# BIOLOGY OF AN EGG PARASITE OF CALLOSOBRUCHUS MACULATUS (FAB.) (COLEOPTERA : BRUCHIDAE).

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## ABSTRACT

Callosobruchus maculatus (Fab.) is a serious pest of pulses. As the chemical control is often hazardous to the consumers and the environment, use of parasites and predators as biological control agents is highly desirable. Uscana mukerjii (Mani) belonging to the super family Chalcidoidae and the family Trichogrammatidae parasitises the eggs of C. maculatus.

The parasite completes its development inside the host egg in 7.2 days at 27°C and 60-63 % R.H. and emerges after cutting a circular hole in the chorion of the host egg. Both mated and unmated females lay about 35 eggs in their life-time and percentage of emergence is about 89 %. The average life-span of the adults varies from 4.5 to 5.5 days. The pre-copulation period ranges from 12 to 30 min. at 28°C and 24 to 52 min. at 18°C respectively. The females copulate only once whereas males are capable of copulating upto 4 times. The copulation period ranges from 4 to 7 seconds and 7 to 11 seconds at 28°C and 20°C respectively. The maximum parasitization of the host eggs takes place within the first 24 hours of the egg laying and declines subsequently. The different aspects of the biology of U. mukerjii are being investigated and will be discussed.

## *INTRODUCTION*

The bruchid species, Callosobruchus maculatus attacks the edible legumes, both in the field and in the store, and is responsible for colossal losses to pulses, beans, peas, grams and lentils that constitute a major source of protein (Hoffman, 1945; Arora, 1977; Southgate, 1957, 1979; Johnson, 1983; Ouedraogo and Huignard, 1981).

As chemical control is often hazardous to consumers and the environment, use of parasites and predators as biological control agents is highly desirable. A detailed study of the biology and bionomics of a parasite is a pre-requisite for the successful introduction and establishment of a parasite from one part of the country into another or from one country to another. In case of a parasites of phytophagous insects, the biology forms the basis for their control and subjugation. Uscana mukerjii (Mani), (super family Chalcidoidae, family Trichogrammatidae), is found attacking the eggs of C. maculatus (Fabr.) (Mani, 1953; Steffan, 1954; Pajni and Singh, 1973). The parasite is one of the smallest known insects and the adult measures about 0.44 mm in length. It completes its life cycle within 7 days in summer months and this period actually coincides with the incubation period of the host eggs. The fact that the bruchid eggs destroyed by the parasites, are laid on the surface of seeds, has not been properly appreciated so far. This is perhaps the reason that, despite the great potential of the parasite as a biological control agent, not much attention has been paid to the study of Uscana species. Very little information is available on the general biology and behaviour of this parasite in relation to the reproductive capacity of their hosts. It is, accordingly, intented to make detailed observations on the copulation, oviposition, development and other connected aspects of the biology of Uscana mukerjii , with the main objective of evaluating the status of the parasite for supressing the populations of bruchids.

## *MATERIAL AND METHODS*

The stock culture of C. maculatus was started on the seeds of Vigna radiata. The parasite was reared in the laboratory on the eggs of C. maculatus. Strips of hard paper were made and seeds of Vigna radiata glued to them. After drying these strips were introduced in the general culture of C. maculatus and were taken out after laying of eggs of C. maculatus. These strips were introduced in borosil tubes separately, into which several pairs of parasites were released. The freshly emerged parasites reared at 27°C and 60-65 % R.H. were kept one each in small glass vial and fed on streaks of honey-water solution (1:1) drawn on the inside wall of the vial. Each female of the pair was offered 100 eggs of C. maculatus on strip on the first day and 50 host eggs on subsequent days till death. These were transferred to experimental temperatures and relative humidities. The temperatures were maintained in electrically controlled incubators and different relative humidities in desiccators by means of various concentrations of KOH -water solution (Buxton, 1931; Solomon, 1951).

## *RESULTS AND DISCUSSION*

The female lays an egg inside the bruchid egg wich first turns light yellow, then orangish-yellow and finally black as the parasite grows. The larval and pupal stages are thus passed inside the host egg and the adult emerges after cutting a circular hole in the chorion of the egg. The contents of the bruchid egg are consumed by the parasite during its development and the seed is saved from the attack by the pest.

## 1 - EMERGENCE

The adult of Uscana mukerjii emerges from the bruchid egg by cutting a circular hole in the chorion of the host egg shell. The hole may be prepared at the broad or narrow end of the egg, depending upon the orientation of the parasite within the egg. The emergence hole is made with the help of mandibles. In order to check the size of emergence hole, the parasite first tries to protrude its head through it. If the hole is not large enough, the adult starts cutting away the margins of the hole to make it bigger. If the emerging parasite is disturbed, it withdraws itself into the egg shell and waits for some time before starting the process again. After emergence, the adult rests for 1-3 minutes. At this time, the wings are wet and sticking to the body. The insect takes each wing between two of its hind legs and rubs them in order to dry them. It takes 5-20 minutes for the wings to dry. In Uscana mukerjii, emergence can take place at any hour of the day. Faure (1926) reported that all individuals of Trichogramma developing in the egg of Acacia leave it through a single emergence hole and emergence takes place largely during the early morning.

