# Time-Shifted Mating Periods in Two Closely Related Corixid Species

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The water boatmen *Corixa dentipes* and *C. punctata* produce an acoustic mounting signal when beginning to copulate. Automated recording of this signal over the entire life cycle of the animals reveals that the main mating period of *C. punctata* occurs in autumn and that of *C. dentipes*, in the spring. In the case of *C. punctata*, mounting signals were routinely recorded even during the winter, at water temperatures below 4 °C.

## Introduction

The corixids, like all water bugs, mate underwater. The males of some species, having mounted the female, stroke the outer edges of the female's hemelytra with their middle femora [1]. This movement produces a characteristic noise, the mounting signal [2, 3], which in the species studied here – *Corixa dentipes* and *C. punctata* – is louder than the species-specific stridulatory sounds produced with the anterior femora [4]. The frequency spectrum of the mounting signals has a distinct peak between 1 and 2 kHz [5].

It was recently shown that the main phase of stridulatory activity of *C. punctata* occurs in autumn, while that of *C. dentipes* is in the spring [6]. A system for the automatic recording of the mounting signal over the entire lifespan of animals in both species has made it possible to determine whether the mating periods of the two species differ in seasonal and/or diurnal timing.

## Methods

The animals were caught in late summer in the vicinity of Regensburg; during the time in which their activity was recorded they were kept outdoors, in an atrium of the University of Regensburg. For each of the two species, males and females were kept together in wire cages with a water volume of 180 l, immersed in a larger tank of water. Further details of their living conditions and the recording methods have been published elsewhere [6].

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## Results

When *C. dentipes* or *C. punctata* pairs begin to copulate, a mounting signal can be heard, which differs distinctly in sound pattern from the other acoustic signals produced by the animals [4]. It consists of a series of identical pulse trains (Fig. 1 c). Because an individual pulse train coincides in time with a stroking movement of the male's middle femora over the outer edges of the female's hemelytra, it may be inferred that the acoustic event is produced by this movement. Like the North American *Palmacorixa* [3], animals of the species studied here bear a row of short bristles on the inside of the middle femur. In *C. punctata* and *C. dentipes* the sockets of these bristles are conspicuously thickened in the males (Fig. 1 a). The repetition rate of the leg movement in *C. dentipes* differs from that in *C. punctata*, so that the mounting signals of the two species can be distinguished acoustically (Fig. 1 b). Males occasionally engage in homosexual mounting; in this case no mounting signal is produced.

In a cage containing 15 male and 15 female *C. punctata* the first mounting signals were recorded in the middle of October. Mating activity reached a peak in November. It continued throughout the winter, with occasional pauses, even though the water in the tank was completely covered with ice for at least three months, and the water temperature at the floor of the cage became as low as +2 °C (Fig. 2). Recording was stopped at the end of March, because the mounting signal is rarely produced in April and an increased mortality rate reduced the number of animals. Simultaneous recordings of the mounting signal of *C. punctata* in a considerably larger concrete tank containing 25 $m^3$ of water revealed a similar seasonal rhythm, with only a slight phase shift. Here, again, the mating activity began in October, in the second half of October was about as high as in November, and in the middle of March ceased entirely.

The mating activity of *C. punctata* exhibits distinct diurnal fluctuations, which evidently depend

