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Observations on the Life cycle, Mating and Cannibalism of *Mantis religiosa religiosa* Linnaeus, 1758 (Insecta: Mantodea: Mantidae)

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Abstract

To know the insect world, along with the diversity studies observations on the insect behavior are also significant. The life cycle study and other observations made on the mating and cannibalism in *Mantis religiosa religiosa*. Being hemimetabolous insect, *M. religiosa religiosa* shows ootheca (egg), nymph and adult stages in the lifecycle. The incubation duration of ootheca is about 18 days while nymphal duration is about 61 days with six moults. The average lifespan of male and female is 165 and 196 days respectively. The entire life cycle period of female is 31 days more than male. The mating was allowed mostly when female is engaged in feeding which decreases female aggression. The cannibalism was noticed during nymphal stage by incidence of overcrowding as well as in female which devours the male. As *M. religiosa religiosa* is predatory on grasshoppers, aphids, planthoppers etc. The information of the present study will be applied for biological control of crop pests.

Keywords: Life cycle, *Mantis religiosa religiosa*, mating, development, cannibalism

Introduction

Praying mantids are the predators with peculiar habits of predation, camouflage and reproductive behavior and are known to lay eggs in the complex ootheca. They are very well known for their cannibalistic behavior during courtship. The Praying mantid *Mantis religiosa religiosa* commonly called as European mantis, was first described by Linnaeus in 1758. Some taxonomic account of this species also given by Mukharjee *et al.* [1] and Vyjayandi [2]. Although, several experimental works was done on this species for its behavioral and ecological studies, etc. but studies related to biology of *M. religiosa religiosa* are scanty. Predation efficiency of this species is potent through the course of lifecycle and hence biological studies are very important in insect management. This species is widely distributed throughout the India and habitual to live near human habitation and agricultural fields.

A population of mantids (*M. religiosa religiosa*, Linnaeus, 1758) was studied in natural conditions between August 2003 and October 2003 in a submontane habitat near Vicenza in Italy [3]. The population was observed and studied with the mark and recapture method. Different dynamics between males and females probably linked to sexual cannibalism were recorded. In particular, the estimated population of adult males decreased faster than that of females and in the end of the season only females were present [4, 5]. The seasonal occurrence of the two main colour patterns (green and brown) of *M. religiosa religiosa* was studied and an increase in green specimens percentage was observed from summer to Autumn [3]. The green and the brown colors can occur in different instars of one individual but in addition a partial change in colour from brown to green have been observed in adult specimens kept in laboratory conditions in late season [4]. Literature review indicates, scant information is available on the biology of *M. religiosa religiosa*, hence efforts have been made to work on life cycle of this species.

Material and Methods

The lifecycle study of *M. religiosa religiosa* was studied under laboratory condition at 25 °C to 35 °C and 60% to 70% RH. The field collected female of *M. religiosa religiosa* dated 20th March 2015 was reared in aluminum meshed cage (15cm×15cm×22cm). The hatched nymphs were grouped in to three groups with 20 each and transferred in the different cages of same size and observations were made.

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Early instars i.e. 1st and 2nd instars were fed on diet of *Drosophila* spp. on alternate days. Later instars were fed on the crickets, grasshoppers and plant hoppers, etc. Excess food was avoided because of some cannibalistic species of grasshoppers and crickets cause damage to the mantids. The measurements of each nymphal instars, adults and *oothecae* were recorded by vernier caliper along with photography and finally statistical analysis was done. 1st and 2nd instars were anesthetized with carbon dioxide [6] and measured while other instars and adults measured without anesthesia.

Results and Discussion

In the present study, life cycle of the *M. religiosa religiosa* is studied along with the various observations such as oviposition, hatching, nymphal development, food, mating, cannibalism and colour morphs. The developmental durations of the each stage of life cycle are given in Table 1 and measurements of each developmental stage are given in Tables 2-4.

Table 1: Duration of different life stages of *Mantis religiosa religiosa* in days.