## 2 - REPRODUCTION

U. mukerjii reproduces both by unisexual and bisexual methods. Facultative parthenogenesis is present in this species and takes place when the females are unable to find a mate. The progeny produced by unmated females, consists entirely of males. The pre-copulation period is the time gap between emergence and copulation. It is 12-30 miutes at 28°C and 24-52 minutes at 18-20°C. Copulation period varies from 4-7 seconds and 7-11 seconds at the respective temperatures. The females are monoandrous and copulate only once in their life span, while the male is capable of copulating several times. A male of U. mukerjii was observed to mate with a maximum of 4 females. Taylor (1969) described a copulation period of 30 seconds in Trichogramma semifumatum.

### 2.1 Oviposition

The number of eggs laid by the female of U. mukerjii in each host egg depends on the size of the host. In the eggs of the bruchid C. maculatus only one paratise can grow to maturity, so the female generally lays a single egg in each host. In Trichrogramma embryophagum (Klomp and Teernink, 1962) the female measures the size of a host egg before oviposition, placing more eggs in larger hosts. U. mukerjii females may occassionally lay two or more eggs in a single host egg. Though only one finally develops to maturity. T. evanescens also tends to avoid super parasitism (Salt, 1937), the degree of avoidence being influenced by experience (Klomp et al., 1980). An average of three adults of T. semifumatum can emerge from a single egg of Colias eurytheme (Stern and Bowen, 1963).

### 2.2 Fecundity

It has been observed that temperature and humidity greatly affect the fecundity of U. mukerjii. The fecundfity decreases with increasing temperatures. The results are summarised in Table I. The maximum average fecundity of 35 was observed at 27°C and 62 % R.H. and minimum of 11.4 at 33.2°C and 75 % R.H. One obvious reason for decreased fecundity at higher temperature is the reduction in the longevity of the parasite female. Sterility in T. evanescens at 34.5 C was also reported by Savesen et al (1970).

Table I

**Fecundity of the mated females of U. mukerjii at different temperatures and relative humidities.**

| TEMPERATURE | RELATIVE HUMIDITY | | | |
|---|---|---|---|---|
| | 35 % | 50 % | 62 % | 75 % |
| 19.2°C | 17.7 ± 1.60 | 25.2 ± 2.4 | 27.3 ± 1.9 | 20 ± 1.8 |
| 27°C | 21.6 ± 1.2 | 27.1 ± 1.8 | 35.4 ± 1.4 | 22.1 ± 2.2 |
| 33.2°C | 18.5 ± 2.1 | 19.2 ± 1.8 | 20.4 ± 1.4 | 11.4 ± 2.2 |

Each value is a mean of 15 observations.

Some earlier workers have also observed more or less similar trends in other Trichogramma spp. The fecundity of Trichogramma pretiosum at 25°C and 80 % R.H. is 57.8, while under the same conditions the fecundity of T. retorridum is 69.4 (Orphanides an Gonzales, 1971). But according to Stern and Atallah (1965), the average fecundity of T. retorridum on the eggs of Heliothis zea is 38.6.

In another experiment it is clear that the fecundity of unmated females is higher than that of the mated females (Table II) but percentage mortality is much higher in the eggs of unmated females than that of mated females.

Table II

**Fecundity and percent mortality of mated and unmated females of U. mukerjii at different relative humidities, at a constant temperature of 27°C.**

| S. No. | Relative Humidity | Fecundity of Mated Females | Fecundity of Unmated Females | Percent Mortality of Mated Females | Percent Mortality of Unmated Females |
|---|---|---|---|---|---|
| 1 | 35 % | 21.6 ± 1.2 | 24.1 ± 2.3 | 22 % | 29 % |
| 2 | 50 % | 27.1 ± 1.8 | 30.8 ± 1.9 | 15 % | 20 % |
| 3 | 62 % | 35.4 ± 1.4 | 36.9 ± 2.2 | 10 % | 18 % |
| 4 | 75 % | 22.1 ± 1.22 | 26.4 ± 1.8 | 30 % | 55 % |

It has been reported by Lund (1938) that in Trichogramma evanescens, the females that remained unmated throughout the oviposition period produced an appreciably greater number of eggs than the mated females.

It has been observed that the bruchid eggs which are laid on the sides of the culture jars or petridishes are also attacked by the parasitre which can successfully complete its development in such eggs. The host eggs wich are improperly pasted on the seeds are mostly parasitised. But the parasite can not mature in such eggs which generally undergo desiccation after sometime.

