

COURTSHIP AND MATING BEHAVIOR OF *MEGASTIGMUS PINUS* PARFITT (HYMENOPTERA: TORYMIDAE)¹

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ABSTRACT

The courtship and mating behavior of *Megastigmus pinus* Parfitt was observed in insect cages and under a dissecting microscope in petri dishes. Courtship had 6 components: a premounting rocking performance by the male; mounting by the male to a dorsal riding position on the female; antennation and abdominal and wing movement by the male; a series of forward lurches by the male; signaling of receptivity by the female, and subsequent movement of the male to position for copulation. The average durations of mounting and copulation were 6.76 min and 23.5 sec, respectively. Short courtship and copulation times may reduce the risk of predation.

INTRODUCTION

There are 23 species of *Megastigmus* (Hymenoptera: Torymidae) in North America, all of which are phytophagous (Milliron 1949). About half of them, mostly western, feed as larvae in conifer seeds (Keen 1958). Several species are serious pests. The larvae consume the entire contents of seeds leaving no external evidence of damage (Hedlin et al. 1980). The fir seed chalcid, *Megastigmus pinus* Parfitt, destroys the seed of *Abies* spp. from British Columbia, south to New Mexico (Keen 1958; Furniss and Carolin 1977; Hedlin et al. 1980).

Little research has been done on the sexual behaviour of seed chalcids. Brief reports have described the courtship and mating behaviour of the Douglas-fir seed chalcid, *M. spermotrophus* Wachtl (Hussey 1955), *M. brevis* Girault (Noble 1938), and *M. nigrovariegatus* Ashmead (Milliron 1949). The objective of this study was to investigate in detail the courtship and mating behavior of *M. pinus*.

METHODS AND MATERIALS

Seeds of subalpine fir, *Abies lasiocarpa* (Hook.) Nutt., infested with *M. pinus* (9.3% infestation determined by radiography) were collected from Falkland, B.C., on September 1, 1981, and stored at approximately 0°C. Three lots were removed from refrigeration on August 16, 17 and 18, 1982, respectively, spread in emergence trays and kept outdoors. Adult emergence began August 26 and continued through September 19. Wasps were collected from emergence trays at 4 h intervals each

day from 0700 to 1900. They were segregated by sex and put in 50 x 35 x 35 cm cages placed well apart in an outdoor enclosure. Low ambient temperatures increased their average life span in accordance with Hussey's (1955) observations.

The insects were held at 20-23°C for at least 2 h prior to any observations. Complete observations of sexual behaviour in a 50 x 35 x 35 cm cage were made from September 3 to 5 between 0830 and 1330 in a windowed laboratory with constant fluorescent lighting. Observations were also made under a dissecting microscope of insects in a closed 60 x 20 mm disposable petri dish. Casual observations were made whenever sexual behaviour was noticed in the laboratory and in storage cages.

RESULTS AND DISCUSSION

Courtship is initiated when a male and female pass within about 1 cm of one another. Males become agitated and increase their antennal activity, then face the females, whereupon their antennae cease movement and straighten rigidly in front of their heads, parallel with one another. Parallel placement of the antennae also occurs during perception of host form and alignment by the braconid parasitoid, *Coeloides brunneri* Viereck, in which the elongate sensilla placoidea on the antennae apparently perceive infrared radiation from host larvae (Richerson and Borden 1972).

If females are stationary, or remain within 1 cm, males begin rocking their bodies side to side from a fixed position similar to the premounting movement of *M. spermotrophus* (Hussey 1955) and numerous other chalcids (Assem 1974). The average duration of rocking behavior was 13 sec (Table 1). Many diurnal insects use movement, color and form in finding their mates (Engelmann 1968). Rocking prior to mounting apparently enhances visual acuteness (Assem 1974), but may also enhance heat perception of body form (Richerson and Borden 1972).

