

CURRENT TOPICS IN DRAGONFLY BIOLOGY
Vol. 3

A discussion focusing on the seasonal ecology of
Pantala flavescens in the Indian subcontinent

Transcript of discussion recorded during plenary session
of the 9th International Symposium of Odonatology at
Madurai, India on 20 January 1988

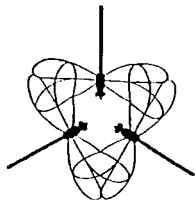
The discussion was chaired, and this transcript edited,
by Philip S. CORBET

DATE OF PUBLICATION

October 31, 1988

Author's address:

The Old Manse
45 Lanark Road
Edinburgh, EH14 1TL, U n i t e d K i n g d o m



Societas Internationalis Odonatologica
Rapid Communications (Supplements)
No. 8

CURRENT TOPICS IN DRAGONFLY BIOLOGY

Vol. 3

A DISCUSSION FOCUSING ON THE SEASONAL ECOLOGY OF
Pantala flavescens IN THE INDIAN SUBCONTINENT

Edited by
Philip S. Corbet

Billthoven
1988

C O N T E N T S

| | |
|--|-----|
| PREFACE | vii |
| DISCUSSION | |
| Preamble | 1 |
| Priorities for research in the Indian subcontinent | 1 |
| Seasonal distribution | 2 |
| Seasonal distribution of <i>Pantala flavescens</i> | 5 |
| A system for collating observations | 11 |
| Larval ecology | 11 |
| Other topics | 13 |
| <i>Pantala flavescens</i> : needed information | 14 |
| APPENDICES I and II | |
| Bibliography | 17 |
| Addresses of contributors | 21 |
| INDEX TO CONTRIBUTORS | 22 |
| INDEX TO CITED AUTHORS | 23 |
| INDEX TO ODONATA | 24 |

PREFACE

At the 7th and 8th International Symposia of Odonatology, in Calgary, Alberta and Paris, France, respectively, the programme included a plenary session devoted to discussion of topics of current interest to odonatologists. Each session was recorded and transcribed, and subsequently published as a Supplement in the Societas Internationalis Odonatologica (S.I.O.) Rapid Communications series as Nos 2 and 6. At the 9th International Symposium of Odonatology in Madurai, India in January 1988 a similar plenary session was held and, thanks to the efforts of the Symposium Secretary, Dr S. MATHAVAN, and of the National Representative of the S.I.O. Indian National Office, Dr B.K. TYAGI, we were again able to record the whole session in a way that made transcription feasible.

In editing the transcript, I have made minor changes, or corrections, needed to improve readability and comprehensibility. The discussion lasted little more than an hour; it was therefore considerably shorter than at Calgary or Paris. The emphasis was different also: at Madurai it was decided beforehand to focus discussion on priorities for odonatological research on the Indian subcontinent. With so short a time available one topic - seasonal distribution, with special reference to *Pantala flavescens* - was explored at some length instead of considering a number of topics, each relatively briefly. As before, to put the discussion in context, I have compiled a short bibliography and a list of contributors and their addresses. Also included are indexes to contributors and dragonfly taxa. Citations to entries in the bibliography are indicated in the text by numbers in parentheses.

In a few places the discussion repeats points that were raised during the corresponding session at Calgary or Paris. This is to be expected, and I have not attempted to exclude such repetition because I consider it desirable that each of these transcripts should present a balanced record of the contemporary discussion.

Readers wishing to cite observations in this publication can do so in this form:

LAHIRI, A.R. 1988. In *Current topics in dragonfly biology*,
P.S. CORBET (ed.), p. 7. *Soc. int. odonatol. rapid
Comm. (Suppl.)* 8: viii + 24 pp.

It is a pleasure to thank Miss Alison MACKAY for producing the final typescript. My warm thanks are again due to Professor Bastiaan KIAUTA for helping to expedite publication.

The original tape of the discussion has been deposited in the archives of S.I.O. The transcript of side 2 begins on page 9.

Philip S. Corbet
May 1988

The Old Manse
Slateford Village
Edinburgh

DISCUSSION

Preamble

CORBET: May I welcome you to the fourth of our plenary seminars which have been a feature of each of the last three S.I.O. International Symposia?

These Symposia have been informative and enjoyable and, as I said the other day, they offer an opportunity to exchange information and experiences in an informal way. In the two previous Symposia the plenary sessions have been recorded very effectively and then transcribed and presented in an edited transcript in the S.I.O. *Rapid Communications* series under the title "Current Topics in Dragonfly Biology" (1,2). I hope that we shall be able to do that with the discussion today. However, we only have about an hour available tonight (although I am sure that we can make excellent use of it) and so I am going to suggest that we approach the discussion rather differently and that we take as our main, and perhaps our only, theme: "priorities for research on the Indian subcontinent." I suggest that when we have focused on what we think some of the priorities are we devote time to discussing how we might implement such research on a regional basis. Now this is very much a participatory event and, because we are going to record and transcribe the proceedings, I would make this request: Please wait until you are handed the microphone and then announce your name and speak slowly and distinctly. This will help me when, in the depths of the Scottish winter, I pore over the tape and try to decipher and transcribe what we have said!

Priorities for research in the Indian subcontinent

CORBET: Let us begin by collecting one or two ideas, which we can explore later, on priorities for research in the Indian subcontinent. At this point I would like to say a word or two to introduce this subject. I suggest that, because the Regional Office in the Indian subcontinent is such a vigorous organisation and is so good at communicating with people in different parts of the subcontinent (3), a preferred choice of topic will be one which draws in information from different parts of the subcontinent on some widespread phenomenon. One such topic that was suggested to me and which I mentioned when I spoke to you earlier is the seasonal distribution of dragonflies on the subcontinent. What has come out of preliminary discussions that I have had with colleagues here is that we might regard this as an opportunity to record the seasonal distribution of certain kinds of species - perhaps monsoon species or summer species - in different parts of the subcontinent in relation to (for example) the arrival of the monsoon and that we might record the occurrence, not only of adults, but also of larvae, egg laying, mating and so on, so that after a year or so it might be possible to coordinate the information centrally and hope that some of the patterns of distribution across the Indian subcontinent would emerge from the data.