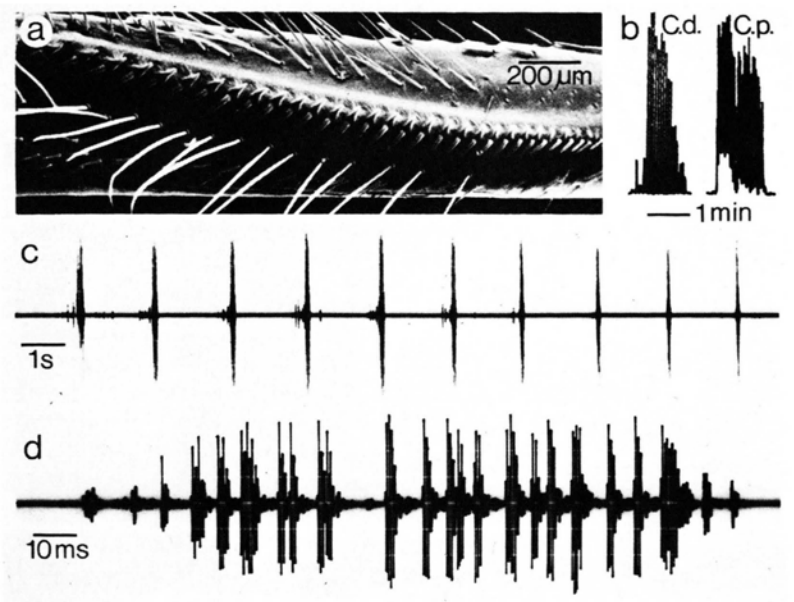


Fig. 1. a. SEM picture of the middle femur of a male *C. dentipes*, ventral aspect. b. Complete mounting signals of *C. dentipes* and *C. punctata* after electronic rectification and integration (integration time 0.3 s), as displayed by the recording apparatus. c. Oscillogram of a mounting signal of *C. dentipes* consisting of 10 pulse trains. d. Oscillogram of an individual pulse train.

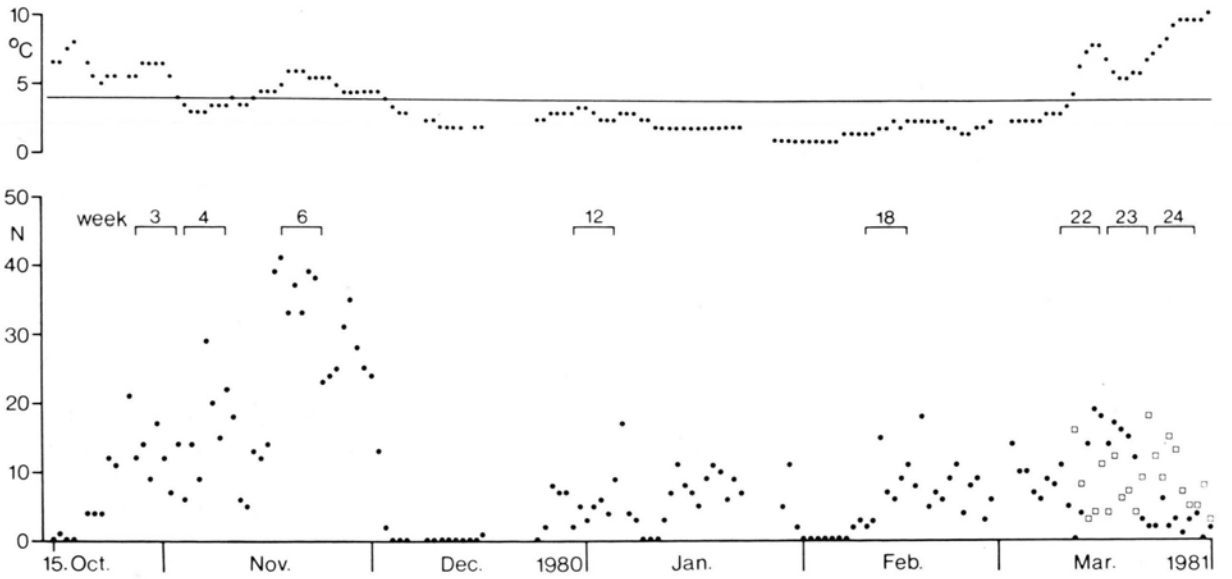


Fig. 2. Daily total numbers (N) of mounting signals recorded in a cage with *C. punctata* (●, ♂♂:♀♀ = 15:15) and one with *C. dentipes* (□, ♂♂:♀♀ = 10:10); the temperatures are the mean daily temperatures at the cage floor (measured to within ± 1 °C). The bars indicate the weeks selected for Fig. 3.

on the water temperature. With a mean water temperature of over 4 °C, the mounting signals are recorded chiefly at night, whereas when the temperature is below 4 °C they are more common during the day (Fig. 3a). As a control, from November 21, 1980, to January 15, 1981, some animals were kept in the open in a 60-l aquarium, the water in which was held at 4° – 5 °C by a thermostat. The mounting signal was produced three times as frequently between 1800 h and 0600 h as during the other half of the day.

