



## Studies on Mass Emergence and Reproductive Behaviour of *Bayadara indica* Selys, 1853 (Odonata: Insecta) around Yamuna River at Village Dakpathar, District Dehradun, Uttarakhand, India

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**ABSTRACT:** The studies on mass emergence and reproductive behaviour of *Bayadara indica* Selys, 1853 (Odonata: Insecta) around Yamuna River at village Dakpathar, District Dehradun, Uttarakhand, India was recorded in the month of June-July during 2020-21. Due to mass emergence the stretch of 50-100 m is dominated by this species. In the reproductive behaviour the Courtship is well marked and male demonstrate a circular territory with a radius of about 5-10 meters and defended it from the intruding intra or some inter specific male by warning signals like wing vibration or abdomen raising. As female entered into the territory, the male starts following her and forms a tandem link, catching hold of her prothorax by his anal appendages. The before wheel tandem lasted for 10-22 minutes and during this period intramale sperm translocation from the gonopore to the vesicular spermalis took place 2-3 times of 40-55 seconds duration. The courtship wheel lasts for about 12-18 minutes and is performed of perching on vegetation near the bank of river. After wheel tandem lasted for 07-09 minutes. Oviposition is endophytic among the aquatic vegetation and lasts for 05-09 minutes. The female in tandem uses her ovipositor to deposit eggs in the submerged vegetation near the bank of river. During oviposition the male in tandem and after release of grip hovers around the female, to defend her from intruding intra or inter specific males. The duration of reproductive behaviour lasts for 34-62 minutes.

**Keywords:** *Bayadara indica*, Mass emergence, Reproductive behaviour, Yamuna river, Dakpathar, Dehradun, India.

### I. INTRODUCTION

The present day Odonata are among the largest living insects. They are amphibious hemi-metabolan insects having the aquatic egg and larval (nymph) stages, while the adults are terrestrial. The distribution of various groups and species of Odonata is highly variable. Some genera and species are widespread while others are highly local in their distribution. Some families are restricted to cool streams or rivers, others to ponds or still clear waters, and some to marshy places. The presence of dragonflies and damselflies may be taken as an indication of good ecosystem quality.

The Odonata exhibit two periods during their entire life: the pre-reproductive period and the reproductive period. The pre-reproductive period is the period in between emergence and reproduction. The main behaviour of a dragonfly during this period is: dispersal after emergence and feeding to help the teneral adults

in becoming fully mature adults within a few days. Hence, the pre-reproductive period is also called maturation period. It does not mean that in the reproductive period, the dragonfly remains on fast. But together with the feeding behaviour the most spectacular phenomenon of this period are the different types of reproductive behaviour, which comprises territoriality, pre-copulatory tandem or before wheel tandem position, copulatory wheel formation, post copulatory tandem or after wheel tandem position and oviposition. The reproductive behaviour of Odonata comprises adult behaviour, which leads to successful mating and oviposition.

The Reproductive behaviour of odonates has been studied extensively by several workers including [1, 5, 8, 10, 11, 12, 18, 19, 30, 4, 6, 16, 20, 21, 22, 29, 40, 41, 41, 3, 24, 37, 38, 2, 9, 13, 14, 23, 25, 26, 27, 28, 39, 31-36] etc. In the present study observations on mass emergence and on various aspects of the reproductive

behaviour of *Bayadara indica* Selys, 1853 recorded around Yamuna River at village Dakpathar, District Dehradun, Uttarakhand, India.

## II. MATERIALS AND METHODS

The mass emergence and reproductive behaviour of *Bayadara indica* Selys, 1853 was studied four times around Yamuna River at village Dakpathar, District Dehradun, Uttarakhand, India having GPS coordinates 30.512610° N 77.833214°E in the month of June-July during 2020-21. Identification of adult individuals was carried out using identification keys provided by Fraser [17]. The wings of Adults of both sexes narrow, hyaline and male apices tipped with black, the hindwing not broader than forewing. Many pairs were observed in copulation. The Nikon Field binocular (30 × 25 DCF) and stop watch have been used for taking observations.

## III. RESULTS AND DISCUSSION

The mass emergence and reproductive behaviour of *Bayadara indica* Selys, 1853 has been studied four times at study site on dated 27.06.2020, 04.07.2020, 19.06.2021 and 10.07.2021. The noticeable sexual dimorphism with a shining thorax black, marked with bright greenish-yellow stripes, wings apices black and abdomen black having mid-dorsal carina finely yellow from segment 1 to 8 in male, while females more robust than the male with shorter stouter abdomen, relatively longer wings without black apices made easy to keep a close watch on a species. Due to mass emergence the stretch of 50-100m is dominated by this species on the bank of river Yamuna. The observations on different activities, their duration and variabilities in the reproductive behaviour of *Bayadara indica* Selys, 1853 were recorded as below.