Now may I open discussion on the proposal that we might choose seasonal distribution as one of the priorities?

Seasonal distribution

KUMAR: We have been able to obtain some basic data on the life-history pattern and on the influence of the monsoons, especially the southwest monsoon, on the life history and larval development of a number of species which may lay their eggs and have their larval biotopes in the monsoon ponds, and of some other species which have their larval biotopes in the hill streams (4-7). In addition to this we have found that the ratio between the adult and the larval stages in India is quite different from what has been recorded in temperate climates, as for example in Europe or North America or Canada. So in my opinion this topic would make an excellent subject for study.

There are data available from the area in which I work, that is about 29°N. There we have, not tropical, but something like subtropical conditions. The place I refer to is the Dehra Dun valley where I have carried out most of my work (8). The valley is situated at about 650 m altitude. We have on the north side the foothills of the small western Himalayas where the ranges go as high as about 2,000 m. We have a peculiar situation there. We have temporary monsoon ponds, we have the impact of the southwest monsoon and also we have the permanent habitat in the form of the hill streams. So the seasonal distributions of these two groups of species contrast with one another. We found that, as the monsoon arrives, the valley becomes dotted with ponds and that a number of species aggregate at these ponds. They then lay eggs there - about 10-15 species do this. During the summer monsoon period, the water is hot and the air temperature is very high, and larval growth is quite rapid. In some of these species I have recorded that larval development, i.e. the interval between egg laying and emergence, is only about two months - being between 50 and 70 days - as in *Lestes praemorsa* (9), *Pantala flavescens*, *Acisoma panorpoides*, *Diplacodes trivialis* and *Brachythemis contaminata*. All these species are able to complete larval development in about 60 days whereupon emergence starts (10). Well, on the other side, as the monsoon has arrived we also have a number of hill streams which are flooded because of these torrential rains. I have found that the hill-stream-breeding species, especially Zygoptera such as species of the genera *Bayadera*, *Anisopleura*, *Libellago* and perhaps *Neurobasis*, try to emerge before the monsoon breaks in. Their larvae, which are then in the final instar, are liable to get washed away by the spate (torrential flood) which develops as soon as the monsoon starts. So, as I have found, they have regulated their emergence from the streams so that it takes place before the monsoon breaks in (5,6). On the other hand, in the species which breed in monsoon ponds, the adults aggregate at the ponds and start laying eggs, larval development is quickly completed and emergence starts at some time from the end of August to the end of September.

CORBET: Well there we have a reference point for patterns of seasonal distribution on the subcontinent at about 30°N in two contrasting habitats: hill streams and monsoon ponds. I have no doubt from what you say, Dr Kumar, that for each of these habitats you could identify a small number of key species which occur elsewhere on the Indian subcontinent and which could therefore offer subjects for a comparative study.

KUMAR: Some of these species occur here also. Some have a very wide distribution; not always the same species, but the same genera may be found here also. We have a number of species which have a very wide distribution in India as such, for example: *Orthetrum sabina*, *Diplacodes trivialis*, *Crocothemis servilia*, *Bradinopyga geminata*, *Neurothemis tullia* and *Tramea virginia*. All these species occur in Dehra Dun as well as in this part of the subcontinent. Another very interesting species which we have is *Pantala flavescens*. This species forms a very peculiar feature in our country. We have two monsoons in India (7). In the middle part of the country we have the southwest monsoon which starts at some time during May or June, depending on the latitude and longitude of the particular locality. In the whole of the country except in the shadow zone of Tamil Nadu, where we are located right now, we have the southwest monsoon which one can generally say is restricted to the period from June to the end of September. Also we have another monsoon - the second monsoon - which we call the northeast monsoon which is restricted to this part of the country (i.e. Tamil Nadu) and occurs from the middle of November to the middle of January. Actually we are supposed to be in the northeast monsoon period here right now in Tamil Nadu. We have worked out the larval development of *P. flavescens* at Dehra Dun and have found that it takes 50-60 days from egg laying to emergence (5,11). We have recorded that adults of *P. flavescens* appear at Dehra Dun in very large numbers in swarms in the month of June. As soon as the monsoon arrives we find numerous swarms of *P. flavescens*. Egg laying is very vigorous at this time and in due course emergence starts at the end of August or in September. And then again we see very large swarms of *P. flavescens* which disappear suddenly. And most of you must have already noticed that we have *P. flavescens* flying in the local campus and in the grounds of our hotel right now.

Before making these observations, I thought that we have only one larval generation of *P. flavescens* which is correlated with the occurrence or arrival of the southwest monsoon in India. Now a pertinent question is whether we have another larval generation of *P. flavescens* in this (southern) part of the country which may be correlated with the arrival or occurrence of the northeast monsoon in Tamil Nadu. So *P. flavescens* is one of the species which offers fascinating possibilities for investigation.

CORBET: Two points have come out of Dr Kumar's introduction to this topic. The first is that in the north of India, we have two seasonal habitat groups of species (those in the monsoon ponds and those in the hill streams) for which the life histories are fairly well known and for which we can use the Dehra Dun data as a reference point for other locations in the subcontinent. And the second point is the correlation that has been observed in Dehra Dun between the arrival of the monsoon winds (which have such a conspicuous effect on the aquatic insects of the country) and the arrival of the well known migrant, *P. flavescens*.

May I now ask if there is anyone based at the other end of India, in Tamil Nadu, who knows anything about the life history of any of these species in the south of India or who knows of opportunities for carrying out similar studies which could provide a comparison? Let us first consider *P. flavescens*.

TYAGI: I have learnt with surprise during several discussions with Dr Kumar that at the time when *P. flavescens* is not seen in some northern areas it has nevertheless been found in the warmer areas of southern India. This is a fascinating feature of this species because at the time that *P. flavescens* was thought to have disappeared from some areas where the temperature was low it was found to be occurring in the warmer areas of the same country. As Dr Kumar has remarked in some of his papers and during his discourses on other occasions, it is very interesting that the same species under the influence of altitudinal differences, temperature differences or certain other geographical or climatic differences behaves differently. It would certainly be interesting to find out whether there is more than one generation per year in a single locality or whether the species is able to breed twice per year only by moving to different geographical areas. This is a fascinating subject, and anyone who has been working in the southern part of peninsular India on the biology of dragonflies should certainly give attention to it.

