

## **BIOLOGY AND ECOLOGY OF DRAGONFLIES (INSECTA : ODONATA) WITH NOTES ON THEIR ADAPTATIONS IN DIFFERENT ECOSYSTEMS OF INDIA**

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### **INTRODUCTION**

Dragonflies constitute the primitive insect order Odonata. Their ancestors have been reported from the Carboniferous rocks; but no remarkable change in the morphology has taken place after the Jurassic.

These insects are noteworthy for their cute appearance; flight power and sharp eye-sight. These flying machines can fly backward move vertically like a helicopter or stop in turn in the midst of the most rapid progression as if they have been rammed into. This could be possible due to adjustment of the centre of gravity between the bases of the wings and leaves a sharp contrast with all other living insects.

Dragonflies have the highest development of compound eyes (Huxley 1953). It has been estimated that an eye of an adult dragonfly may contain 10,000 to 28,000 facets. The eyes occupy almost the whole of the head; other parts of the head viz. labium, labrum, clypeus, frons, occiput etc., are very small. The head is movable and can be twisted sideways  $180^\circ$ , backward  $70^\circ$  forward and downward  $40^\circ$ ; the meso- and meta thorax are fused to form the synthorax and the legs have shifted forward to form the basket with the help of spines. These help them to capture prey while on wings and to take rest. The abdomen is relatively slender and long. The genitalia is found to be at the tip; only in case of male the copulatory organ is on the second abdominal segment. Copulation takes place usually in the air but eggs are laid in water.

### **Adult life (General)**

Adults are terrestrial. They feed on adult insects; some times fight for food (Mitra 1994).; some of them display courtship, territories for food and breeding are also visible. Territorial fight sometimes depend on the size of insects (Mitra 1994). There are some globe trotters. They prefer to stay near water with bushes on the fringe, so that both adult and larvae get food and places for roost.

*Classification* : According to age life of adults can be divided into three phases...(a) Maturation or pre reproductive (b) Reproductive and (c) Post reproductive.

(a) *Pre reproductive period* : In this period the imago do all activities of a matured individual excepting the sexual life. During this phase the just emerged imago wait for some time in the emergence site and then fly away from the place and after maturation they arrive in the nearest breeding ground (Fig 2). But sometimes immature but not just emerged, dragonflies are also visible in the breeding site. This is probably to get food.

The range of the period necessary for maturation of zygopterans extend from 2 days to 30 days (Corbet 1962, Johannson 1978 & Lutz 1968); and for anisopterans from 6-45 days (Pajunen 1962, Schmidt 1964). The maturation period is usually shorter in males than in females. For instance, males of *Plathemis lydia* take 8-14 days in the case of females it is 13-24 days. In case of *Anax imperator* the males take 7-12 days and females take 13-16 days (Corbet 1962). In a few species the maturation period serves as the aestivating stage and lasts for 8-9 months (Corbet 1980). Sometimes it varies according to latitude. In *Lestes sponsa* the maturation period lasts about 20 days at all latitudes between 40° and 58°N. but lengthens progressively South of 40° N to about 100 days near the southern limit, 34° N., of species (Uéda 1978). The body colour changes at the sametime. The differences in color and other features sometimes causes confusion in identification; Fraser (1933, 1934 & 1936) contain descriptions of several immature forms of Indian dragonflies.

(b) *Reproductive period* : In this stage the mature imagos show breeding activities. This activity of adults determine the flying season (Corbet 1962). In case the breeding season is discrete the duration of the reproductive period depends upon the emergence curve and on adult longevity (Corbet 1980).

In the permanent habitats of the humid tropics the flying season is continuous; in other cases of the tropics it depends on the seasonal rain. Outside the tropical belt, the flying season is not continuous. Species of those regions can be grouped according to their flying period (Corbet 1980). According to Trottier (1971) that the species which usually maintain a resident populations in the tropical area as well as in the temperate latitude the flying season becomes shorter at higher latitudes.

On reaching the breeding ground the adult usually tend to remain there, unless driven away by storm or by aggressive behaviour of other males. The roosting sites of the mature adults ranges from less than one metre to more than 200 metres from the mating site (Hasan 1976; Parr & Parr 1974 and Uéda 1976).

