period, since the females that were kept in cages during December (average temperature 17.5°C) began to oviposit after 9-12 days.

Oviposition period and number of eggs per female

Twenty-five fertilized females were kept separately in cylindrical wire cages provided with food and futna pods. The number of eggs laid daily by each female was recorded till mortality, after which each female was dissected to count the number of well developed eggs in its ovaries. The results show that, in captivity, most of the fed and fertilized females keep ovipositing for 3 to 4 days. Out of twenty-five females, one only keep ovipositing for 2 days, eighteen for 3 days and six for 4 days, the average being 3.2 days.

Also the number of eggs laid per female, under laboratory conditions (average temperature 28.5°C), ranged from 85-156 with an average of 99.3 eggs.

Similar determinations were also made on 25 unfertilized females out of which one kept ovipositing for 2 days, four for 3 days, seven for 4 days, two for 5 days, three for 6 days, seven for 7 days and one for 8 days, the average being 5.1 days. The number of eggs laid per each unfertilized female during its life-span under laboratory conditions (average temperature 28.5°C), ranged from 11 to 93 with an average of 34.5 eggs.

The indication of these results is that the pre-oviposition period as well as the oviposition period, are shorter and the number of eggs laid by female is higher in the case of fertilized females than in unfertilized ones.
It seems also that oviposition is greatly affected in captivity, as many well-developed eggs were found in the ovaries or the dissected females after death. The number of well-developed eggs found in the ovaries of fertilized females ranged from 29 to 96, with an average of 51.6 eggs, whereas in unfertilized females it ranged from 36 to 105 with an average of 69.2 eggs.

Most of the fertilized females continued to oviposit until the day before death. Out of twenty-five fertilized females, twenty-three died the next day after ceasing oviposition, and two persisted for another day. One the other hand, out of twenty-five unfertilized females, seventeen died on the next day after ceasing egg laying, six stayed for two days.

Longevity of the adult

Sixty pairs of adults were isolated separately in one cubic foot cages, and kept under room temperature (26°C.). Thirty of them were provided with 20% honey solution and the rest left to starve. The records of the daily mortalities among the two sets revealed the following ranges of the life-span:

Fed male, 5-14 days; fed female, 5-15 days; unfed male, 3-11 days; unfed female, 3-11 days.

Hanna (1939) mentioned that the life-span of this insect, fed with a diluted solution of honey, was 5 to 6 days.

When the butterflies were kept separately in glass vials, the average life-span was found to be 14.7, 15.9, 13.3 and 14 days for the fed males, fed females, unfed males, and unfed females, respectively.

Hibernation

Green futna pods were collected during winter months of 1963 from Giza and Belbis regions. These pods were searched for the different stages of the insect in order to determine whether the insect hibernates during these months. The findings are shown in Table IX.

It is evident from Table IX that different stages could be found during winter season. This indicates that there is no true diapause, but only the duration of the stages is prolonged.
Number of individuals in different stages

<table>
<thead>
<tr>
<th>Month</th>
<th>Eggs</th>
<th>Larvae</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hatched</td>
<td>Unhatched 1st instar</td>
</tr>
<tr>
<td>November</td>
<td>475</td>
<td>459</td>
</tr>
<tr>
<td>December</td>
<td>555</td>
<td>15%</td>
</tr>
<tr>
<td>January</td>
<td>174</td>
<td>70%</td>
</tr>
<tr>
<td>February</td>
<td>8</td>
<td>20%</td>
</tr>
</tbody>
</table>

Annual number of generations

To determine the annual number of generations in nature, especially on its main hosts, Embaha (Giza) and Belbie (Sharkia) districts were selected because of the extended futna hedges and aunt trees surrounding the orchards and because in both of them the pods begin to form at about the middle of September and continue till the end of June. Infestation begins also, in both of them, at the same time, but because the pods of futna are easier for inspection, the number of generations was studied on them.

During 1963 and 1964, patches of 500 futna pods each, were brought continuously every ten days from each of the two districts soon after the beginning of green pods formation till the end of the season, and in these pods the number of eggs, different larval instars and pupae were continuously recorded. To support the field observations, the different stages which were found in the inspected pods, were reared under laboratory conditions and the durations of the different stages were recorded. These field and laboratory observations revealed that Vira-kola liae may have six generations on futna pods.