CORBET: May I suggest that anyone living in Tamil Nadu who is in a position to carry out regular, simple observations of *P. flavescens* let Dr Tyagi know as soon as possible so that we might be able to start some work in southern India?

Dr Suribabu, you live more or less in the middle of this latitudinal range - in Sagar - do you not? I wonder if you would comment on the seasonal distribution of *P. flavescens* near Sagar, if you happen to know about it, and on the possibility of carrying out studies there?

SURIBABU: The seasonal patterns of dragonflies have not been worked out in central India. It is a very interesting topic. Along with the physical factors we have to study the physicochemical factors of the water also. I worked at latitude 20°50'N, in Sagar, on two damselflies: *Pseudagrion decorum* and *Ceriagrion coromandelianum*. The study site for *C. coromandelianum* was a permanent body of water: a small, cemented pond, in a garden. This pond contains water throughout the year. Another study site was a large eutrophic lake in Sagar. I observed that four generations of these species were completed in one year. Two generations were confined to the summer, one generation occurred during the rainy season, and one generation during the winter season. The summer generations each take about 45-50 days, the rainy season generation about 3 months and the winter generation about 5 months. I noticed one peculiar thing: even in winter the lake absorbs the heat from the sun which is retained during the night also. Sometimes I observed a water temperature of about 20°C in the lake. In the small, cemented tank I observed that *P. flavescens* could complete three generations (within a year).

CORBET: Is there a time of the year when adults of *P. flavescens* are absent?

SURIBABU: Yes: during the severe winter season, i.e. during the whole of January and up to the middle of February.

CORBET: Do you say then that adults of *P. flavescens* are present during every other month of the year?

SURIBABU: Yes.

Seasonal distribution of Pantala flavescens

CORBET: We have here the possibility of obtaining fairly quickly the seasonal pattern of *P. flavescens* at three different latitudes. There may well be other climatic regions in India which should be chosen for study also, on criteria other than simply a latitude gradient.

May I ask at this point whether anyone thinks there are other locations where it would be useful to record the seasonal distribution of *P. flavescens* in an initial study? What about the Gangetic delta for instance? Are the rain patterns different there?

CHOWDHURY: I would like to add here that in Chittagong and Chittagong hill tracts - a locality which lies in the southeastern corner of Bangladesh - I have personally observed, for about the last five years, that *P. flavescens* is active in flight almost throughout the year except during the last few weeks of December, and the whole of January, reappearing again in the first week of February (12). Its presence tallies well with the seasonal arrival of the monsoon. The monsoon arrives in Chittagong hill tracts by mid April, or at least by late April, and continues right through to the end of September or early October.

CORBET: This is the southwest monsoon?

CHOWDHURY: Yes: this is the southwest monsoon. We have a little bit of the northeast monsoon but that consists of only a few drops of rain occasionally towards the end of September. It is not really a fully fledged 'rain' as we have in the southwest monsoon. We do not really consider it to be monsoon. We call it 'the winter rains'.

Together with this, may I take the opportunity to mention an interesting phenomenon which I have observed this year? Most of these species, as Dr Kumar pointed out, are monsoonal species, arriving with the monsoon and remaining active up to the end of September or until October and then going away. I thought that after a three-year study I had a more or less dependable picture of the seasonality of a majority of our species of Anisoptera; but this year, concurrent with the unusually mild winter, I have found up to 8 January that three species which were not 'supposed to be' present in November, December, January and February are still active. These three species are: *Orthetrum sabina*, *Palpopleura sexmaculata* *sexmaculata* and *Rhodothemis rufa*. May I here point out that *R. rufa* and *P. sexmaculata* *sexmaculata* are stream breeders, whereas *O. sabina* is what I call an 'opportunistic breeder' using both stagnant and water bodies? That will be all, thank you.

CORBET: In relation to your last point, may I ask whether there was anything exceptional about the weather in Chittagong during November and December last year? You mention that there was a peculiar pattern.

CHOWDHURY: Yes: that was an unusually mild winter. The temperature was unusually high for the time of the year. We have not seen anything like this in the last 5-7 years at least.

KIAUTA: With reference to the migratory habits of *P. flavescens*, I would like

to draw attention to its vertical distribution. In the Himalayan region, in Nepal, there are a great many incidental records from the plains up to an elevation close to 6,000 m (13,14). I am not sure as to the dates but I believe the records are between March and November.* Perhaps a systematic study of the occurrence at different elevations would also be of considerable interest. *P. flavescens*, next to *Aeshna juncea mongolica*, is the only species that one encounters in the Himalayas above 5,000 m (the latter species probably above 6,000 m) as a migrant. There are records from Pakistan I believe of *A. juncea mongolica*.**

CORBET: I would now like to ask if anyone has a supposition of how *P. flavescens* is moving around India? Is it travelling on the rain-bearing winds that form the monsoons?

TEMBHARE: My observations are from central India. I observed that, with the monsoon, that is by the end of June, we can see large swarms of *P. flavescens* flying up to a considerable height; and *P. flavescens* can be observed up to December in large populations. As far as dragonflies are concerned, we can see them in the field - in their natural habitats - in large populations from June to December; these comprise *Orthetrum sabina* and *Diplacodes* and some *Zygoptera* also. They are associated with the cultivation of paddy. So in my region, until about 5-6 years ago, the practice was to harvest only one crop of rice, that is from June to December; but nowadays we are taking two crops. In the summer also we are taking one more crop. So what I have observed is that some of the species which are associated with the rice fields appear also in the summer, a period when it was expected that they would have disappeared. So it also should be noted that there are ecological factors which have some impact on the development, reproduction and behaviour of some species of dragonflies.

KUMAR: We have some records for *P. flavescens* for localities in India. May I cite these?

CORBET: Yes, thank you: that would be appropriate.

While you are assembling them, Dr Kumar, I might mention that it can be very useful when recording the seasonal distribution of a migrant to have under observation small ponds which are known to be suitable breeding sites for the migrant and which contain water all the year; then the absence of the migrant from these ponds can provide firm information about its seasonal distribution.

