

**TERRITORIAL BEHAVIOUR IN *PLATYCNEMIS ECHIGOANA*  
ASAHINA AT SUNFLECKS IN CLIMAX DECIDUOUS FORESTS  
(ZYGOPTERA: PLATYCNEMIDIDAE)\***

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Diurnal change in territorial behaviour at a sunlit point in a stand (sunfleck) was studied by observation in climax forests of Urabandai, Fukushima Pref., Japan. The number of patrolling flights of a male occupying a sunfleck increased towards noon and decreased afterwards. The flight height above the perching site was around 50 cm, including a round-trip flight along the periphery of the sunfleck. Hovering above the perching point was also observed. During a patrolling flight males did not encounter conspecific males, females or other insects, so that such a flight may be understood as a display of the occupation of the sunfleck. Encounters with conspecific males mainly occurred when the male was perched at the sunfleck. The number of fight encounters was high until noon, while non-aggressive encounters increased in the evening. High success rate in capturing prey occurred in the evening. Males moved out from among sunflecks in the morning, but stayed at one sunfleck in the evening. The habitat of *P. echigoana* in relation to its territorial behaviour is also discussed.

## INTRODUCTION

While many damselflies are non-territorial (e.g. LUTZ, 1968; AOYANAGI, 1973; HIGASHI, 1981; ROBERTSON, 1982, 1985; FINCKE, 1982, 1985; BANKS & THOMPSON, 1985), some species show territorial behaviour near water (e.g. JOHNSON, 1962; UEDA, 1976; NARAOKA, 1980; UTZERI et al., 1983). CORBET et al. (1960) identified two species of Anisoptera which are

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exceptional in that they defended territories away from water. However, no observations on territoriality of damselfly species away from water have been made, except for *Platycnemis echigoana*. Most of the mature males spend much time in the climax deciduous forests near the pond, and perch in sunlit points in the forests, defined as sunflecks (e.g. EVANS, 1956; TAMAI, 1976). They defend such sunflecks from conspecific males but do not show any territorial behaviour at the waterside (OHSAWA & WATANABE, 1984; WATANABE & OHSAWA, 1984).

The present study is based on 1101 min and 1616 min of observation carried out in early August of 1983 and 1984, respectively, by ten observers. Special attention was given to the diurnal change in territorial behaviour of the white-legged damselfly, and to ecological significance for the territoriality in the forests.

### MATERIAL AND METHODS

We have already described our study area, Urabandai, Fukushima Prefecture, in the cool-temperate zone of Japan (OHSAWA & WATANABE, 1984, 1985). Among eight study plots of the forest near water, one main plot (O-numa) and two subsidiary ones (G-ike and K-ike) were chosen for observation of territorial males in this study. The former was a climax deciduous forest of *Quercus crispula*, and the latter two were secondary forests.

Before beginning the observations, we intensively patrolled in the study plots for two days to mark males. Imagines were captured in a net, and marked individually on their hind wings with a felt pen. It was easy to read such marks individually with a little practice during the investigation. The degree of worn wing condition and the colour of the abdomen were recorded in order to obtain information on aging. The individuals wounded by marking, if any, were not considered; they are treated as dead in this study.

Imagines were continuously followed, from the time of arrival on the forest floor in the morning to the time of roosting in the forest crown in the evening, monitoring the time they spent on various activities. Observations were made from 9:00 to 18:00 for one and two days in early August, 1983 and 1984, respectively. The identities of single males perching, flying, fighting with conspecific males, preying upon small insects, etc., in the sunflecks were recorded by direct observation. The behavioural patterns have been outlined in detail by OHSAWA & WATANABE (1984). The duration, the distance and the height of each flight were also recorded. Time spent flying was subdivided into two types of behaviour: moving flight and dashing flight. The former included the cruising flight within a sunfleck and between sunflecks. The flight velocity of the latter was faster than that of the former. The dashing flight was caused by interference with other insects coming into a sunfleck. Data from males observed continuously during less than 10 min were not analyzed.

On the day following the recording, the study plots were again inspected and the damselflies recaptured. Then, the population size in each study plot was estimated by Jolly's method (JOLLY, 1965).

### RESULTS

Judging from the little worn wing condition and from the colour of abdomen (blue), all the males studied were mature. In 1983, 9 of the 168 marked and 21 unmarked males were followed, though the data were treated as supplementary, except for the analysis of flights and encounters resulting in fights. Because the

weather was cloudy with drizzle, the males were inactive in the forest, where no well defined sunflecks existed.