Infestation of pomegranate was observed to start at about the end of the fifth generation, and owing to the dryness of futna pods starting from about the end of June or early in July, the butterflies of the 6th generation shift to pomegranate.

**Number of generations on pomegranate and date fruits**

As mentioned before, the butterflies of the fifth and sixth generations are attracted to pomegranate fruits, and start to lay eggs on
them in the middle of May, as has been observed at Giza district during 1963 and 1964. Pupae were found in pomegranate fruits in high numbers during July and early in August, while egg laying decreased or became rare during the same period and continued till the end of pomegranate season in September. This assumes the existence of one generation on pomegranate fruits. Presumably, the butterflies that emerge from the pomegranate fruits turn to infest dates.

Dates were observed during 1963 to be infested in Giza district at the end of July or early in August. One generation only was observed to attack dates and it lasted for about one month. The butterflies started to emerge from dates at the beginning of September to resume their life-cycle on futna and sunt pods.

The final conclusion is that there are indications that *Virachola livia* (Klug) has eight successive generations per annum, six on futna and sunt pods, one on pomegranate fruits and one on dates.

**Behaviour of the larvae and adults**

The morphological features of the egg, larva, pupa and adult of *Virachola livia* (Klug) have been thoroughly described and illustrated by Hanna (1939).

**The larva**

The first instar larva after hatching, roams about slowly over the pomegranate fruit or the other hosts to find a suitable site for burrowing. While moving, it spins very fine threads on the surface to which the claws of the thoracic legs cling. It keeps wandering for 30 to 150 minutes before it begins to burrow into the fruit or pod.

Out of forty larvae placed on pomegranate fruits under room temperature (25°C.), 26 kept moving for 30-50 minutes, 10 moved 60-90 minutes, two moved 120 minutes and two moved 150 minutes. This period is critical in the life of the insect, since it is exposed to natural enemies as well as to the effect of the insecticides.

During this period, the larva chooses its burrowing site by feeling the fruit or pod rind with its mouth-parts. In case of pomegranate fruits, the burrowing site includes all the fruit surface except the base of the calyx and receptacle regions presumably because the rind at these parts is too thick for the larvae to burrow through. Thus, larvae
that hatch from eggs laid inside the calyx do not burrow through the base of the calyx, but have to leave their hatching place to find a more suitable site. In futna pods, the favourable place for burrowing is near the apex of the pod, but the larva can burrow in other parts too.

The larva disappears completely inside the pomegranate fruit within a period of 100 to 335 minutes. Out of forty larvae, 16 kept burrowing for 100 to 135 minutes, 16 for 195 to 280 minutes and 8 for 310 to 335 minutes.

The small larva uses its mandibles to make the entrance hole through the pod or fruit rind. In performing this job, the larva seems that it does not consume any of the rind particles, but brushes them in minute pellets around the hole. When the hole gets deep, the larva travels in and out from time to time to clean the rind particles, until it reaches the seeds.

The first instar is spent inside this preliminary tunnel with the head directed inside. To discharge its excretion, it retreats so that its anal segment protrudes out of the entrance hole. Such behaviour persists in all later instars.

The larva feeds first on the soft pulp surrounding the seed and then it may try to work on the seed itself. Early developed seeds of pomegranate fruits are very soft and are contained in a white viscous liquid which seems to be the main food of the larva, but as the seeds become harder the larva feeds on the surrounding pulp. At that stage it confines its feeding on a limited number of seeds.

In case of the leguminous pods, the first instar larva works on one of the cotyledons of the seeds. In dates, it feeds on the flesh as well as on the seeds so long as these seeds are soft.

After feeding for a short time, the larva becomes more brownish in colour. A few hours before moulting, it ceases to feed. The first moult usually occurs inside the seeds, and the exuvium is pushed outside the entrance hole. The exuvium is detected by the dark head capsule and anal shield.

The second instar larva after the first moult resumes feeding on the same seed, through in very few cases it may shift to feed on another seed. Laboratory observations showed that a single larva consumes one seed of pomegranate or futna, and sometimes it may need a part of another seed to end the second instar. The second moult occurs
also inside the pod or fruit and the larva pushes the exuvium together with the excrement outside through the entrance hole. The entrance is enlarged as the larva grows in size. When at rest, the larva plugs the outer hole deftly with its anal shield.