**(a) Territoriality:** The males of *Bayadara indica* Selys, 1853 arrived at the rendezvous during 11:05 a.m. to 03:30 p.m., while the females appeared from the surrounding vegetation late during 11:40 a.m. to 03:00 p.m. The males after arrival perched on nearby vegetation on the banks of river Yamuna (Fig. 1).



Fig. 1. Territorial male.

The perch forms the centre of a circular territory with a radius of 05-10 meters, which was defended by the

resident male from the intruding intra or some inter specific males. The resident male showed an aggressive abdomen raising display or by wing vibration against the conspecific and hetero specific male intruders. When disturbed it moves down stream with a strikingly flashing flight and soon coming back to same perch in the territory.

**(b) Before wheel tandem:** As soon as the female arrived in the territory, the male started following her and after a short dual flight, got success to bind her in tandem link, catching hold her prothorax by its anal appendages. The pair in tandem flew to some nearby vegetation, where the male anchored the branch and the female hanged vertically. The pair in tandem changes perch 2-3 times to nearby vegetation. The before wheel tandem lasted for about 10-22 minutes (Fig. 2). This was the time when intramale sperm translocation, from the gonopore to the vesicula spermalis took place 2-3 times of 40-55 seconds duration at an interval of 1-2 minutes.



Fig. 2. Before wheel tandem.

**(c) Copulatory wheel position:** After the completion of intramale sperm translocation, the male relaxed its abdomen and in tandem rest for 30-40 seconds, after this the male started bending its abdomen and also forced female to bend her abdomen to initiate process of wheel formation. The female then tried to interlock its vulvar region with the secondary copulatory apparatus of male by curling her abdomen forward to form the copulatory wheel (Fig. 3).



Fig. 3. Copulatory wheel position.

After 2-3 attempts, the spectacular courtship wheel was formed. At the starting of the wheel position, an upward and downward motion of the male's abdomen has been noticed. If the wheel breaks in the process due to other conspecific males interfered or during change of perch, the pair in tandem formed the wheel again. The duration of the wheel position varied from 12-18 minutes. In single branch or perch the Copulatory Wheel pairs of 10-15 individuals observed due to dominance of this species in the study site due to mass emergence (Fig. 4).



**Fig. 4.** Many Copulatory wheel on single perch.

**(d). After wheel tandem:** After breaking of the wheel, the male lowered the female and the female also grasped some vegetation by her legs (Fig. 5). After a rest of 02-05 minutes, the post copulatory flight was observed over the aquatic vegetation to choose the suitable spot for oviposition near the bank of Yamuna river and it lasted for 07-09 minutes.



**Fig. 5.** After wheel tandem.

**(e) Oviposition:** The female of *Bayadara indica* Selys, 1853 oviposited endophytically among the aquatic plants and the eggs were laid in the tissue of leaf, petiole and stem. During oviposition the female hold the perch of plant and the male, just stayed in the air, balancing upon the prothorax of the female. The endophytic oviposition process on vegetation lasts for about 05-09 minutes. During oviposition the male in tandem and after release of grip hovers around the

female, to defend her from intruding intra or inter specific males. The duration of reproductive behaviour lasts for 34-62 minutes.

Darwin, (1859), stated in the "Origin of Species", that sexual selection, "depends, not on a struggle for existence, but on a struggle between the males for possession of females [15], the result is not death to the unsuccessful competitors, but few or no offspring". In odonates many different reproductive tactics have evolved to optimize the number of opportunities to successfully reproduce with females and the territorial behaviour, copulation and oviposition are carried out within or near the territory [7]. Several variation of the ovipositing behaviour exists in odonates, but the male has become territorial of these oviposition sites respective to its species [10].

The phenomenon of male territoriality amongst Zygoptera, is exhibited well in the damselflies of family Coenagriidae [37, 41], Calopterygidae [22, 42] and Protoneuridae [38]. Corbet [11] observed that aggressive behaviour of mature male odonates at the rendezvous was directed predominantly towards conspecific males, but in *Bayadara indica* Selys, 1853 males demonstrate aggressive behaviour against both conspecific and heterospecific males. During the present study in *Bayadara indica* Selys, 1853 the range of their territory is 05-10 meters is more as that of *Ceriagrion coromandelianum* and *Pseudageion rubriceps* 30-80cm [27] and in *Pseudageion rubriceps* 40-70cm [26]. The duration of copulatory wheel position was 12-18 minutes, which is more to the duration 03-08 minutes recorded for the other Coenagriidae species [26, 27] and the mating behaviour was similar to that of other zygopterans [6, 10, 29]. The endophytic oviposition by the female and the upright tandem posture adopted by the male during oviposition was quite similar to that described by Furtado [18, 30, 26, 27, 37, 39] for other species of Zygoptera. Hence, it reveals that the time period during reproductive activities observed for a particular event during present and previous studies may relatively changes with the inter or intraspecific interference, according to the habitats or by various environmental factors. Therefore, the long-term monitoring studies are required for different behavioural studies in different wetlands, riverine, reservoirs, marsh lands habitats for odonates.

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