In 1984, out of 153 marked males, 21 were followed continuously during more than 10 min. Nine unmarked males were also observed. The weather was sunny, and many sunflecks occurred. The daily male population density and the daily proportion of recapture were estimated by three recaptures: 819 (SD = 520) and 6.41%, respectively.

The size of most sunflecks was ca 30 x 30 cm (cf. OHSAWA & WATANABE, 1984; WATANABE & OHSAWA, 1984). As a rule, a single male occupied one sunfleck. The duration of occupation was highly variable, ranging from 1 min to 185 min, mean  $24.7 \pm 4.2$  min ( $n = 64$ ,  $\pm$  SE). Table I shows details of sunfleck occupation per hour from 09:00 to 18:00 h. A male occupied about two or three sunflecks in an hour successively in the morning but one in the afternoon (mean 1.42, 13:00-17:00), which was significantly different ( $0.05 > P > 0.01$ , U-test). The duration of occupation at each sunfleck increased toward the evening except at 17:00-18:00, when most males returned to the roosting sites in the tree crowns. This means that moving activity between sunflecks was higher in the morning than in the afternoon. In 2 out of 53 moving flights between sunflecks, the males encountered either a conspecific male, or an other damselfly at the next sunfleck occupied:

Table I  
Sunfleck occupation (09:00-18:00 h) by *Platycnemis echigoana* males

|  | 09:00-10:00    | 10:00-11:00    | 11:00-12:00    | 12:00-13:00    | 13:00-14:00    | 14:00-15:00    | 15:00-16:00    | 16:00-17:00    | 17:00-18:00   |
|--|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---------------|
| Number of males tracked                    | 6              | 6              | 5              | 6              | 6              | 6              | 4              | 5              | 7             |
| Number of sunflecks occupied               | 12             | 11             | 8              | 18             | 9              | 9              | 5              | 5              | 9             |
| Mean number of sunflecks occupied per male | $2.2 \pm 0.3$  | $1.8 \pm 0.5$  | $1.5 \pm 0.3$  | $3.5 \pm 1.0$  | $1.7 \pm 0.5$  | $1.4 \pm 0.2$  | $1.3 \pm 0.3$  | $1.3 \pm 0.3$  | $1.8 \pm 0.6$ |
| Duration of occupation (min)               | $13.8 \pm 3.3$ | $12.4 \pm 4.6$ | $24.5 \pm 7.9$ | $10.4 \pm 2.4$ | $18.3 \pm 5.8$ | $23.4 \pm 7.2$ | $38.8 \pm 9.1$ | $47.4 \pm 7.1$ | $9.8 \pm 2.5$ |

Males at a sunfleck showed some behaviours that one could differentiate as movement, predation, attack on intruders, disregard, and so on. Moving flight, which occurred in the absence of intruders and other insects, was the most frequent behaviour. As shown in Figure 1, males flew only 1 or 2 s at a time (max. 5 s). Flight duration was significantly lower near noon and higher in the morning and evening (F-test:  $P < 0.01$ ). The height of flight above the perching site decreased from 40 cm to 8 cm in the afternoon and then increased in the evening (t-test:  $0.01 > P > 0.005$ ).

Most of the moving flights were restricted to within a sunfleck. Around noon, males usually returned to their original perching point after a flight. Males sometimes hovered just above the perching point during that period, so flight distance was zero. Therefore, the flight distance of 50 cm around noon (Fig. 1) was largely due to the movements along the periphery of a single sunfleck. Such round-trip flights within a sunfleck were consecutively observed till the evening.

Since the male returned to the tree crown for roosting in the evening, the flight durations, heights and distances for taking off to the tree crown increased.

The frequency of the moving flights per 10 min gradually increased toward noon (from 3.0 to 4.5) and decreased toward the evening, though such a tendency was somewhat obscure in 1984 (Fig. 2). Since the flight duration was very short (1 or 2 s), total duration of moving flights must be about 10 s in 10 min. Dashing flight duration was also very short. The frequency was lower than that of the moving flight. Consequently, damselflies spent much time perching at the sunfleck.

