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Flash communication in *Hotaria tsushimana*

(Coleoptera: Lampyridae)

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ツシマヒメボタルの発光交信

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対馬ヒメボタル *Hotaria tsushimana* は1970年に中根によって長崎県対馬から記載され，ヒメボタル *H. paruvula* に酷似する。前胸背が淡黄赤色で黒色大紋を欠くことでヒメボタルと区別できる。雌は不明であったが，本研究により形質が明らかとなり，ヒメボタルの雌と同様に後翅を欠いていた。ツシマヒメボタルの習性や行動についてはこれまで全く不明であった。筆者は1984年7月8-9日に長崎県厳原町の山腹を通る道路の周辺でツシマヒメボタルを観察するとともに雌雄間の発光交信を室内実験によって明らかにすることができた。本種の発光交信様式はヒメボタルのそれに一致し，きわめて近縁な種といえるが，両種は地理的に生殖隔離されている。ツシマヒメボタルの雄が発光すると雌は少し遅れて応答発光する。この雌の応答のタイミングが種の識別に役立っている。沖縄に分布する *Luciola kuroiwae* やヤエヤマボタル *Luciola yaeyamana* とツシマヒメボタルは基本的に同一な発光交信様式を有する。韓国や台湾にきわめて近縁な種が分布していることから，*Hotaria* 属ホタルの分布拡散，種分化を考察する上で本研究の知見は重要といえる。

Introduction

The mating behaviour of one *Hotaria* firefly has previously been studied OHBA, 1980). The female of *H. parvula* was found to respond to male flashes after a definite time delay. This flash communication system has been termed signal system II by Lloyd (1973) and Ohba calls this the Hp system (OHBA, 1983a). The same communication system was observed in *Luciola kuroiwae* in the Okinawa Isls. (OHBA, 1983a). However, there is a point of difference in the manner of male flashing (OHBA, 1983b). *Hotaria tsushimana* was described by Nakane from Tsushima Is., Nagasaki Pref., western Japan (NAKANE, 1970). Since the mating behaviour and flash pattern of this species have not been described, this study is useful for its comparative use for understanding of the evolution of *Hotaria* fireflies. In this paper, flash communication in *H. tsushimana* is described and discussed.

Material and methods

Observations were made on *Hotaria tsushimana* inhabiting Izuhara-cho,

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Tsushima Is., Nagasaki Pref., western Japan. *H. tsushimana* occurs in the mountains (alt. 300 m), and is found at the edges of forests and roadsides. The flash interval of flying males were measured with a stopwatch. Recording and analysis of flash interactions between males and females were made by the methods described previously study (OHBA, 1984). The temperature range during the observation was 18–24°C.

Results

Field observations Observations were made from 7 to 8 July 1984. Flashing and flying activity of males began approximately at 20:00. Males flew 1–2 m above the ground. Their flashes were very rhythmical. Flash period was approximately one second at 18°C. After the males began flying and flashing, females soon climbed up stems of grass (Fig. 2), and began emitting flashes. Calling signals of female flashes are approximately 2 seconds in period (Fig. 1) and 0.4 second in duration at 18°C.

Laboratory observations Males and females of *H. tsushimana* were placed individually in small plastic cases (2.8×4.0×1.5 cm) approximately 5 cm apart. At first males emitted irregular flashes. Females seldom responded to such male flashes. However, the flash interval of captive males gradually shortened and females then began to respond frequently. This occured when the interval between male flashes was approximately 0.8 second and duration of the flashes was about 0.4 second at 24°C. Female response flashes were flashed

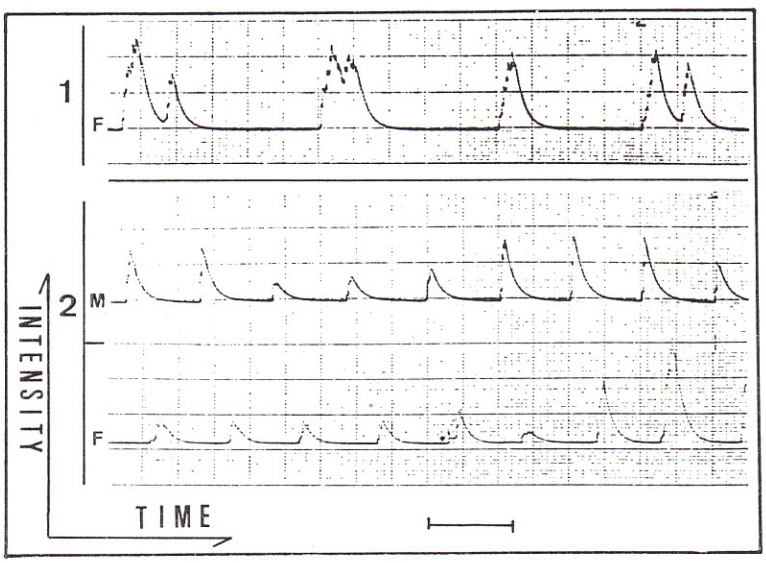

Fig. 1. Flash communication in *H. tsushimana*
1. Calling signal of a female. 2. Male-female flash interaction. M=male, F=female. The female responds to the male's flash after a brief delay. The scale 1 second.