*Reproductive behaviour* : Generally the males arrive at the breeding site earlier, both in season and day, than the females. Males of some species show courtship behaviour and establish territories also. Males then try to catch the receptive females for copulation. Reproductive behaviour of different species have been described by Bick & Hornuff (1966), Bick & Sulzback (1966), Furtado (1972, 1974 & 1975), Kumar & Prasad (1977 a), Mitra (1987), Moore (1952 a, b), Prasad & Ghosh (1982).

*Selection of the breeding site* : The action is often referred to as the habitat selection. It depends on the microgeographic distribution of adult and microhabitat of the larvae (Corbet 1980). A

newly formed dam, for example, is occupied first by species with wide microgeographic distribution and then by those characteristic features of later stages of ecological succession (Corbet 1980). Sometimes man made habitats are also utilised, *Bradinopyga geminata*, for instance, occur almost through out India. In plains it breeds in the stagnant pools and drains. In the western Himalaya, it breeds in rocky pools. Kumar (1973) has collected larvae of it from cemented tanks. The present author has seen to lay eggs and collected its larvae from the open container for aquarium fishes. Gambles (1986) has also reported larvae and ecdyses of *Bradinopyga strachani* and *pantala flavescens* in small rain water puddles in west Africa. During the period of October-November, 1991, the author has seen *Pantala flavescens* laying eggs in small water collected in the depressions on the metal roads of Aizwal (Mizoram). The author has also seen in the suburban of Calcutta that *Pantala flavescens* making oviposition activities over the shining surfaces of the motor car. Nevile (1960) has also reported the similar activities of the species in Ghana.

**Territoriality :** Some odonates are territorial in habit. Males of those species localize in an area within which he behaves in a way that evokes escape and avoidance among intruders (Corbet 1980). The dimension of the territories depend on the density of the male population in the area (Corbet 1980, Mathavan 1975, Mitra 1994). Mitra (1987) has contended that the area of the territory also depends on the area of the breeding site as well as some intrinsic factors. He (Mitra *op. cit.*) has also noted that the territory is defended both in horizontal and vertical direction.

**Copulation :** The male first appear in the breeding site and capture the receptive female as soon as available with the aid of their anal appendages and then remain in tandem, with or without prior evident of courtship. The pair then form the "Wheel position" and copulation takes place either at the breeding site or nearby place even on trees (Mitra 1994)

During the breeding season interspecies tandem flight is also visible. (Bick & Bick 1981; Mitra & Lahiri 1972).

**Post Copulatory behaviour :** After the copulation the female begins to lay eggs. In several species of Zygoptera and Anisoptera the male usually remain associated with the ovipositing female. The pair may be in tandem, continuously, intermittently and repeatedly as in *Tramea*, *Pantala*, *Hadrothemis* (Corbet 1980). In *Tholymis tillarga* the male guards the ovipositing female (Mitra 1987). Tyagi and Miller (1991) have reported similar behaviour in *Ictinogomphus rapax*. In some Zygoptera, females oviposit without the assistance of the males. This type of behaviour is usually seen in species of *Ischnura* (Bick 1972, Parr 1973, Rowe 1978). On the June 9, 1997, the author noted that after a slight dizzle at 6. 30 A.M (Sunrise at 4.50A.M) a pair of *Diplacodes trivialis* copulated on the grass field. After the copulation was over the pair detached and male and female went in the opposite directions. From the above it is presumed that sometime female may carry fertilised egg to a suitable place for laying.

**Post reproductive period :** In this phase the brightness of body colours disappears and becomes duller. The gonads regress. The dragonflies reduce their activities. Their wings sometimes becomes covered with thin film as a result the wing becomes blurred.

**Longevity** : Borror (1934), Corbet (1962, 1980), Gambles (1960) Kormondy (1959), Moore (1952), Parr and Parr (1972) have discussed about the longevity of the dragonflies. Among the populations of the same species the average longevity varies very little. Excluding the maturation period, the average longevity among the studied species of Zygoptera are one to two weeks which may be 5-8 weeks; 2-3 weeks and 3-6 weeks in case of Anisoptera (Corbet 1980). When the maturation period is added, those which neither hibernate nor aestivate after emergence, the longevity in cases of Zygoptera ranges from 7-9 weeks, while the corresponding values in Anisoptera is 8-9 weeks (Corbet 1980).