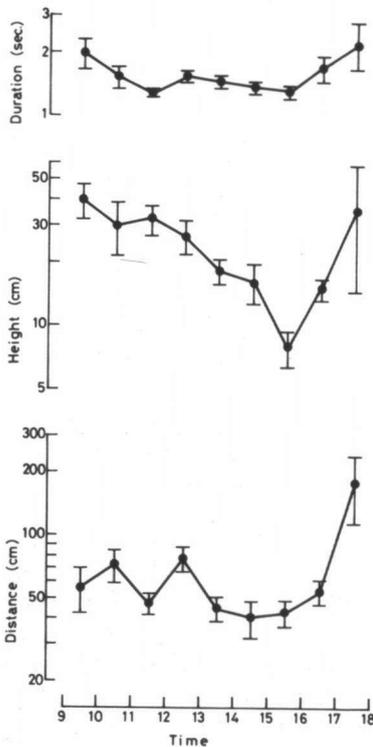


Fig. 1. Temporal change in the duration, height and distance of patrolling flight by resident males perched at sunflecks ( $\pm$  SE).

During the flights within a single sunfleck, the resident males did not encounter conspecific males. Most encounters with conspecific males (or females or other insects) occurred when the male was perching at the sunfleck. When another non-territorial male came into the sunfleck, the resident rapidly dashed to the intruder and usually chased him away. Only two of the 92 encounters resulted in loss by the resident males. Encounters were frequent until noon and decreased toward the evening. The number of encounters in which both males disregarded each other increased in the evening (Fig. 2). Such high territorial activity in the morning is related to the mating behaviour (copulation, tandem flight and oviposition) around noon (WATANABE & OHSAWA, 1984). However, we did not observe copulations but tandem flights around noon during the study period. Only one copulation, which took place on the shrub layer of the forest near a sunfleck, was recorded in the afternoon (15:03-15:05), and then a tandem was formed and disappeared towards the water.

Six tandem flights at the sunflecks were observed during 10:00-16:00. Three of these occurred inside the forest. However,

durations of such tandem flights could not be measured continuously (less than 10 min), because the couples were too alert on approach, and they flew fast. Three other tandem flights were observed from the sunflecks to water. They flew by the

pond and were searching for a place to deposit the eggs. Accompanied by the male which remained in tandem, a female inserted the eggs into floating stems. The oviposition duration was 9.25 min ( $n = 4$ , min. 6 and max. 16 min). Thereafter, they flew fast toward the forest where we lost sight of them.

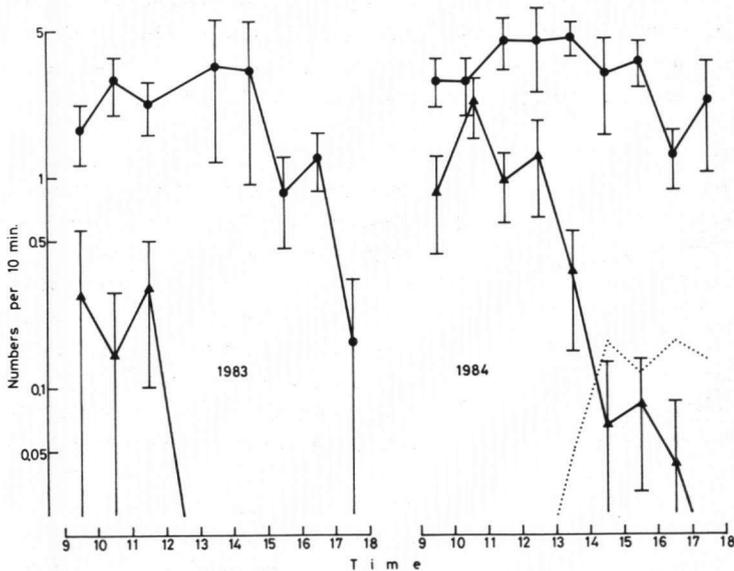


Fig. 2. Temporal change in the number of patrolling flights (circle), encounters resulting in fights (triangle), and non-aggressive encounters (broken line) for males which perched at sunflecks ( $\pm$  SE). In 1983, the number of non-aggressive encounters was not counted.

Although we could not ascertain whether the resident male dashed to defend the sunfleck, or to prey upon the insects which came into the sunfleck, the male did attack the insects smaller than he. Small moths (Lepidoptera), Diptera and Hymenoptera were attacked at the sunflecks. High attack activity was apparent between 11:00-12:00 and in the evening (Fig. 3). The earlier period was roughly coincident with that of high territorial activities, but the success rate of prey capture was low. In the evening, the damselflies became more successful.