KUMAR: Fraser (16) has recorded that in India *P. flavescens* emerges in millions from marshes and shallow, weedy lakes in submontane areas during September to start a steady, sustained migration which may last on into November. Fraser recorded the westerly directed movement of this species from Ceylon and the Western Ghats of India. Then Singh and Singh (17) recorded a swarm of *P. flavescens* moving north to south in the state of Rajasthan, that is in the north-central part of India.

* Actually between March and September (ed.).

** And of several Anisoptera and Zygoptera from Tadzhikistan (15) (ed.).

CORBET: At what time of year was that north-to-south movement recorded?

KUMAR: The period was not mentioned - the observation was a casual one: suddenly they observed that thousands of adult dragonflies (identified as *P. flavescens*) were moving from north to south and they simply placed this on record. Then of course I have recorded the sudden appearance of a swarm of *P. flavescens* in the Dehra Dun valley during late June when adults aggregate and oviposit in temporary ponds. They disappear by the end of September or October after they emerge and disperse from these ponds. Then again Corbet (18) has recorded that in tropical Africa the movement of *P. flavescens* has been correlated with rain-bearing winds. So these are some of the records regarding seasonal movement of *P. flavescens*.

MITRA: I have seen the migration of *P. flavescens* from west to east in Calcutta in 1966, probably (as I have recorded in 1974) during September (19). In Calcutta *P. flavescens* probably arrives around March. In Darjeeling, at an altitude of about 3,000 feet, I have captured a just-emerged *P. flavescens* in the middle of April. The records are not with me here but I can supply them when I return to Calcutta.

CORBET: Does anyone have any information about *P. flavescens* on the eastern side of the Indian subcontinent? Or in a rain-shadow area?

LAHIRI: I had the experience of collecting and observing *P. flavescens* in Calcutta and in Shillong and in many parts of the Khasi Hills, in rain-shadow areas and in rainfall areas (20,21).

CORBET: This region is in the northeast is it not?

LAHIRI: Yes: the Khasi Hills are in northeastern India. In Shillong my experience is this. It is a cool place and I tried to observe the distribution of *P. flavescens*. In Shillong the climate is too cold in winter to collect specimens and my observation is that for only about one month (from mid December to mid January) not a single specimen of *P. flavescens* could be captured but then the species became evident, although in low numbers, and numbers thereafter increased. The maximum fell in the post-monsoon period, that is June, July and August. This pattern in northern India, in which the population is very small or perhaps totally absent during the winter months of December and January, is quite different from the pattern in the south. I was recently in Andhra Pradesh (the state north of Tamil Nadu) in southern India. There I found *P. flavescens* in abundance and now here also I have found it during December and January. So, from the observations discussed earlier there is a real difference between south and north India. In north India populations of *P. flavescens* are not found in the winter months but in south India they are readily available. That is one point. And then, as Dr Tembhare pointed out, in certain parts where there are paddy fields *P. flavescens* is restricted to those habitats. Now, in many parts there is artificial irrigation and some of the species which would normally not be expected are found in those places. And, regarding migration, I have only one observation to report, made about three years ago. It attracted my notice particularly because it was in central Calcutta - in a very busy area. There *P. flavescens* was sometimes seen in September during the afternoon at about 2 p.m. I estimated that more than 50,000

specimens were visible at one time; the sky was almost dark with the swarm which was moving a southwesterly direction. I was wondering where so many specimens had come from because there were no water bodies, only buildings, in that part of Calcutta.

CORBET: What month was that please?

LAHIRI: It was probably in September.

CORBET: Is that when the northeast monsoon begins?

TYAGI: No: that is at the end of the southwest monsoon.

CORBET: On a point of information, is there also a northeast monsoon?

TYAGI: That begins some time near the end of October and continues during November until early December.

CORBET: That is, after Dr Lahiri made his observation?

LAHIRI: Yes.

SRIVASTAVA: I am also from Sagar. I have made some observations casually in 1956, 1957 and 1958 when I was at Allahabad in the Indogangetic plains in northern India. I observed large populations of *P. flavescens* during the monsoon months, especially July, August and September. Now, this abundance of *P. flavescens* was gradually decreasing and at the same time populations of *Lathrecista asiatica* increased. Specimens of *L. asiatica* continued to be collected until December, and *P. flavescens* almost disappeared from October onwards until the end of April. From the beginning or middle of May some specimens were collected by me. I noted down the collection dates but do not have them with me at the moment. I wanted to mention them during this discussion on *P. flavescens*. From the middle of May some specimens appeared and as soon as the monsoon rains arrived, the population suddenly increased. That is what I have to say.

CORBET: At this point in the discussion I would like to say how exciting it is to hear these observations - anecdotal observations - on the seasonal distribution of *P. flavescens* in different parts of India and how useful it would be if these could be committed to print as short notes (46). Then one could begin to see the questions that should be asked about *P. flavescens*. So may I urge that those who have spoken and those who have not spoken who have useful information of this kind about *P. flavescens* to publish it, in the form of short notes if necessary, so that it can be placed on record?

One of the mysteries surrounding *P. flavescens* is where adults go after emergence. This is one event in the life history for which there is extraordinary little information. At this point we are getting close to half-way through the time available; so I should like to inject some information about the behaviour of *P. flavescens* on the North American continent just to give what may be an additional perspective to our suppositions about *P. flavescens* in India.

P. flavescens is of course circumtropical and it occurs in the New World

tropics. But it makes annual excursions up to 45°N, up into Ontario (22). It almost certainly comes up on the air systems in May and June - it might even arrive earlier if it were not too cold for it. One of its companions on this journey, *Anax junius*, which is very like *A. guttatus*, which you have here, makes a similar movement, and we know more about that. *A. junius* will sometimes come up to Ontario in April if the wind is right (23). The origin of the migratory individuals is unknown but it is assumed that they originate in latitudes far to the south - perhaps in the tropics.

(Side 2 begins.)