**Death** : Death caused by automobiles, accidents, starvations, by predators and for other reasons have been cited by Kennedy (1950), Kiauta (1965, 1971), Mitra (1974c, 1994); Moore (1951) and Ram and Prasad (1978). Mitra (1977 & 1994) cited some examples of natural deaths (death without any visible external injury).

Death may be due to clashes with automobiles; heavy rainfall and storm. Among the predators birds come first. Kennedy (1950) have made a list of birds preying on Odonata. In India House Crow, House sparrow, and Mynah act as predators. Among lizards, House geko, *Hemidactylus brookii* is also known as predator of dragonflies which come in the houses (Mitra 1974 c). Mitra (1990) and Ram and Prasad (1978) have mentioned some species of spiders which feed on dragonflies. Fishes also some times feed on larvae. In case of *Bradinopyga geminata* the cryptic coloration and habit of taking rest on tree trunks or on stone wall as well as its crepuscular habit help it to escape from the predators. Similarly in case of *Tholymis tillarga* the superficial resemblance of the wing to the hymenopterous ones and their crepuscular habit also help them to escape the predators. These features of these two species are evolutionary adaptations. On October 10, 1989, the author found that one domestic cat caught and ate completely one male *Urothemis signata signata* when the latter entered a house at Gobardanga, North 24 Parganas district of West Bengal, India. Another record of predation by mammal was made by white *et. al.* (1979) when they reported attack of *Myotis lucifugens* a bat, on *Anax junius* Dr. in America.

**Migration** : Like many other insects dragonflies undertake migratory flights. Fraser (1933) has listed *Pseudagrion decorum* (Rambur), *Pseudagrion microcephalum* (Rambur), *Aciagrion occidentale* Laidlaw, *Onychargia atrocyana* Selys, *Pantala flavescens* (Fabricius) and *Hemianax ephippiger* (Burmeister) as migratory dragonflies of India. *Hemianax ephippiger* appears in Calcutta during the summer. Mitra (1974 & 1994) reported migratory flights of *Pantala flavescens* in Calcutta and Sikkim in September. In North America *Anax junius* and *Pantala flavescens* occur from the tropics to North Canada (Corbet 1980). Matured forms are carried by North winds in early spring (Butler, Peterson & Corbet 1975). In this way they cross the bioclimatic zone where larvae can survive in the winter (Trottier 1966, 1967). The larvae of such spring immigrants usually emerge in late summer and probably fly southwards as immatures roost en route (Corbet 1980).

**Roosting** : Roosting place is important as regards breeding site is concerned. The roosting place in the afternoon or evening may be less than 1m to 200m or so from the breeding area (Corbet

1980). It includes bushes, other vegetations close to the grounds and sometimes walls of man made wells and buildings. Fraser (1944) has described aggregations of roosting *Bradinopyga geminata* in buildings in India. The present author has also noted similar behaviour of *B. geminata* in Jodhpur, Rajasthan, during March-April, 1980; Mitra (1990) has reported roosting of *Brachythemis contaminata* on the walls of wells. Gambles (1971) has recorded associations of *Lestes virgatus* returning to the same spot in consecutive nights in Nigeria. The present author has recorded mass roosting of *Aciagrion pallidum* and *Ceriagrion olivaceum* on the tall grass on the bank of river Sankosh at Jamduar (Assam valley) in December, 1973. Joseph and Lahiri (1989) and Miller (1989) reported communal roosting in *Potamarcha congener* in South India. The function of the communal roosting is not clearly known; but Miller (*op.cit*) concludes "that communal roosting in *Potamarcha congener* serves to reduce nocturnal predators, and that this enhances survival in a long-lived species which may remain in reproductive diapause throughout a long dry season" Other factors in the past may have played important roles for this behaviour. The evolutionary priority of cause and effect cannot, therefore, be determined.