The third instar larva moves deeper inside the fruit or pod, working on 3-4 seeds. In sunn and Caesalpinia, where the pods are constricted into separate compartments with a single seed in each, when the larva consumes the contained seed it has to emerge on the surface of the pod to reach another seed in another compartment. The third moult occurs inside the host fruit or pod, but the exuvium is left inside, since the feeding site of the larva is deep and far from the entrance hole. Thus, such exuvium could be detected among the destroyed seeds inside the fruit or pod.

The fourth instar larva can consume from 6 to 8 pomegranate seeds a day till it reaches its full size. In futna, it devours a total of 10 to 14 seeds throughout the duration of the instar.

The size of the full-grown larva varies considerably according to the host plant. Larvae fed on futna, Caesalpinia, broad bean seeds or green dates, were larger in size than those fed on sunn or pomegranate seeds.

If the full-grown larva is gently touched with a needle, a drop of secretion soon appears on the center of the dorsal side of the last apparent segment, where the four openings of the sugar glands are located.

Before entering the prepupal stage, the full-grown larva enhances the entrance hole, which becomes almost round or oval in shape, with a diameter 5-7 mm., to be used as an exit hole for the emergence of the butterfly.

Cannibalism among larvae

The fourth instar larvae were seen to feed on prepupaee and pupae. It was also observed that when several larvae were confined in a rearing box with a limited number of futna pods, they start to attack each other or the prepupaee or pupae found with them.

Also, it was observed that if it happens that two larvae come in contact with each other in one pod, one of them has to leave. This ex-
plains why a larva, before entering the prepupal stage, prefers to emerge to another uninfested pod.

Number of larvae in a single infested fruit or pod

The number of larvae that may exist in a single infested pomegranate fruit or futna pod varies according to the degree of infestation. At the beginning of the season of infestation, there is usually one or two larvae in each attacked fruit or pod, whereas at the end of the season, as many as nine larvae could be found.

Counts of the number of larvae per each futna pod and each pomegranate fruit at different levels of infestation were made during April, May and June for futna, and during June and July for pomegranate. Results showed that in weak infestation of futna pods 99.4% carried 1-2 larvae and 0.6% 3-4 larvae; in moderate infestation 92.3% carried 1-2 larvae, 7.4% 3-4 larvae and 0.4% 5-6 larvae; in high infestation 42.1% carried 1-2 and 3-4 larvae, respectively, 12.2% 5-6 larvae, 28% 7-8 larvae and 0.8% 9-10 larvae. In moderate infestation of pomegranate fruits 91.7% carried 1-2 larvae, 6.5% 3-4 larvae, 1.2% 5-6 larvae and 0.6% 7-8 larvae; in high infestation 36.9% carried 1-2 larvae, 31.6% 3-4 larvae, 21.9% 5-6 larvae, 7.3% 7-8 larvae and 2.3% 9-10 larvae.

The adult

_Virachola litia_ is a swift flyer. At repose, the wings are held upright above at a right angle with the thorax, touching each other at their medium upper surface, while their under-surface becomes disclosed; ash-grey in colour, with darker curved transverse lines which tend to give them a protective picture.

Butterflies were seen in great numbers on _Khilah shaataniyah_ plants, which grown in orchards, imbibing nectar. They were also observed feeding on citrus blood. In the field, females were observed to lay their eggs on futna pods or pomegranate fruits during morning time till mid-day or shortly in the afternoon, but when the weather gets hot at mid-day, they seek shelter under shady places such as citrus leaves or branches of _Casuarina_. In captivity, the butterflies always laid their eggs in the afternoon.
Determination of the damage caused by the larvae in pomegranate fruits

Fifteen newly hatched larvae were bred on pomegranate seeds till they completed their larval stage, and the number of pomegranate seeds consumed by each larval instar was determined. It was observed that during the first and second instars, the larva consumes one seed only, rarely attacking a part of another seed. The third larval instar devours 3-4 seeds, whereas the fourth instar larva consumes as many as 34 to 57 seeds. The total number consumed by a single larva throughout its duration reached an average of 49.3 seeds. The average number of seeds per one fruit of the Balady variety was found to be 466 seeds. Thus, the percentage of seeds ruined by a single larva or any number of larvae could be calculated. At high levels of infestation, up to about 38% of the seeds are ruined. Such a high percentage of seeds damage could be considered as a minor loss, as the actual damage is caused by fungus and fermenting bacteria invasion as well as the breeding of Drosophila melanogaster and Carpephillus dimidatus. In most cases, the damage caused by these factors may lead to complete loss of the infested fruit.