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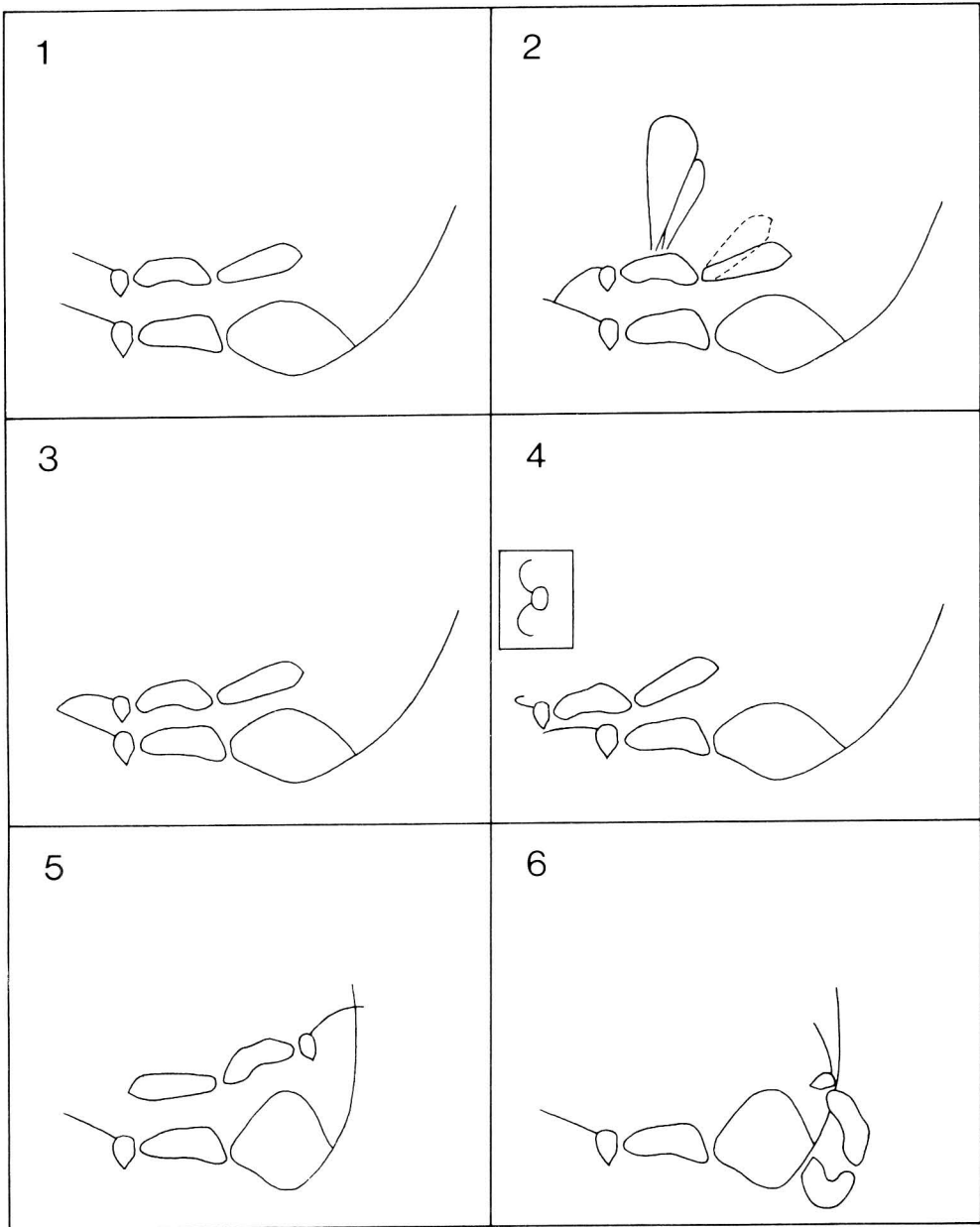


FIGURE CAPTIONS

Figs. 1-6. Schematic sequential representation of courtship and mating behaviour of *Megastigmus pinus*. Fig. 1, dorsal riding position assumed by male after rocking performance. Fig. 2, antennation and abdominal and wing movement by male. Fig. 3, beginning of "lurching" cycle by male in lower riding position with antennae extended to tip of female's antennae. Fig. 4, male at most forward position in lurching cycle, with antennae curled backwards (insert). Fig. 5, receptive female with exposed genitalia detected by male. Fig. 6, position of male and female *in copulo*.

After rocking, the male quickly mounts the female's back either from the side or rear. If the female walks off during rocking the male may follow her for several centimetres and resume his performance if he gets within 1 cm of her again.

Once mounted, males assume a dorsal riding position (Fig. 1), front tarsi resting on the female's head, the middle pair on the metathorax and hind tarsi grasping the anterior edges of the female's folded wings. This courting position is also used by *M. spermotrophus* (Hussey 1955) and other chalcids, such as the Pteromalinae (Assem and Povel 1973).

Almost immediately after mounting, the male begins tapping and stroking the female's antennae with his own, and his abdomen starts vibrating (Fig. 2). Occasionally he may fan his wings with his abdomen raised. Wing fanning was also observed in *M. nigrovariegatus* but only in conjunction with a

forward surge by the male (Milliron 1949). In *M. pinus* these 2 activities are distinct.

About 29 sec after mounting, the male assumes a lower, slightly forward position, touching the tips of the female's antennae with his own (Table 1, Fig. 3). The male then makes a smooth, forward and slightly downward lurch until his head is just past the distal ends of the female's antennae (Fig. 4). His head moves forward between and just above the female's antennae, which are lowered at the same time the male lurches. From here, he immediately returns to the normal courting position, thus completing one lurching cycle. This cycle is repeated about 15 times in sequence over approximately 26 sec; there are approximately 5 lurching sequences/courtship (Table 1). When the male moves forward, his antennae curl behind his head (Fig. 4), but do not contact the basal joints of the female's antennae as in *M. spermotrophus* (Hussey 1955).