Stages	Duration in days.		Mean	SD	SEM
	Minimum	Maximum			
Ootheca (Egg)	17	20	18.1	1.19721	0.39907
Ist instar	6	8	6.8	0.78881	0.24944
IInd instar	7	8	7.3	0.48304	0.16101
IIIRD instar	7	10	8.4	1.17378	0.39126
IVth instar	8	12	9.8	1.47573	0.49191
Vth instar	12	14	13.1	1.22927	0.40975
VIth instar	14	18	16.2	1.47573	0.49191
Adult male	35	60	48.9	8.64677	2.48452
Adult female	70	90	81.27	7.12868	2.25428

n=10

Table 2: Width of Head capsule of different life stages of *Mantis religiosa religiosa*.

Stages	Width of Head capsule (mm)		Mean	SD	SEM
	Minimum	Maximum			
Ist instar	1.12	1.30	1.20	0.060788	0.024817
IInd instar	1.72	1.82	1.77	0.036904	0.015066
IIIRD instar	2.12	2.39	2.29	0.087439	0.029146
IVth instar	3.54	3.60	3.21	0.023868	0.007197
Vth instar	4.18	4.26	4.22	0.026328	0.007938
VIth instar	4.83	4.92	4.86	0.029025	0.008751
Male	5.31	5.35	5.33	0.015982	0.006041
Female	6.60	6.64	6.62	0.015899	0.015899

n=10

Table 3: Length of Pronotum of different life stages of *Mantis religiosa religiosa*.

Stages	Length of Pronotum (mm)		Mean	SD	SEM
	Minimum	Maximum			
Ist instar	1.45	1.6	1.54	0.058907	0.026344
IInd instar	3.02	3.20	3.13	0.069841	0.024693
IIIRD instar	4.93	5.23	5.10	0.201784	0.067261
IVth instar	7.14	7.69	7.41	0.180278	0.054356
Vth instar	9.45	9.88	9.63	0.156371	0.047147
VIth instar	12.24	12.39	12.33	0.061644	0.030822
Male	13.40	14.37	14.02	0.344306	0.153978
Female	17.13	18.96	18.04	0.556711	0.210417

n=10

Table 4: Total body length of different life stages of *Mantis religiosa religiosa*.

Stages	Total body length (mm)		Mean	SD	SEM
	Minimum	Maximum			
Ist instar	5.3	5.5	5.42	0.066667	0.14110
IInd instar	11.3	11.7	11.13	0.446206	0.15930
IIIRD instar	18	18.7	18.23	0.246060	0.07781
IVth instar	25.8	26.1	25.90	0.138477	0.03840
Vth instar	34.9	36.2	35.7	0.454913	0.34497
VIth instar	46.8	49.36	45.59	0.526477	0.18613
Male	56.58	57.5	57.07	0.574749	0.25703
Female	70	71.8	70.98	0.625643	0.25541

n=10



Oviposition

1. The field collected female laid oothecae on the stick placed in the cage after 4 days of collection. Some oothecal material was adhered on the anal cerci of female indicating that female already placed an ootheca before collection. The first oviposition was observed at night of 25th March 2015 under laboratory conditions.
2. The ootheca was very soft and cream colored when freshly laid, and afterwards it got dried and hardened and turned faint yellow (Image 10). After some days, its colour changes to faint brown. The female lays nine oothecae during rearing period at the interval of 6 to 9 days and with variable deposition time shows variation. Most of the oothecae were deposited in early morning i.e. 6 am to 11 am. According to the total adult lifespan calculated, mated females laid 12 to 18 oothecae. On the provided twig in the cage, laying of ootheca was done from downward to upward direction.

Hatching

The hatching of ootheca which was laid on 25th March 2015 was observed after 17 days in the morning hrs (6 am to 10 am). The hatching process lasted for one to one and half hours. Next day some new but very few hatchlings were observed. After that, the total number of eggs and hatching percentage was recorded by dissecting the ootheca. About 60% eggs hatched out successfully, remaining eggs were unable to hatch. James [7] reported 96% hatching in December, 42% hatching in January and 44.3% in February. Some nymphs hatched from eggs but they were unable to

escape from passage of exit of oothecal outer covering. As Crosby [8] reported all nymphs were hatched out from ootheca within a day. Hatching requires a period of several weeks in some mantid species [9]. As above all the observations for rest of oothecae were made. Last five oothecae remain unhatched.

Nymphal development

During the present study, all the developmental stages were observed and 6 molts were observed with nymphal period 54 to 90 days.