Natural enemies

Brackymena spec., probably aegyptiaca Masi (Hymenoptera: Chalcididae), was found to attack the fresh pupae of the pomegranate butterfly, Vraschola leuca. It has been reared from pupae collected from fruits pods during autumn, winter and spring months.

Also Trichogramma coenescens Westw. (Hymenoptera: Trichogrammatidae) was found to parasitize the egg during summer and very rarely during winter months.

Brackymena spec.

In early stages of parasitism, the parasitized pupa does not show any external symptoms, but as the parasite develops, the colour of the pupa turns into dark brown, emits an unpleasant odour and becomes lighter in weight.

The adult parasite emerges from the pupa of the host through an irregular circular hole, occurring anywhere in the skin.

An estimation of the percentage of parasitism was carried out.
during 1964. Every month, pupae of F. livia were collected from fulna pods and dissected for the different stages of the parasite, Brachymera spec., occurs mostly during autumn and spring months. In October and November, the percentage of parasitism were 88.9 and 50%, respectively, whereas in December and January no pupae were noticed to be parasitized. On the other hand, it was noticed that the percentage of parasitism increased to 20% in February and to 28.6% in March, and then started to decrease gradually when hot weather entered. The percentage of parasitism were 16.6, 5 and 2 in April, May and June, respectively. During July and August no parasitism was observed.

The general conclusion is that this parasite does not occur during cold winter months or in summer months, whereas it occurs in good numbers during mild weather months.

**Trichogramma evanescentes Web.**

Eggs of the parasite are laid inside the eggs of the host. After hatching, the parasite larva lives inside the host egg and gradually consumes its fluid. When full-grown, it pupates inside.

The adult parasite emerges out through a slit made in the chorion of the host egg. The presence of such slits characterizes the parasitized eggs, because the normal hatched eggs could be distinguished by the presence of a circular hole made by the tiny larva at the point of the micropile.

The highest percentages of parasitism (about 50%) were found during summer months, and very few parasitized eggs were found during winter.

**Summary**

The present work includes detailed studies on the life-history of the pomegranate butterfly, *Vinachela flava* (Klug) under field and laboratory conditions. The points studied are oviposition site, number of eggs laid on each fulna pod or pome, incubation period of the eggs, number of larval instars, affecting the duration of larval instars, prepupal stage and fasting affecting its duration, sex determination of the pupa, effect of host, the size of the pupa, factors affecting the pupal period, time of emergence of butterflies, percentage of emergence, sex ratio, pre-oviposition period, oviposition period and number of eggs per female, longevity of butter-
flies, hibernation and annual number of generations. Remarks are also given on the distribution of the pest in the country and its host plants.

The main distinctions in the behaviour of the larvae are the following:

1. Just after hatching, the tiny larva roams about slowly over the fruit to find a suitable place for burrowing. It keeps burrowing for 30 to 150 minutes before it begins to burrow into the fruit.

2. The larvae have the habit of migration from one fruit to another, a tendency which causes a great increase in the number of damaged fruits. This migration occurs due to shortage of food or when a larva comes in contact with another to avoid cannibalism.

Cannibalism exists among the larvae especially during the fourth instar, which were seen to feed on prepupae and pupae.

The total number of pomegranate seeds consumed by a single larva throughout its duration is about 50.

The number of larvae usually found in a pomegranate fruit varies between 1-9 according to time and degree of infestation.

*Brachymena* spec. (possibly *B. aegyptiaca* Mast) attacks the pupae from September to March. *Trichogramma evanescent* Westw. parasitizes the eggs during summer and very rarely during winter.

**REFERENCES**