Well *P. flavescens* arrives in southern Canada in May or June; it oviposits and it can complete one generation by September (24). It then disappears from ponds but in peninsulas projecting south into the Great Lakes at about 41°N *P. flavescens* and *Anax junius*, both in an immature condition, appear in very large numbers in late September and then disappear (25). The assumption, and I think it is a justifiable one, is that, like many birds which are known to migrate south at that time of year, these dragonflies are flying south, away from the Canadian winter. So on the North American continent we have a number of species - not just *P. flavescens* - but also *P. hymeneae*, *A. junius*, *Erythemis simplicicollis* and two species of *Tramea*, that come up in spring from further south, complete a generation during the hot summer of southern Canada, and then fly south as immatures (22). Now I mention this for two reasons. One is that in a continent like the New World which, like India, extends over a wide latitude range we have a fairly well recognised north-south migration of *P. flavescens* but there of course we do not have monsoon winds which dominate the air movements across the continents elsewhere; we have north-south winds. However we see *P. flavescens* moving with north-south winds as the climate permits; and it is too cold in winter for *P. flavescens* to survive in Canada - indeed the larvae cannot survive in ponds there during the winter (24). The other reason why I mentioned this is that the migratory forms of *A. junius* (26) and *P. flavescens* fly away from the breeding site when they emerge but then do not come back to it after the maturation period as do most non-migratory dragonflies. They disappear.

Now I should like to devote some time in the discussion to two matters. First, I wish to ask if anyone has any information about the emergence of *P. flavescens* in different parts of India, and about what the adults do after they emerge. Second, I want to ask Peter Miller to indicate to us how we might usefully record the condition of adults of *P. flavescens* (by visual observation or by dissection) in ways that would tell us something about their age, their reproductive maturity and possibly their ovipositional history.

First, then, the emergence of *P. flavescens*. Has anyone witnessed emergence or the maiden flight of *P. flavescens* in India?

Well, is that not a remarkable thing? This is an extremely common, widespread species and yet it appears that very little is known about its emergence and maiden flight. From my reading of the literature I myself know of only two instances where someone has witnessed what has happened immediately after emergence. In both these cases, one in Florida (27)

and one in Japan (28), a large-scale emergence was observed, the immature adults were seen for a few days flying in large numbers in the hinterland of the emergence site for a few days and then they disappeared. So I would ask that anyone who wants to contribute information about *P. flavescens* give priority to this interesting but little-known subject of emergence and its immediate sequel.

Passing now to the second matter: if we are going to record the presence and absence of *P. flavescens* throughout the year I think that we can make the records much more valuable, in a seasonal-regulation context, if we record the condition of the adults. So, Peter, would you kindly say something to us about the possibilities that exist here?

MILLER: I do not regard myself as an expert on *P. flavescens* but I have been watching it here intermittently for three and half months and there has never been a day when it has not been present on the campus of the Madurai Kamaraj University, albeit in widely varying numbers. I have been making irregular collections of adults which are now in preservative; so I cannot answer Philip's question completely. However it is quite apparent that many of the flocks of *P. flavescens* on the campus are of mixed age. We have been seeking gravid females in order to look at eggs which I have been persuading these females to dump. I've found in my collections many clearly teneral, soft adults flying alongside mature ones which had eggs or sperm in them. Such facts are very easy to discover. I would guess that such immature adults are only a few days old in many cases. People have told me that they are emerging from the rice fields in this area but I have not seen this myself. I have seen many 'pantaloid' larvae which have nearly always turned out to be *Tramea* in the few cases in which I have been able to correlate a larva with the emerging adult. So I am not certain whether I have ever seen *P. flavescens* emerging here. I have seen it emerging in Africa but that is not relevant for the moment. There are certain features such as cuticular softness, development of gonads, shininess of wings, deepening of body colour, changes in wing colour and a reddening in the case of the male abdomen which will indicate the degree of maturity. These features could be listed and made use of for this purpose. I think that is all I can say at the moment that might be useful.

CORBET: Thank you Peter. May I ask you to comment on something else? Is it useful to record abdominal fat, and food in the gut?

MILLER: I certainly think it would be useful but I cannot say what correlation it might have with the development of gonads. It might merely depend on the availability of food locally. However one would expect fat deposits to be very heavy before a migration although also at other times, perhaps just before gonads were maturing. I think that fat could be slightly misleading if one associated it exclusively with migration. It might also be accumulating at other times just before reproductive activity. Perhaps you had in mind *Hemianax* (29)?

CORBET: Yes, I did.

A system for collating observations

CORBET: We have here the possibility of people in different parts of India placing on record observations they have already made on *P. flavescens* and then stating their willingness to act as recorders - seasonal recorders - for biological observations on *P. flavescens* over the next few years. I suspect that it may be necessary to carry on such a study for several years because I understand that the arrival time of the monsoon is variable and that, as Dr Kumar, Professor Chowdhury and other speakers have pointed out, there are some years which an atypical seasonal distribution is experienced. If there is a possibility that recorders would be willing to undertake such work, two things are needed: a protocol, which would ensure that the observations were standardised; and a 'central office' which would act as coordinator and receiver of records and disseminator of information, so that reports could be sent out to the observers year by year to tell them how things were going and what sort of patterns were emerging.

Dr Tyagi, I ask you if you think that the early stages of developing the guidelines and protocol and obtaining the names of recorders is something that could be undertaken by certain members of Council of the S.I.O. National Office in India - perhaps yourself and someone else?

TYAGI: I fully agree with you and we shall proceed along these lines. I shall circulate this information to the various Council members in the Indian subcontinent and a decision will be passed to you.

CORBET: Thank you. Are there any comments please on what we have discussed so far?

Larval ecology

JOHNSON: I have been listening with much interest to what you are saying about a coordinated effort to study the seasonal distribution of *P. flavescens*. As a person interested in larval ecology (30), I am a little distressed that all the discussion has been about when the adults are flying. If you are going to undertake a project like this I would like to encourage you to do two things: first, try, if you can, to collect information on size-frequency distributions of larvae (31) so that you can do the kind of analysis that others have carried out in investigating the response of larvae during seasonal regulation; and second, try to obtain a copy of Ulf Norling's 1984 paper (on the evolution of life-history strategies in odonates) which is available from the Calgary University Press (32). That paper is a very valuable summary of life-history information and it treats the expected series of events in the adaptation of tropical insects to increasingly temperate and to very cold climates. You have an excellent opportunity to document the beginning of that process here, on a gradient from the strongly tropical situations here in Tamil Nadu to more and more subtropical situations and then up to higher elevations in the north.