## 3 - AGE OF HOST EGGS IN RELATION TO PARASITIZATION

It has been observed that Uscana mukerjii selects those bruchid eggs for oviposition wich are not too old. An experiment was performed in wich 100 eggs each of different ages were provided to 2 pairs of parasite and the total number of eggs parasitized were noted (Table III).

It is clear from the Table III that as the host eggs grow older, their attractiveness and acceptibility to the parasite decreases, till a stage comes when the eggs are no longer attacked by the female. Young host eggs are most susceptible to the parasite attack because in such eggs the development has not proceeded too far and so there are enough nutrients to sustain the development of the parasite. But in older eggs, where the food contents have been used up by the bruchid embryo, there is no scope for the development of parasite.

**Table III**

**Effect of the age of host eggs on parasitisation by U. mukerjii at 27°C and 60-65 % R.H.**

| Age of host eggs | Total number of eggs given | Number of eggs parasitized |
|---|---|---|
| 12 | 100 | 51.6 |
| 24 | 100 | 74.2 |
| 48 | 100 | 70.4 |
| 60 | 100 | 54.3 |
| 72 | 100 | 32.6 |
| 96 | 100 | 30.4 |
| 108 | 100 | 20.8 |

Five replicates were used in each case.

Such eggs are thus rejected by the parasite. The maximum parasitization of the eggs takes place within the first 24 hours of the egg laying of the host and it declines subsequently.

## 4 - LIFE SPAN OF ADULTS OF USCANA MUKERJII AT DIFFERENT CONSTANT TEMPERATURES AND HUMIDITIES

The life span of an individual is the time period from its emergence till its death. The longevity of U. mukerjii is dependent upon the prevailing temperature and humidity. The life span of this parasite was noted during different constant temperatures.

**Table IV**

**Longevity of adults of U. mukerjii at different constant temperatures and 60-63 % R.H.**

| Temperature | Mated | | Unmated | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| 20°C | 6.4 ± .84 | 5.6 ± .70 | 8 ± 1.2 | 7 ± 1.1 |
| 27°C | 5 ± .52 | 4.7 ± .50 | 6.5 ± 1.6 | 5.5 ± 2.0 |
| 30°C | 4 ± .62 | 3.8 ± 1.2 | 5 ± 1.3 | 4.0 ± 1.1 |
| 33°C | 3.45 ± 1.1 | 3 ± .45 | 4 ± 2.4 | 3.2 ± 1.8 |

15 Replicates were used in each case.

It can be seen from the table that maximum longevity of 8 days has been reported at 20°C and minimum of 3 days at 33°C. Unmated males and females live longer than the mated ones and at lower temperatures also their longevity increases. In Trichogramma evanescens the average longth of adult life at a temperature of 25°C has been reported to be approximately 6 days (Lund, 1938).

## 5 - DEVELOPMENT

The developmental period is the time taken by an individual to develop from the egg stage to emergence as an adult. The developmental period of U. mukerjii is greatly influenced by the prevailing temperature. The developmental period at different constant temperatures is shown in Table V.

**Table V**

**Developmental period of U. mukerjii at different constant temperatures and 60-63 % R.H.**

| Temperature | Developmental period Days |
|---|---|
| 20°C | 13.2 ± 2.4 |
| 27 °C | 7.2 ± 1.2 |
| 30 °C | 6.8 ± 1.2 |
| 33°C | 6.6 ± 1.6 |

15 Replicates have been used in each case.

The average development period of 6.6 days has been reported at 33°C and maximum of 13.2 days at 20°C. At lower temperature, their developmental period increases. At 25°C and 80 % R.H., the developmental period of T. pretiosum is 9.9 days (Orphanidae and Gonzalez, 1971). In T. semifumatum at 30°C and 80 % R.H., the maximum time from oviposition to emergence is 6 days and 12 hours (Stern and Bowen, 1963).

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*REFERENCES*

**Arora, G.L.** (1977) Taxonomy of the Bruchidae (Coleoptera) of North-west India, Part 1 - Adults Oriental insects Supplement, No. 7, 1-132.

**Buxton, P.A.** (1931) The measurements and control of atmospheric humidity in relation to entomological problems. Bull. Entom. Res. XXII (3).

**Faure, J.C.** (1926) Contribution à l'étude d'un complexe biologique : La pieride du chou (Pieris brassicae L.) et ses parasites Hymenopteres. Lyon Faculté des Sci. de l' Univ.; 222 pp.

**Hoffmann, A.** (1945) Faune de France-Coleopteres bruchides et Anthribides. Paris : Paris : Lechevalier, 44 : 7-106.

**Johnson, C.D.** (1983) Ecosystematics of Acauthos celides (Coleoptera : Bruchidae) of Southern Mexico and Central America. Ent. Soc. Amer., 56, 1-370.