*Thermo-regulation* : The ability of odonates to maintain a relatively constant body temperature is related to their body size as well as their behaviour (Corbet 1980). Corbet (*op. cit*) believes that perchers thermo-regulate primarily by making postural adjustments which involve both body and wings, thus varying exposures of the body to the sun. Corbet (1962) has reported the 'Obelisk' position of *Trithemis festiva* on a hot, stony stream bed at midday in Java. In this position the tip of the abdomen is directed towards sun, the wings shade the thorax., Mitra (1990) has also reported similar behaviour of *Brachythemis contaminata* and *Diplacodes trivialis* in Calcutta. Perching in the shade seems to be a means of thermo-regulation (Utzeri & Ginandrea 1989). During March-April in 1980 the present author has observed in Jodhpur of Rajasthan (Indian Desert), that a large number of *Bradinopyga geminata* specimens rest on a shaded wall during the day time and comes after the sun set. Perching in the bush or near water also help in thermo-regulation. In the period from April to May, 1990, the author has recorded in Azamgarh of eastern Uttarpradesh that *Ceriagrion coromandelianum* remains inside the bush from midmorning (10AM) to late afternoon when the ambient temperature ranges between 35°-36°C. *Pantala flavescens* and *Tholymis tillarga* perch under leaves in the hot summer days in Calcutta. Sometime the former fly 400-600 Cm above the ground in the sun although no difference of temperature from the ground level has been recorded. In the Himalaya perching in the sun help in thermo-regulation (Fig. 1)

*Reaction during changes in weather conditions* : Lahiri (1975) reported that during the rain *Bayadera hyalina* hangs under the wire on which they perched before the rain in Shillong. Recently a pair of *Neurothemis tullia*, (1♂ 1♀) were found to remain in the rain for continuous seven (7.8.97 to 14.8.97) days without changing the position, in Calcutta. Mitra (1996) cited the behaviour of dragonflies during the solar eclipse in 1995, with descent of temperature from 25° to 23° C and ascent of temperature up to 29° C. It was noted that with the descent of temperature the dragonflies reduced their activities, and finally stopped at 23° C; and with the rise of temperature they gradually resumed their activities.

*Food and feeding activities* : Adult dragonflies feed on adult odonate and nonodonate insects. Bhargava and Prasad (1980) have recorded that *Orthetrum glaucum* captures *Palpopleura sexmaculata*; Prasad and Biswas (1981) have reported that *Orthetrum sabina* captures *Acisoma panorpoides panorpoides* and feed on the species. The author has observed that *Ischnura senegalensis*, *Ceriagrion coromandelianum* and *Orthetrum sabina* feed on *Agriocnemis pygmaea*; *O. sabina* feeds on *Ceriagrion coromandelianum*. Among non-insects prey the author recorded that *Pseudagrion rubriceps* attacks aphid (*Aphis cracivora*) *Pseudagrion microcephalum* attacks the ant (*Paratrachina longicornis*), *Ceriagrion coromandelianum*, *Diplacodes trivialis* attack the ant (*Solenopsis geminata*), *Brachythemis contaminata* and *Crocothemis servilia* capture the House fly (*Musca domestica*), *Pantala flavescens* and *Tholymis tillarga* feed on mosquito, *Ischnura senegalensis* and *Crocothemis servilia* capture butterfly, *Pantala flavescens* attacks workers of termites. Mathur (1960) has also observed the similar behaviour of odonate species. Wright (1946) reported several predators and preys of adults and larvae.

*Reaction towards mobile objects* : Sometimes dragonflies follow mobile vertebrates and other objects like bicycle, automobiles etc. This behaviour has been reported by Acharya (1961), Corbet (1962), Corbet and Millar (1991) Mitra (1974 b & 1994), Tyagi and Miller (1991) and Worth (1961). In Africa *Brachythemis leucosticta* follows mobile objects, in Calcutta *Ictinogomphus rapax*, *Brachythemis contaminata* *Diplacodes trivialis* and *Pantala flavescens* follow men and vehicles. In Rajasthan *Trithemis aurora* follows men. In Madurai, Tamil Nadu state, India, Corbet and Miller (1991) have been successful in inducing this behaviour in some examples of *Brachythemis contaminata* of the existing populations, but have failed in case of *Diplacodes trivialis*. The author has observed that *D. trivialis* follow the object in a peculiar way. It goes ahead of the mobile object wait there, till the object reaches and again it goes ahead. Finally it returns to the original position. The causes of this behaviour is not clearly known.