I think you could provide information if the project that you undertake is done in a way that can contribute to, and criticise, Norling's model of the evolution of life-histories.

CORBET: Gordon, would you like to speak?

PRITCHARD: I would like to add my support to virtually everything that has been said so far, including what Dan has just said. But I would like to make an observation. We in the northern hemisphere have very much concentrated on larvae because that is where the action has seemed to be, starting as I said the other day with Philip's work 30 years ago (33) and coming up to the present with Ulf Norling's review paper which Dan has just mentioned (32). (Incidentally, I have a large number of reprints of Ulf's paper and I can provide any workers in southern Asia with a reprint of it if I receive a request for one.) I think many of us have perhaps become preoccupied with larvae. I certainly have taken the stance that the life histories we see in temperate regions have evolved from life-history patterns that we should encounter in the tropics (34), and that we should be able to find a nice series, as Ulf Norling's model suggests; but from what Dr Kumar especially has said it seems to me that the larval stage plays only a minor role in seasonal regulation in tropical systems and that here we should be looking at the adult stage. This I think would fit in with the views of Masaki (35) who, from his work on Japanese crickets, has argued that the insect endocrine system gives all insects the potential for diapause - for a variety of diapauses in fact - and that we should not necessarily expect there to be a phylogenetic relationship in the types of diapause that different species of insects exhibit. It seems to me that in tropical regions we may well have a set of mechanisms for seasonal regulation completely different from those that exist in temperate regions. I clearly support the initiative on *P. flavescens*. It obviously is an excellent species through which to explore some of these ideas, but I would like to put in a plea for other species as well. I do think it is important that we collect information on non-migrant species also.

CORBET: The remarks of Dan Johnson and Gordon Pritchard bring us back to the companion topic with which we opened this seminar, that is the patterns of life-history of certain selected species at different latitudes. Our time is getting on: we only have about 10 minutes left. So I should like to ask the same question that I asked just now. If I may address you, Dr Tyagi, as the National Representative, I would ask whether you think it would be feasible to do the same thing with a series of selected species and request information on larval growth and adult presence at different latitudes?

TYAGI: In this respect also I fully agree with you. We have somewhat more than 400 species and we do not know the life-history patterns of most of them. In most cases the life-history patterns have been studied only in the commonest species available, and mostly in the warmer parts but we really know hardly anything about the species in the Himalayan areas, in the far-eastern areas such as Assam, in the desert areas of Rajasthan, in the marshy areas of Kutch - in the Great Rann of Kutch, in Gujarat - and in the areas where the dragonflies have been studied very little, such as the Andaman Nicobar Islands and Laccadive Islands where we know nothing about the biology or seasonal patterns of the dragonflies. So it would certainly be worthwhile to study the seasonal occurrence and the biology of the dragonflies of these species in the region.

CORBET: That is encouraging. I think we have the framework to get comparative information on the life-history of certain selected species, preferably ones that have a wide distribution in the Indian subcontinent, and also to build up what will I'm sure be a valuable data base on the life history and seasonal movements of *P. flavescens*.

Other topics

TYAGI: In this connection, I would like to mention that the study of the genetics or the cytology of any species (36-39) has proved to be a very important instrument in identifying various mechanisms in relation to the ecology or the behavioural patterns of any species of a particular group and this has been established in various other insect groups. When we are embarking on a very important subject like the study of variation, either in regard to emergence, abundance or other factors, it would be perhaps opportune also for someone who is working along the line of cytotaxonomy to be in touch with those people who are studying the biology of dragonflies so as to obtain material simultaneously and thus correlate his findings, because cytological studies or the chromosomal or complementary pattern of the species will certainly be able to give some information relevant to the behaviour of that species in a particular geographical region. So it would be better to study certain other aspects concurrently with ecological and biological ones.

CORBET: Thank you for those observations. You have reminded us that we were talking about priorities for research and, as our time is so limited, I shall now invite further suggestions regarding priorities for research in the Indian subcontinent. We should not of course forget the pressing problems of taxonomy (40,41) in our discussion, which has so far been ecologically orientated.

JOHNSON: Ignoring for a moment the pressing problems of taxonomy, I would like to make one suggestion arising from what I have heard. I am very impressed with the potential in India for documenting the possible role of odonates in controlling mosquitoes. I think that all of us, as odonatologists, when trying to defend the right of dragonflies to live on earth, always come back to saying: "Well, they eat mosquitoes!" But most of us have never produced documentary evidence that this is an important phenomenon. I have heard several references during this conference to a newspaper article from Maine (42) which states that in the U.S.A. larvae of odonates are sold to control mosquitoes (43). But this seems a trivial example. There is apparently no evidence available about their effectiveness as control agents. It has not been documented at all. I myself have been involved in trying to show the effect of larval odonates on prey populations. Mosquitoes don't live in the lake where I do my research but I think that many of the techniques that I and my colleagues have been using to document and test the effects of odonates on depletion of prey populations would be easy to adapt to the shallow water, quiet rice field, shallow ditch kind of habitats that I have seen here. I think there is much potential for applying some experimental methods that might actually show that odonates do affect mosquito populations and, if they do, we could all make a claim for the effectiveness of odonates with confidence, rather than relying on a

newspaper article from several years ago*.

CHOWDHURY: At this point I could inform you that I conducted an experiment on adult *P. flavescens* and its food on the basis of stomach-content analysis. The report was due to be published in *Annals of Entomology* in December last but I have not yet received copies. My records of *P. flavescens* collected from the field covering three rice-growing seasons in Chittagong, Bangladesh show that the gut contents of adults vary slightly depending mainly on the population of prey insects in the paddy fields. One thing is certain: in all three seasons most food consisted of: first, rice leaf-hoppers which I identified as belonging to the family Jassidae, on the basis of characters of the hind tarsi; second, rice borer moths, which we recognised on the basis of the bipectinate antennae and the scales; and third, many male mosquitoes quite clearly identifiable by the plumose antennae and occasional wings. That is all, thank you.

CORBET: That is heartening information.

Pantala flavescens: needed information

KUMAR: I know that we are short of time but there are still one or two questions which I should like to ask the other seminar participants. This again relates to temporary-pond species in India. Immediately we come back to *P. flavescens*.