In another cage, containing 10 male and 10 female *C. dentipes*, only three mounting signals were recorded during the autumn. In contrast to *C. punc-*

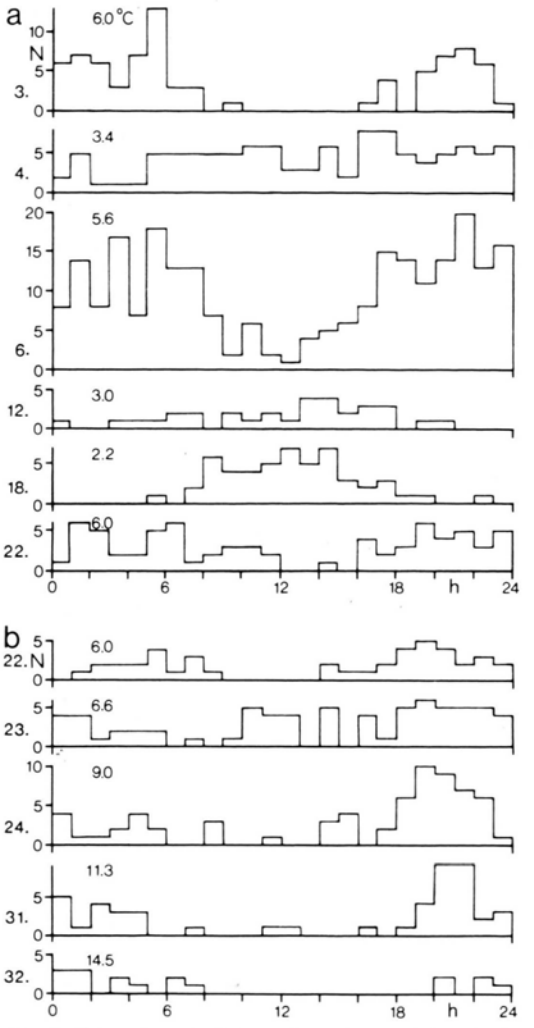


Fig. 3. Diurnal periodicity of mating activity during the *n*-th week (ordinal numbers at left) following October 15, 1981 (cf. Fig. 2). N: number of mounting signals recorded during each hour of the day, summed over the indicated week. For each week the mean temperature at the cage floor is given. a. Recordings in a cage with *C. punctata* (♂♂:♀♀ = 15:15). Note the phase shift at the transition between temperatures above and below 4 °C. b. Recordings in a cage with *C. dentipes* (♂♂:♀♀ = 10:10) from March 9 to 29 and May 5 to 19, 1981.

*tata*, *C. dentipes* does not enter its main reproductive period until the spring, when the water temperature exceeds 4 °C (Fig. 2); the mating season then lasts until about the end of May. Both species, however, prefer the hours of darkness for their mating activities during this period (Fig. 3b). Because from April until June the population died off gradually – first the males and later the females as well – and the animals tried to fly away on warm days, no attempt was made to obtain quantitative data on mating activity during these months.

In view of the possibility that the other sounds produced by the males are related to mating behavior, in some cases the typical stridulatory sounds produced by *C. dentipes* were recorded together with the mounting signals. In one cage with three males and 15 females, 90 mounting signals were recorded within three weeks. 20 of these signals were found to have occurred more than 5 min after the last preceding stridulation; therefore, as in the case of other corixid species [3, 7], mounting need not be immediately preceded by a particular courtship song. Comparison of the seasonal change in mating activity shown in Fig. 3b with the stridulatory activity of the same population [6] shows a similar time course only for Song B + C of *C. dentipes* males. It may be that this song is of special significance in pair formation.

## Discussion

From the recordings of stridulatory sounds [6] and mounting signals over the entire life cycle of *C. dentipes* and *C. punctata*, sympatric in Central Europe, one can conclude that the main mating seasons of the two species are fundamentally separated, although there is some overlap. During the periods of overlap – in the months October, November and March, April – the two species exhibit synchronous diurnal periodicity, with greater activity during the hours of darkness. Because of its later and shorter mating period, *C. dentipes* must search for a suitable sexual partner with greater urgency than *C. punctata*, which may explain the greater diversity and precision of the stridulatory sounds of *C. dentipes* [4].

During the weeks of maximal copulatory activity, on the average 1 – 2 mounting signals are recorded per pair of animals in the experimental cages per day; whether sperm is transferred at each mounting remains to be discovered. This rate of copulation is probably higher than under field conditions, because the population densities in the field are lower in general. However, the data indicate negligible difference in diurnal and seasonal periodicity between the animals in the cages and in a tank with a

water volume more than a hundred times as great. It appears likely, then, that the periodicity demonstrated in these experiments is also present in the local habitats, and is not an artefact of confinement of the animals to cages.

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