### Larval life

(a) *Habitat* : The larva usually occupies the aquatic habitat. However, there are certain zygoptera which develop in water that accumulates in the leaf bases; the larva of Megapodagrionidae, *Podopteryx selysi*, develop in the water contained in tree holes (Corbet 1980). The larva of New Zealand Petalurid, *Uropetala carovei*, live in damp soil. According to Fischer (1964), Tkeo (1971), Willey and Ellar (1972) larvae of certain species can survive even being out of water for months. Corbet (1980) thinks that certain burrowing larvae locate themselves according to particle size of the substrate.

(b) *Food habit* : The larvae feed on aquatic animals. According to Moore (1960) dragonfly larvae feed on larvae of Mayflies, aquatic beetles bugs fish fry even earthworm which drop in water and show wriggling movement as they sink in the bottom, Corbet (1962) reports that *Aeshna umbrosa* and *Calopteryx maculata* catch larvae of *Simulium venustum*; he continues that the gut contents of *Pantala flavescens* and *Anax junius* contain chironomid larvae. Larva of *Pseudagrion salisburyense* of South Africa captures chironomid larvae and oligochaete worms.

Recently Sebastian *et. al* (1990) have tried to control the populations of *Aedes aegypti* with the aid of larvae of *Crocothemis servilia* in Mynmar (Burma). In Dum Dum Park area of West Bengal larvae of *Bradinopyga geminata* developed in the open container for aquarium fishes feed on mosquito larvae and sometimes fish fries. Food of the larvae varies according to the position of the larvae in its habitat, size of the prey, hunger etc, They detect their prey by means of their compound eyes, and mechanoreceptors. They catch their prey by the labium or by its palpi.

(c) *Predator* : Himalayan salamandar *Tylototriton verucossus* feed on larvae.

*Resume of ecological records in different eco-systems of India* : In India not much work has been done on the ecology of dragonflies and their adaptations in different ecosystems of the country. Following is the summary of informations available from different sources.

*Calcutta (city)* : Mitra (1990) has summerised ecology of adult odonata of the city on the eve of the completion of hundred years of Odonatology of Calcutta in the following ways. This can be considered as the type for the ecology of Odonata in the Ganga plain.

*Habitat selection* : The adults select their habitat suitable for their larvae as well as suffiecient roosting facilities which provide small insect preys to the adult near the breeding areas.

*Thermo-regulation* : In hot summer *Brachythemis contaminata* and *Diplacodes trivialis* remain in obelisk position in the midday. *Pantala flavescens* and *Tholymis tillarga* hang vertically under the leaves. *Bradinopyga geminata* rests in the shaded areas. Dragonflies in general reduce their activities during hot midday; and on the onset of cool season.

*Activity in different seasons* : In summer (March-May) *Urothemis signata*, *Diplacodes trivialis*, *Orthetrum sabina*, *Brachythemis contaminata*, *Crocothemis servilia*, *Trithemis pallidinervis*, *Neurothemis tullia tullia*, *Ceriagrion coromandelianum*, *Ischnura senegalemsis*, *Agriocnemis pygmaea* become active just after sun rise. In rainy season (June-November) the population of dragonflies become less visible due to rain. But in clear days they remain active and during the rain they hide themselves under leaves or any other shelter. In cool season (December-February) the dragonflies become active when the ambient temperature is high enough to clear the fog.

*Food and cannibalism* : Houseflies, mosquitos, ants, aphids, butterflies and beetles are the preys of dragonflies, *Ceriagrion coromandelianum*, *Ischnura senegalensis*, *Orthetrum sabina* feed on *Agriocnemis pygmaea*. *Orthetrum sabina* capture *Ceriagrion coromandelianum*, *Ischnura senegalensis*, *Pseudagrion microcephalum*; *Crocothemis servilia* catches *Pseudagrion rubriceps*. It is interesting to note that although dragonflies eat dragonflies but no record is available on the attack of the member of the same species for the purpose of eating

*Predators* : House sparrow (*Passer domesticus*), Mynah (*Acridotheres tristis*), House crow (*Corvus splendens*), House gecko (*Hemidactylus brookii*), spiders (*Plexippus paykuli* and *Crossopriza lyoni*) have been recorded as predators.

*Effect of urbanisation* : Several species enter houses, *Lestes platystylus*, *Pseudagrion australasiae*, *Macrogomphus montanus* and *Epophthalmia vittata* are not visible for more than fifty years in Calcutta. *Macrodiplax cora* is not visible for more than three decades.