Now we know more or less the pattern of the southwest monsoon and its correlation with populations of *P. flavescens*. We find that a large number of adult *P. flavescens* appear around the monsoon ponds with the onset of the monsoon, that is in mid or late June, or July. They are there in thousands at that time and lay eggs. We have recorded that the larval development is completed in about 50 days (11). We do not have detailed records of emergence but we presume that they emerge without delay and we find that the *P. flavescens* adults are present during September, October, November and so on, again in very large numbers. I have not been able to understand one thing. Where do those adults which appear at these habitats, or these ponds, during June and July go after that? Do they remain at the same ponds, and if so for how long? And then there are the adults we observe increasing abruptly in numbers in September and October. Do these constitute the new batch of adults that have emerged from the larvae that developed in June, July and August? Or are some of the adults at ponds in September individuals which have remained there from the first batch of arrivals in June?

There is another question. In addition to the temporary ponds, perennial ponds are present in the area. Why do *P. flavescens* not lay eggs again in perennial ponds? Why, when water is available, do these adults not make use of these perennial ponds and lay a second batch of eggs, as we have seen to be the case for other species? I have reported that there are certain other temporary-pond species, such as *Orthetrum sabina sabina*, which have become adapted in such a way as to make use of these temporary ponds by completing one larval generation there and staying on the wing there for some time. Then in October or thereabouts they lay a second batch of eggs in the perennial ponds (5).

* There are a few reports of dragonfly larvae effectively suppressing aquatic stages of mosquitoes in the field (e.g. 44,45) (ed.).

I shall be very happy if it is found possible for us to carry out studies along the proposed lines.

CORBET: Thank you Dr Kumar. Our time is now up and we have only discussed a very few topics; and we have only scratched the surface of these! What we have not done is to have an open discussion on priorities for research on Odonata of the Indian subcontinent. However I suggest that part of the same operation that we have agreed to undertake could usefully include a request for suggestions from members of the Society for topics which might be included in such a research programme.

Thank you all for your participation. I declare this seminar closed.

APPENDIX I

BIBLIOGRAPHY

Listed here are publications which, in the editor's opinion, document or amplify certain facts or ideas mentioned in discussion and which in some cases can provide points of departure for the reader who wishes to pursue a topic further.

Numbers refer to numbers in parentheses in the text. References to Odonatological Abstracts are included for some citations thus:
'(OA 1234.).'

1. CORBET, P.S. (ed.), 1984. *Soc. int. odonatol. rapid Comm. (Suppl.)* 2: 1-46.
2. CORBET, P.S. (ed.), 1986. *Soc. int. odonatol. rapid Comm. (Suppl.)* 6: 1-32.
3. TYAGI, B.K., 1988. *An introduction to the activities of the S.I.O. National Office in India.* Int. Odonatol. Soc., Pondicherry. (OA 6180.)
4. KUMAR, A., 1972. *Odonatologica* 1: 199-207.
5. KUMAR, A., 1976. *Bull. Ent.* 17: 37-47. (OA 3535.)
6. KUMAR, A. & M. PRASAD, 1977. *Newsl. Zool. Surv. India* 3: 270-273. (OA 2178.)
7. KUMAR, A. & M. PRASAD, 1981. *Rec. Zool. Surv. India, Miscell. Publ., Occas. Publ.* 20: 1-118. (OA 3223.)
8. TYAGI, B.K., A. TYAGI & S.K. SANGAL, 1986. *Occas. Publ. S.I.O. Nat. Office, India* 2: 1-14. (OA 5683.)
9. KUMAR, A., 1972. *Treubia* 28: 3-20.
10. KUMAR, A., 1979. *Sci. & Culture* 45: 126-127. (OA 2901.)
11. KUMAR, A., 1984. *Annals Ent., New Delhi* 2(1): 43-50. (OA 4773.)
12. CHOWDHURY, S.H. & M. AKHTERUZZAMAN, 1983. *Chittagong Univ. Stud. (Sci.)* 7(1): 39-48. (OA 4822.)
13. JACKSON, J.A., 1955. *More than mountains.* Harrap, London.
14. WOJTUSIAK, J., 1974. *Odonatologica* 3: 137-142.
15. BORISOV, S.N., 1985. *Mater. nauchno-teor. Konf. molodyh Uchenyh & Specialistov tadzhik. SSR, Dushanbe (Biol)*, pp. 87-88. (OA 5496.)

16. FRASER, F.C., 1936. *The fauna of British India. Odonata*. Vol. 3. Taylor & Francis, London.
17. SINGH, G. & S. SINGH, 1957. *Indian J. Ent.* 19: 67-68.
18. CORBET, P.S., 1962. *A biology of dragonflies*. Witherby, London.
19. MITRA, T.R., 1974. *Entomologist's Record* 86: 53-54.
20. PRASAD, M. & S.K. GHOSH, 1984. *Bull. zool. Surv. India* 6(1/3): 37-44. (OA 5199.)
21. LAHIRI, A.R., 1985. *Rec. Zool. Surv. India* 82(1/4): 61-67. (OA 5885.)
22. WALKER, E.M. & P.S. CORBET, 1975. *The Odonata of Canada and Alaska*. Vol. 3. University of Toronto Press.
23. BUTLER, T., J.E. PETERSON & P.S. CORBET, 1975. *Can. Ent.* 107: 1253-1254. (OA 1304.)
24. TROTTIER, R., 1967. *Can. Field-Nat.* 81: 231.
25. CORBET, P.S. & S. EDA, 1969. *Tombo* 12: 4-11.
26. TROTTIER, R., 1971. *Can. Ent.* 103: 1671-1683. (OA 128.)
27. BYERS, C.F., 1941. *Proc. Fla Acad. Sci.* 6: 14-25.
28. KUWADA, K., 1973. *Tombo* 15: 10-12. (OA 421.)
29. CORBET, P.S., 1984. *Odonatologica* 13: 81-88.
30. JOHNSON, D.M., R.E. BOHANAN, C.N. WATSON & T.H. MARTIN, 1984. *Adv. Odonatol.* 2: 57-70.
31. JOHNSON, D.M., 1987. *Bull. N. Amer. benthol. Soc.* 4(1): 71. (OA 5932.)
32. NORLING, U., 1984. *Adv. Odonatol.* 2: 127-156.
33. CORBET, P.S., 1958. *Proc. 10th Int. Congr. Ent., Montreal (1956)* 2: 755-757.
34. PRITCHARD, G., 1982. *Adv. Odonatol.* 1: 227-241.
35. MASAKI, S., 1980. *Ann. Rev. Ent.* 25: 1-25.
36. KIAUTA, B., 1968. *Genetica* 39: 64-74.
37. KIAUTA, B., 1968. *Genetica* 39: 430-446.
38. KIAUTA, B., 1975. *Cytotaxonomy of dragonflies, with special reference to the Nepalese fauna*. Nepal Research Center, Kathmandu. (OA 1003.)