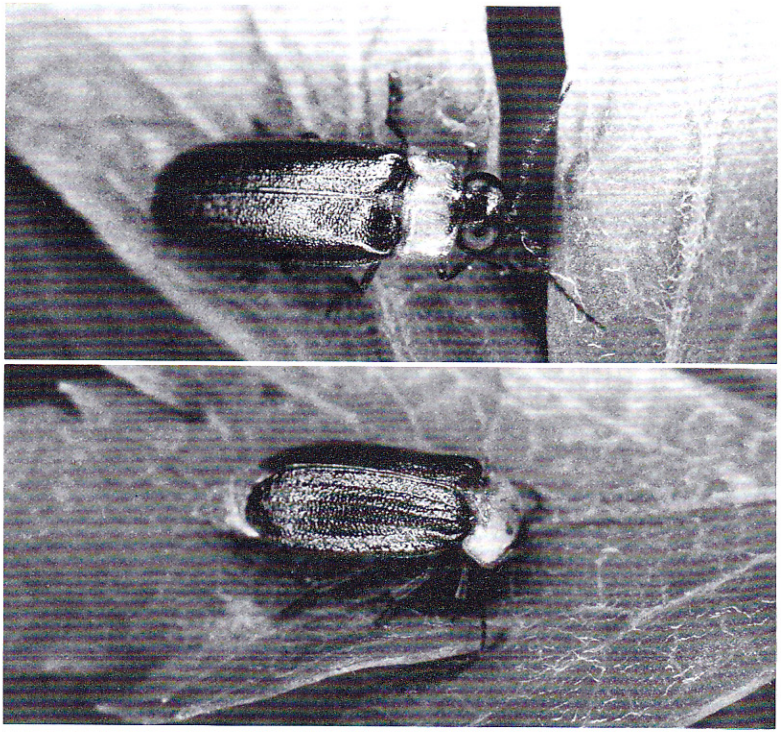

Fig. 2. Male (above) and female (below) *Hotaria tsushimana*.

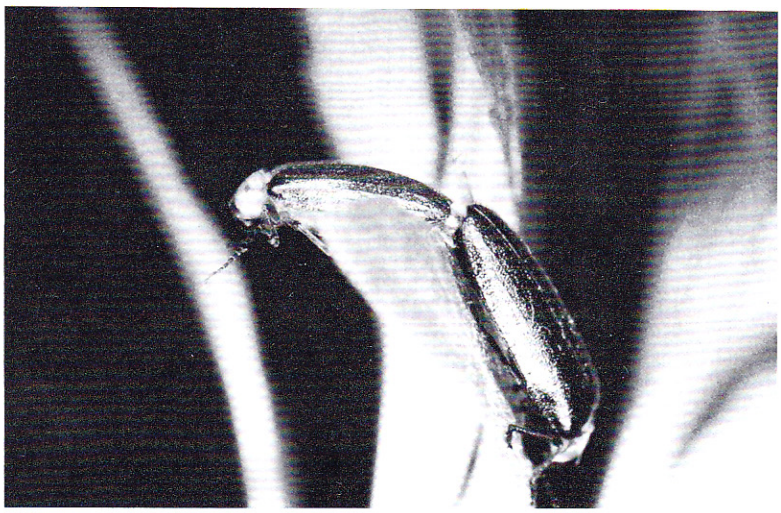

Fig. 3. Male and female *H. tsushimana* in copulation.

Table 1. Response delay time of female *H. tsushimana*

Mean(s)	Sd	Recorded value(s)					
0.32	0.02	0.36	0.32	0.31	0.32	0.36	0.34
		0.32	0.32	0.32	0.32	0.34	0.31
0.30	0.04	0.32	0.34	0.36	0.32	0.30	0.30
		0.20	0.32	0.32	0.30	0.32	0.30
0.34	0.03	0.32	0.30	0.40	0.36	0.32	0.34
		0.32	0.32	0.34	0.34	0.36	0.30

Sd=standard deviation.

after a short delay (Fig. 1). Females emitted flashes at average delay time of 0.32 seconds (n=12, sd=0.02) (Table 1) at 24°C. When males stopped flashing, female flashing stopped; when female flashing returned to normal, males walked toward them, flashing, and their flash period approached approximately 0.7 second, and flash duration, 0.2 second. When males and females were in the same plastic case, males mounted females upon reaching them, both stopped flashing and they immediately copulated (Fig. 3).

Discussion

H. tsushimana closely resembles *H. parvula* in mating behaviour and morphology (Fig. 1). The male flash pattern of *H. tsushimana* is the same as that of *H. parvula*. A marked difference between the two species in their pronotum. In *H. parvula*, the pronotum is pale reddish and shows a black spot near the apex of the front margin, while that of *H. tsushimana* is not spotted and its color is pale reddish yellow. *Luciola papaliensis*, which occurs in Korea, closely resembles *H. tsushimana*. *Luciola filiformis* and *L. cerata* of Taiwan, and *L. kuroiwae*, and *L. yayeyamana* of Okinawa Isls, also closely resemble *H. parvula* in morphology and behaviour. Perhaps, speculating from the above, these species originated in Southeast Asia. From geographical distribution of fireflies possessing the Hp system, it might be inferred that the ancestor of *H. parvula* spread through two passages. It is possible that *H. tsushimana* aquired the use of system II from its ancestor during the migration from each locality, pre *H. tsushimana* and *H. parvula* became geographically isolated from each other, and their communication system from the ancestor was retained and they evolved into two species. These species had no competitive species in their habitat, so that they could keep their communication system after they spread in Japan.

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