1st instar: It is in pink to faint brick colored after hatching, latter become dark brick colored and semitransparent. Mid and hind legs are with black band at the joint of tibia and tarsus. It measures about 5.42 mm with 1.54 mm pronotum (Image 1). They are very active and feed on provided flies of *Drosophila* spp. The first instar lasted for 6 to 8 days.

2nd instar: The second instar nymphs were very active, pale green colored feeds on *Drosophila* spp. flies with mid-dorsal faint line running from pronotum to abdominal tip. Femora of hind and mid legs were pink to faint brick colored. Black band which was present at tibia-tarsus joint is disappears. The body length was 11.13 mm long with 3.13 mm pronotum (Image 2). This stage lasted for 7 - 8 days.

3rd instar: The nymphs were very active, straw to green colored with prominent mid-dorsal faint line running from pronotum to abdominal tip. In straw colored nymph, legs are faint and transparent where in green colored nymphs, femora of hind and mid legs are pink to faint brick colored. The edge of pronotum was lined by pink colored. It feeds on *Drosophila* spp. flies as well as small nymphs of grasshopper and crickets. The body length was 18.23 mm with 5.10 mm pronotum (Image 3). It moults to the 4th instar within 7 - 10 days.

4th instar: It is green to straw colored, abdomen slender, coxa of fore legs show transparent colored tubercles, fore femora having yellow spot at caudal groove. Mid-dorsal line becomes very prominent, femora of hind and mid legs was pink to faint brick colored; edge of pronotum was lined by pink colour ends in yellow colour. Wingbuds appeared in this stage. It feeds on nymphs and adults of grasshopper and crickets. Body length was 25.90 mm with 7.41 mm pronotum (Image 4). It moults to the 5th instar within 8 - 12 days.

5th instar: It is mostly green to straw colored, abdomen slender in male and broader in female, mid-dorsal line very prominent; edge of pronotum lined by pink colored and ends in yellow colour; coxae of fore legs show prominent white colored tubercles, fore femora having yellow spot at caudal groove, brick colored tinge of mid and hind leg femora vanished and legs become semitransparent. Wingbuds are in just growing stage reaches up to the 1st segment of abdomen. Feeds on nymphs and adults of grasshopper and crickets. Body length was 35.70 mm with 9.63 mm pronotum (Image 5). This stage lasted for 12-14 days.

6th instar: It is green to straw colored, mid-dorsal line very prominent but light colored; coxa of fore legs show prominent white colored tubercles, fore femora having yellow spot at caudal groove, legs become semitransparent. Wingbuds are full grown, reaches up to the 2nd segment of abdomen. Feeds on nymph and adults of grasshoppers and crickets. Body

length was 45.59 mm long with 12.33 mm pronotum (Image 6). It moults to the adult within 14 - 18 days.

7th instar or Adult: Morphological features (Images 6 to 8) of this species have given by Mukherjee *et al.* [1] and Vyjayandi [2]. Body length (vertex to the abdominal tip) 56.2 mm to 63.3 mm for male and 68.44 mm for female. The head was wide and triangular with globular compound eyes, superior margin of frontal sclerite angular with flat carinae, prozona slightly carinate and metazoan carinate. Pronotum was elongated with supra-coxal dilation and indistinct mid-longitudinal carina. The meso-sternum contains paired brown blotches with tubercles. The femur of raptorial leg was with spines viz. 4 discoidal (dark at the tip), 6 longer internal (black except last) and 7 shorter internal (dark at the tip); claw groove of femora yellow. In addition, femur was modified with 4 external (dark at the tip) and tibia was with 7 external and 11 internal spines (all dark at the tip). Coxae with divergent internal apical lobes; internally callous spots or tubercles, a black spot at the base which sometime encloses an oval yellow spot; internal edge with 6 to 8 obtuse spines and few spicules between them. Fore wing semi-hyaline in female with elongate cream colored stigma mark. Anterior margin of hind wing blackish, opaque near apex. Antennal size was about 23 mm and 20 mm long in male and female respectively.