39. TYAGI, B.K., 1986. *Indian Rev. Life Sci.* 6: 215-229.
40. KUMAR, A. & V. KHANNA, 1983. *Oriental Insects* 17: 127-157.
41. KAPOOR, V.C., 1985. *Perspectives in insect systematics*. Inter-India Publs, New Delhi. (OA 6087.)
42. MARSTERS, S., 1977. *York County Coast Star, Maine*, 11 May: 1, 16 (OA 1912.)
43. ANDERSON, P., 1983. *Plain Dealer, Cleveland, Ohio*, 30 June. (OA 4504.)
44. CORBET, P.S., 1986. *Waterlines, London* 4(3): 10-11.
45. URABE, K., T. IKEMOTO, S. TAKEI & C.AIDA, 1986. *Jap. J. appl. Ent. Zool.* 30(2): 129-135. (OA 5591.)
46. LARSEN, T.B., 1987. *Notul. odonatol.* 2: 154.

APPENDIX II

ADDRESSES OF CONTRIBUTORS

- Chowdhury, S.H., Department of Zoology, University of Chittagong, Chittagong, Bangladesh.
- Corbet, P.S., The Old Manse, 45 Lanark Road, Edinburgh EH14 1TL, U.K.
- Johnson, D.M., Department of Biological Sciences, East Tennessee State University, Johnson City, Tennessee 37614-0002, U.S.A.
- Kiauta, B., P.O. Box 256, 3720 AG Bilthoven, The Netherlands.
- Kumar, A., Zoological Survey of India, Northern Regional Station, 13 Subhas Road, Dehra Dun 248001, India.
- Lahiri, A.R., Department of Zoology, College of Horticulture, Kerala Agricultural University, Vallaikkara, Trichur 680 054, India.
- Miller, P.L., Department of Zoology, South Parks Road, University of Oxford, Oxford OX1 3PS, U.K.
- Mitra, T.R., Zoological Survey of India, M-Block, New Alipur, Calcutta 700 053, India.
- Pritchard, G., Department of Biological Sciences, University of Calgary, 2500 University Drive N.W., Calgary, Alberta T2N 1N4, Canada.
- Srivastava, B.K., Department of Zoology, Dr H.S. Gour University, Sagar, India.
- Suribabu, B., Forensic Science Laboratory Mobile Unit, Murty Lane, Quarter No. 13, Jagdalpur 494 001, India.
- Tembhare, D.B., Department of Zoology, Nagpur University, Nagpur 440 010, India.
- Tyagi, B.K., Vector Control Research Centre (I.C.M.R.), Pondicherry 605 006, India.

INDEX TO CONTRIBUTORS

Names listed are those of persons (excluding the chairman) who contributed to the discussion.

Chowdhury, S.H., 5, 14

Johnson, D.M., 11, 13

Kiauta, B., 5

Kumar, A., 2, 3, 6, 7, 14

Lahiri, A.R., 7, 8

Miller, P.L., 10

Mitra, T.R., 7

Pritchard, G., 12

Srivastava, B.K., 8

Suribabu, B., 4

Tembhare, D.B., 6

Tyagi, B.K., 4, 8, 11-13

INDEX TO CITED AUTHORS

Names listed are those of persons cited by name during the discussion or those of authors of publications listed in Appendix I.

| | |
|-----------------------------|--------------------------|
| Aida, 14 | Norling, 11, 12 |
| Akhteruzzaman, 5 | Peterson, 9 |
| Anderson, 43 | Prasad, 2, 3, 7 |
| | Pritchard, 12 |
| Bohanan, 11 | Sangal, 2 |
| Borisov, 6 | Singh, G., 6 |
| Butler, 9 | Singh, S., 6 |
| Byers, 9 | |
| Chowdhury, 5, 11 | Takei, 14 |
| Corbet, 1, 7, 9, 10, 12, 14 | Trottier, 9 |
| | Tyagi, A., 2 |
| Eda, 9 | Tyagi, B.K., 1, 2, 4, 13 |
| Fraser, 6 | |
| Ghosh, 7 | Urabe, 14 |
| | Walker, 9 |
| Ikemoto, 14 | Watson, 11 |
| | Wojtusiak, 6 |
| Jackson, 6 | |
| Johnson, 11, 12 | |
| Kapoor, 13 | |
| Khanna, 13 | |
| Kiauta, 13 | |
| Kumar, 2, 3, 4, 11, 13, 14 | |
| Kuwada, 10 | |
| Lahiri, 7, 8 | |
| Marsters, 13 | |
| Martin, 11 | |
| Masaki, 12 | |
| Mitra, 7 | |

INDEX TO ODONATA

Species are listed under the generic name only.

- Acisoma panorpoides*, 2
Aeshna juncea mongolica, 6
Anax,
 guttatus, 9
 junius, 9
Anisopleura, 2

Bayadera, 2
Brachythemis contaminata, 2
Bradinopyga geminata, 3

Ceriagrion coromandelianum, 4
Crocothemis servilia, 3

Diplacodes, 6
 trivialis, 2, 3

Erythemis simplicicollis, 9

Hemianax, 10

Lathrecista asiatica, 8
Lestes praemorsa, 2
Libellago, 2

Neurobasis, 2
Neurothemis tullia, 3

Orthetrum,
 sabina, 3, 5, 6
 sabina sabina, 14

Palpopleura sexmaculata sexmaculata, 5
Pantala,
 flavescens, 2-11, 13, 14
 hymenea, 9
Pseudagrion decorum, 4

Rhodothemis rufa, 5

Tramea, 9, 10
 virginia, 3