*Western Himalaya* : Ecology of Odonata of western Himalaya has been recorded by Kumar and Prasad in several papers. They have been summarised as follows.

*Classification according to brood per year* : *Drepanosticta carmaichaeli*, *Bayadera indica*, *Anisopleura lestoides*, *A. comes* and *Macromia moorei* are univoltine, *Neurobasis chinensis* is bivoltine species *Pseudagrion rubriceps*, *Ceriagrion coromandelianum*, *Ischnura aurora* *Agriocnemis pygmaea*, *Crocothemis servilia*, *Diplacodes trivialis* and *Orthetrum sabina* are multivoltine since more than two larval generations are visible (Kumar 1985).

*Period for Life Cycle* : *Orthetrum pruinosum neglectum* completes its life cycle in 155 days, *Trithemis festiva* in 109 days, *Ceriagrion coromandelianum* in 49 days to 61 days, *Anax immaculifrons* in 132 days, and *pantala flavescens* in 56 to 61 days.

*Larval Habitat* : Larvae of *Calicnemia miles* live in semiterrestrial condition on damp soil with thick carpet like growth of mosses and fungus which grow near waterfall on vertical hill rocks. Larvae of *Anisopleura lestoides* occur in small hill streams, which have currents, and remain concealed in crevices among small stones and pebbles in shallow water (Kumar & Prasad 1977c). Larvae of *Rhinocypha quadrimaculata* and *R. trifasciata* remain under submerged stones and pebbles in the rapid flowing hill streams with no vegetation; on the other hand larvae of *R. biforata beelsoni* remain hidden within drifted debris in the shaded forest streams (Kumar & Prasad 1977d).

*Breeding* : Kumar and Prasad (1977a) described breeding of *Neurobasis chinensis chinensis*, they discussed the concentration of the species during the period from March to June and from October to November.

*Eastern Himalaya (Eastern Himalaya & Assam region)* : The present author (Mitra 1994) reported the following events.

*Breeding* : *Orthetrum sabina* has been observed to breed in December at Raimona forest of Goalpara district (Western Assam).

*Orthetrum pruinosum neglectum* and *Pantala flavescens* have been found to show breeding activities during October-November in Mizoram.

*Emergence* : Emergence of *Brachythemis contaminata* was found at 10.30 hrs. at Kachugaon forest of the district Goalpara of western Assam. *Pantala flavescens* emerged at 14.30 hrs in April, 1981 at Samsingh, in the district of Darjiling, while *Neurothemis intermedia* has emerged in September, 1988 at 9.30 hrs at Tumin, Sikkim. Asahina (1958) and Svihla (1962) have reported that they have collected larvae of *Epiophlebia laidlawi* in March, April and October from different parts of Darjiling. Svihla (*op. cit*) has opined that probably June-July may be better season for collecting adults of the species.



**Fig. 1.** *Orthetrum pruinatum neglectum*(Rambur) basking in the sun in the midst of snow at Leh (c. 2600m.), Himachal Pradesh; at 10 A. M. in March, 1987. (Courtesy : Sri S. Chattopadhyaya, Scientist, SE.)



**Fig. 2.** Breeding ground of *Bradinopyga geminata* (Rambur), *Brachythemis contaminata* (Fabricius), *Tholymis tillarga* (Fabricius), *Onychargia atrociana* Selys, *Agriocnemis pygmaea pygmaea* (Rambur), and several others, at Hazaribag National Park, Bihar.

*Migration* : A migratory swarm of *Pantala flavescens* has been observed on 22.9.1988 at Tumin, Sikkim.

*Mass roosting* : *Aciagrion pallidum* and *Ceriagrion olivaceum* have been observed to roost en masse on the tall grasses on the bank of the river Sankosh at Jamduar of the district, Goalpara, Assam, during December, 1973.

*Predator* : Dasgupta (1996) recorded Himalayan Salamander (*Tylotriton verrucosus*) as predator of dragonfly larvae in Darjiling Himalaya.

*Feeding* : Dasgupta (1988) reported larvae of *Rhinocypha cuneata*, *R. bifasciata*, *Ictinogomphus rapax* as potential predators of larval *Tylotriton verrucosus* in Darjiling.