An average of 0.75 attacks per hour was observed against insects that were equal in size or larger than the damselfly (*Cercion calamorum*, *Lestes sponsa* [particularly in the morning], *Sympetrum frequens*, moths and spiders). They were not preyed upon but rather driven away from the sunfleck. The males also sometimes disturbed the searching ants near the perching point.

On the other hand, *Coenagrion terue* and ants occasionally attacked the perching *Platycnemis* male, and he abandoned his perching site or his sunfleck. The attacks occurred mostly in the morning when males began to perch. *Lestes*

always displaced *Platycnemis* in the afternoon.

Abdominal bobbing (BICK & BICK, 1963) was observed throughout the day, the peak occurred between 11:00-12:00. This behaviour was not identical to the "cleaning" of wings with the abdomen, described by CORBET et al. (1960). Like in *Ceriatrigon melanurum* (cf. AOYANAGI, 1973), in *P. echigoana* it is still unknown.

## DISCUSSION

Mature males of *P. echigoana* spent much time in the climax deciduous forests. Most of them perched at sunflecks, where, in the absence of intruders, they performed flights between 09:00 and 17:00 h. The flight distance was about 50 cm, accounting both for the round trip flights and for the alteration of the perching site location, which moves gradually with the movement of the sun. Such flights may also be regarded as patrolling flights, as suggested by UTZERI (1983). No encounters occurred during a moving flight. Perching males showed aggressive behaviour when they encountered other males coming into the sunfleck. Therefore, the patrol flight does not seem to have a direct defence function, but should be understood as a display of occupation of the sunfleck, much like the territorial song of birds. This being so, higher patrol flights will be more effective and, indeed, the flight height was highest during the periods of high aggressive activity (morning to noon), while it decreased thereafter.

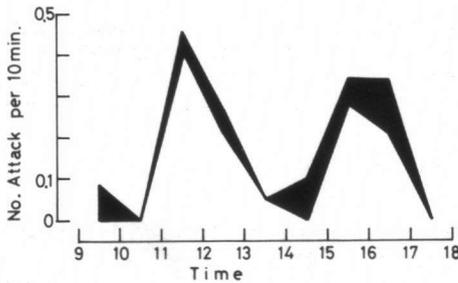


Fig. 3. Mean temporal change in the number of predation attacks by males, which perched at sunflecks. Shaded area indicates the successful predation attacks. Data were combined from all males observed.

A number of sunflecks were observed in the climax deciduous forest studied, though their abundance depends upon forest structure (cf. TAMAI, 1976). Not all sunflecks were always occupied by *Platycnemis* males. A perching male encountered another male once or twice in 10 min, though a few of them did meet females there. This shows an excess of

sunflecks compared with the number of males perching. Indeed, most of the sunflecks visited by the males were not occupied by other males. Furthermore, if a male flew to water in tandem after coupling, the sunfleck became available to others, and the original owner, returning to the sunfleck after tandem oviposition, might become an intruder. This occupation process may be similar to the territoriality of the speckled wood butterfly, *Pararge aegeria* (DAVIES, 1978).

The operational sex ratio in the forest of Urabandai shows that male density was greater than that of females (WATANABE & OHSAWA, 1984). OHSAWA & WATANABE (1984) pointed out that females visit the sunflecks for mating. Low probability for encounter with females at the sunfleck, however, might force males to move out of several sunflecks. Males moved from sunfleck to sunfleck around noon (3.5 sunflecks/h), when they were most aggressive. This behaviour may serve to defend the site for encountering with females. On the other hand, males were apt to stay at one sunfleck in the afternoon. Therefore, the behaviour of males at sunflecks is related to mating in the morning and feeding in the evening.

CORBET (1952) described a distinct gap in recapture of *Pyrrhosoma nymphula*, between emergence and the beginning of the flying season. General adult *Platycnemis* also require time for maturation, away from water, in the adjacent forests, but they do not return to water. Instead they stay in their forests and show territorial behaviour there. Thus, the sites for mating (forest floor), oviposition (by water) and those for roosting (tree crowns) are all indispensable in the habitat of *Platycnemis echigoana*.

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