TABLE I. Quantitative measures of each component of courtship and mating behaviour in *Megastigmus pinus*.

Activity*	Range	Mean \pm Standard Deviation
Duration of rocking performance (sec)	4 - 33	13 \pm 11.6
Time from mounting to first "lurching" sequence** (sec)	13 - 54	28.6 \pm 16.7
Number of "lurching" sequences/mating	3 - 9	5.4 \pm 2.19
Duration of "lurching" sequences (sec)	8 - 45	26.2 \pm 10.3
Number of "lurches" per sequence	6 - 23	14.6 \pm 4.80
Frequency of "lurching" (lurches/sequence)	1.27 - 4.5	1.78 \pm 0.73
Time <u>in copulo</u> (sec)	16 - 33	23.5 \pm 7.14
Total time mounted (min)	3.25 - 9.25	6.76 \pm 2.33

* observations from 5 pairs of insects.

** one sequence consists of one continuous series of "lurching" movements.

Lurching behavior has been observed in *M. spermotrophus* (Hussey 1955), *M. nigrovariegatus* (Milliron 1949) and *M. breviculvus* (Noble 1938) as well as other chalcids (Assem and Povel 1973). However, each species has distinct differences in amplitude, speed and length of movements. Similar examples of variation in courtship movements occur in widely divergent taxa, and include variations in leg movements by displaying fiddler crabs (Crane 1957, 1966) and head and body movements in displaying lizards (Hunsaker 1962; Purdue and Carpenter 1972). Such differences in specific courtship pattern can provide ethological isolating mechanisms which prevent hybridization between closely related sympatric species (Solbrig and Solbrig 1979).

During lurching, *M. spermotrophus* males do not move as far forward as do *M. pinus* males, only bringing the head of the male in contact with the female's (Hussey 1955). Observations under a dissecting microscope revealed that the mandibles of *M. pinus* males do not actually touch the head or antennae of the female, as Milliron (1949) has observed in *M. nigrovariegatus*.

The lurching performance by *M. pinus* males apparently makes females receptive to mating. During the last lurching cycle performed by the male, the female raises her abdomen, thus exposing her genital aperture. This postural change is indicative of female receptivity in chalcids, and is usually coupled with characteristic antennal and head position changes which provide a secondary signal to the male (Assem 1974). Neither of these latter signals was observed in *M. pinus*.

When the *M. pinus* male detects the female's receptivity (Fig. 5) he quickly turns around and moves into position for copulation (Fig. 6). In contrast, male *M. spermotrophus* (Hussey 1955) and *M. nigrovariegatus* (Milliron 1949) move backwards into position for copulation. Copulation lasts about 24 sec (Table 1), a much shorter period than in some other insects such as the meloid beetle, *Lytta nuttalli* Say, which copulates for 8 to 10 h (Gerber 1973). *M. pinus* males sometimes remounted females directly from the *in copulo* position, and repeated their entire courtship behavior, terminating in copulation. One *M. pinus* pair was observed to copulate 4 times in succession. Similarly

repeated courtship also occurs in *M. nigrovariegatus*, but does not result in multiple copulations (Milliron 1949).

Short courtship and copulation periods may be selectively advantageous to *M. pinus*. In nature, *Megastigmus* spp. copulate on host foliage. The longer a pair remains *in copulo*, the greater the risk of exposure to enemies or to unmated males which may harass the copulating pair, thereby drawing the attention of predators (Richards 1927).

The activity of *M. pinus* males throughout courtship and mating was noticeably aggressive, whereas females appeared passive once mounted. Unmated males were apparently attracted to mating pairs and sometimes performed a rocking display. Interfering males sometimes mounted the back of an already mounted male, or displaced another male from a female. Interference of mating pairs by unmated males has been observed in other insect species including the striped ambrosia beetle, *Trypodendron lineatum* Olivier (Fockler and Borden 1972) and the alfalfa weevil, *Hypera postica* (Gyllenhal) (LeCato and Pienkowski 1970a).

Homosexual behavior of *M. pinus* males was noticed in the presence and absence of females. Males performed rocking displays before mounting other males. These mounted males were sometimes in turn mounted by other males. Males of other insect species which have been observed to display homosexual activity include *T. lineatum* (Fockler and Borden 1972), *H. postica* (LeCato and Pienkowski 1970a) and the grasshopper, *Aulocare elliotti* (Thomas) (Ferkovich *et al.* 1967).

The apparent high degree of sexual tension present in the insects studied may have represented maximum sexual activity brought about by crowded conditions and previous isolation of the sexes, as occurs in *H. postica* (LeCato and Pienkowski 1970b). However, the intricate, stereotyped courtship behavior with multiple mating by a single pair represents a highly evolved, species specific behavior well adapted to ensure reproductive success.

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