*Central India : Breeding Season* : Mitra (1988) has reported breeding activities of *Copera marginipes*, *Orthetrum c. cancellatum* and *Orthetrum pruinosum neglectum* in November in Madhya Pradesh.

*Larval habitat* : Saini and Singh (1984) reported the habitat of larvae of *Copera marginipes*, *Pseudagrion decorum*, *Ceriagrion coromandelianum*, *Ischnura aurora*, *I. senegalensis* and *Libellago lineata*.

*Chhotanagpur plateau* : The author has recorded following events (Mitra 1994).

*Breeding activities* : *Brachythemis contaminata* and *Tholymis tillarga* have been observed to show breeding activities in June at Hazaribagh (Bihar); while the breeding activities of *Crocothemis servilia* and *Orthetrum sabina* have been recorded in November at Purulia (West Bengal).

*Emergence* : Emergence of *Copera marginipes* and *Bradinopyga geminata* have been recorded at Hazaribagh lake at 14.15 hrs of November 1, 1974, and 18.05 hrs of October 29, 1974 respectively.

*Arid zones (Rajasthan and Gujarat)* :

*Breeding activities* : Tyagi & Miller (1991) have recorded breeding activities of *Disparoneura quadrimaculata* and *Ictinogomphus rapax* on August 31 and September 1, of 1991 respectively.

*Follow of mobile objects* : Tyagi & Miller (1991) have observed that *Trithemis aurora* follow mobile human beings.

*Thermo-regulation* : The present author has observed perching of *Bradinopyga geminata* on the shaded walls during March-April of 1980 at Jodhpur, Rajasthan. *Crocothemis servilia* fly within the bush of *Acacia* in the midday of April of 1980 at Little Rann of Cutch (Gujarat).

*Predators* : Sharma & Varshney (1985) have reported amphibians *Rana cyanophlyctis*, *R. tigrina*, *R. limnocharis* and the lizard *Calotes versicolor* prey on dragonflies.

*Southern India (Eastern Ghats and Western Ghats)* : Fraser (1924, 1931) has reported some ecological notes on dragonflies of the western Ghats; Mathavan (1975) have reported ecophysiological studies of some odonates. After this Mathavan *et. al.* (1989), A. Kumar (1990) and Miller (1990) have contributed to the study of ecology of dragonflies of the region.

*Breeding activities* : Mathavan *et. al.* (1989) have reported breeding activities of the following species in January, 1989 at Periyar National Park (Kerala), *Rhinocypha bisignata*, *Ischnura aurora*, *Brachythemis contaminata*, *Neurothemis tullia tullia*, *Orthetrum sabina*, *O. pruinatum neglectum*, *Pantala flavescens*, *Tholymis tillarga*, *Tramea basilaris burmeisteri* and *Trithemis aurora*. Kumar (1990) have recorded in Vedanthangal Water Bird Sanctuary in Tamil Nadu, oviposition of *Coperia marginipes* in November, *Pseudagrion rubriceps* during November to January *Ceriagrion coromandelianum* *Ischnura aurora* and *Agriocnemis pygmaea* during November to April *Ictinogomphus rapax*, during October-November, *Anax, guttatus* in November, *Anax immaculifrons* during March to April, *Potamarcha congener* during November to December, *Orthetrum sabina* almost round the year. So is the case with *Orthetrum pruinatum neglectum*.

*Emergence* : Emergence have been recorded in *Coperia marginipes* during November to February, *Pseudagrion rubriceps* during January to February, *Agriocnemis pygmaea* during January to April. *Ictinogomphus rapax* during October to November; while in *Ceriagrion coromandelianum* and *Ischnura aurora* emergence occurs almost throughout the year; *Anax guttatus* emerges in January. *A. immaculifrons* during October-November; *Potamarcha congener* emerges from April to May; *Orthetrum sabina* round the year and *Orthetrum pruinatum neglectum* from January to February in Tamil Nadu.

## SUMMARY

The paper reviews biology of dragonflies in general on the basis of current informations available on the subject. In addition to the above it contains summaries of ecological records of different ecological areas viz. Gangetic Plain, Eastern and Western Himalaya, Chhota Nagpur Plateau, Arid zones, Eastern and Western ghats including valleys of southern India.

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