**Klomp, H. and Teerinic, B.J.** (1962) Host selection and number of eggs per oviposition in the egg parasite Trichogramma embryophagum Htg. Nature, 195, 1020-1021.

**Klomp. H., Teerink, B.J. and Wei, C.M.** (1980) Discrimination between parasitised and unparasitized hosts in the egg parasite Trichogramma evanescens and T. embryophagum (Hymenoptera : Trichogrammatidae) : a matter of learning and forgetting. Netherlands J. Zool., 30, 245-277.

**Lund, H.O.** (1938) Studies on longevity and productivity in Trichogramma evanescens. J. Agricc. res., 56 : 421-439.

**Mani, M.S.** (1935) First record of the Trichogrammatid chalcid genus Chaetoslricha walker, from India with a description of a new species. Rec. Ind. Mus., 37 (111), 337-338.

**Orphanides, G.M. and Gonzalez, D.** (1971) Fertility and life table studies with Trichogramma pretiosum and T. retorridum (Hymenoptera : Trichogrammatidae). Am. Entomol. Soc. Am., 64, 824-834.

**Ouedraogo, A. and Huignard, J.** (1981) Polymorphism and ecological reactions in Callosobruchus maculatus (F.) (Coleoptera : Bruchidae) in upper volta. In the ecology of Bruchids attacking legumes (pulses), Ed. by V. Labeyrie. Dr. W. Junk Publishers, Hague.

**Salt** (1937) The sense used by Trichogramma to distinguish between parasitized and unparasitized host. Proc. Roy. Soc. London Ser. B. 122, 57-75.

**Solomou, M.E.** (1951) Control of humidity with potassium hydroxide, sulphuric acid or other solutions. Bull. Ent. Res., 42, 542-554.

**Southgate, B.J.** (1979) Biology of the Bruchidae. Ann. Rev. Entomol., 24, 449-473.

**Southgate, B.J., Howe; R.W. and Brett, G.A.** (1975) The specific status of Callosobruchus maculatus (F.) and Callosobruchus analis (F.). Bull. Ent. Res., 48, 78-89.

**Steffan, J.R.** (1954) Notes sur le genre Uscana Girit (Hymenoptera Trichogrammatides) et descriptions d'especes nouvelles parasites de Bruches. Bull. Mus. Hits. Nat. France. 2ème Série, 26, 667-673.

**Stern, V.M. and Atallah, Y.H.** (1965) Ecological studies of T. retorridum and emergence of two Trichogramma species from the same host egg. Ann. Entomol. Soc. Am. 58, 76-81.

**Stern, V.M. and Bowen, W.** (1963) Ecological studies of Trichogramma semifumatum with notes on Apanteles medicaginis, and their suppression of Colias eurytheme in Southern California. Ann. Entomol. Soc. Am. 56, 358-371.

**Taylor, T.** (1969) Observations on oviposition behaviour and parasitization in Trichogramma semifumatum (Hymenoptera : Trichogrammatidae) Ghana J. Sci., 9(1), 30-34.

# LA BIOLOGIE D'UN PARASITE DES OEUFS DE *CALLOSOBRUCHUS MACULATUS* (FAB.) (COLEOPTERA : BRUCHIDAE)

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## RESUME

*Callosobruchus maculatus* (Fab.) est un important déprédateur des légumineuses. La lutte chimique présentant souvent un risque vis-à-vis du consommateur et de l'environnement, l'utilisation de parasites et de prédateurs s'avère grandement utile. *Uscana mukerjii* (Mani) appartenant à la super-famille des Chacidoidae et à celle des Trichogrammatidae parasite les oeufs de *C. maculatus*.

Le parasite se développe dans l'oeuf de l'hôte en 7.2 jours à 27° C et 60-63 % HR, et émerge après avoir découpé un orifice circulaire dans le chorion de l'oeuf de l'hôte. Les femelles accouplées on non pondent à peu près 35 oeufs au cours de leur vie et le pourcentage d'adultes émergents est d'à peu près 89 %. La durée de vie moyenne des adultes varie de 4,5 à 5,5 jours. La période pré-copulatoire dure, respectivement de 12 à 30 mn à 28° C et de 24 à 52 mn à 18° C. Les femelles ne peuvent s'accoupler qu'une fois tandis que les mâles peuvent le faire jusqu'à 4 fois. L'accouplement dure, respectivement, 4 à 7 secondes et 7 à 11 secondes à 28° C et 20° C. Le parasitisme maximal de l'oeuf de l'hôte a lieu dans les 24 heures après la ponte et décroît ensuite. L'étude de la biologie de *U. mukerjii* est présentée sous ses différents aspects et les résultats sont discutés.