Earlier studies on the biological and lifecycle study states that average developmental period for male was 72 days and for female 84 days [5]. Beeson [10] reported 8-9 moults and 70-110 days nymphal period in *Hierodula ventralis* in July to October. Suckling [6] reported 6 molts and minimum of 11 week of nymphal developmental period in *Orthodera ministralis* in Palmerston North, New Zealand climate. James [7] mentioned brief observations on the biology of *M. religiosa religiosa*, in which he focused on the egg survival, seasonal life history and food habitats of nymphs and adults. His observation lacks description of each developmental stage of *M. religiosa religiosa*. Hideg [5] studied population cycles of *M. religiosa religiosa* in outdoor and in laboratory conditions. The adult male and female lived for 35-60 and 70-90 days respectively. The total lifespan of male ranged from 89 to 150 days and for female 124 to 180 days. According to Hideg [5] average lifespan of female was 165 days with maximum of 196 days; while in males, it was 110 and 176 days respectively. This difference of number of instars and lifecycle duration was due to the different climate and environmental aspects.

Food: Generally, after hatching nymphs need some water, therefore spraying of some amount of water was done which didn't wet the nymphs fully as they get trapped in water and died. After hatching 1st instar nymphs drinks water then become very active. They were provided with the diet of *Drosophila* spp. flies. First two instars completely depended on the diet of *Drosophila* spp. flies then after third instar they fed on small nymphs of grasshopper and crickets along with *Drosophila* spp. flies. Later in stars and adults fed mainly on the diet of nymphs and adults of grasshopper and crickets. When scarcity of food was there, they fed on other nymphs of own species.

Mating: Mating in the praying mantids is very popular phenomenon in which female devours male. The mating behavior of praying mantids was very well studied in different species. The observations on mating behaviour vary with the

species to species. With the reference of these observations several hypothesis has been placed.

Liske and Davis [11] observed pre-copulatory behavior of male who decreases the female aggression in Chinese mantis *Tenodera aridifolia*. Birkhead *et al.* [12] mention the mating behavior of *Hierodula membranacea* in which the male grasps female which is invariably initiated from well outside the females grasp. The male made their leap on to female when the female not looking to male and distracted by moment.

In *M. religiosa religiosa*, it was observed that the male approaches towards the female mostly when she is engaged in feeding. The pre-copulatory behavior of male was very interesting that the male continuously observe the moments of female and when female engaged in capturing the pray, male immediately come near the female from behind not from front. He carefully observes the approach of the female of his presence and then he holds the female from the dorsal side by grasping the pronotum with forelegs, i.e. leap. That leap i.e. mating lasts for half an hour to almost for a day. On the contrary, when the approach of female towards male is aggressive, then pre-copulatory cannibalism was observed.

Cannibalism: The cannibalism in praying mantid is very well known. Here, cannibalism behavior in the nymphal stage was due to mostly scarcity of food. However, cannibalism was observed among the nymphs even the availability of food was plenty. This cannibalistic behaviour of nymphs is defending behaviour.

The sexual cannibalism was observed when i) the female was very hungry ii) the mating leap was not from perfectly dorsal side of female i.e. the head of male come near the forelegs of female as she can easily grasp the male and iii) mating lasted for the long time, therefore the female get more time to catch the male.

Colour morphs: *M. religiosa religiosa* shows colour variation, it may be seasonal or environmental adaptations. Here we observed most of brown or straw colored morphs in summer season (February to June) along with some green colored morphs (Images 6&7). Rest of duration shows mainly green colored morphs (Image 6). Earlier studies on the morphological changes in *M. religiosa religiosa* noticed that the green form is always found upon green grass and the brown form found upon dried straw colored grass; the green form is sluggish and the brown form is more active. Such colour morphs and behaviour protects mantids from the enemies [13]. Also the sunlight, humidity and vegetation are responsible for colour morphs. Battiston and Fontana [3] observes that the hot sun, low humidity and intense light of summer will increase the production of dried or brown ground vegetation along with brown mantids and more moderate temperatures stimulate higher humidity and low light intensity promotes green vegetation and green morphs of mantids. Krolak [14] also reported this species from Western Poland with the both forms with their respective habitat. If the environmental or seasonal aspects and protective behavior are considered for the colour variation, here we observed the colour variation from the same batch of *M. religiosa religiosa* at the same environmental conditions. Also we observed the green morphs in the dried grass and brown morphs on green grass. According to the observations, those individuals adapted to their respective habitat, the survival rate of such individuals is more [1, 4].

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