

Article

## Sex ratios, mating frequencies and relative abundance of sympatric millipedes in the genus *Chersastus* (Diplopoda: Pachybolidae)

Mark Ian Cooper

Department of Biological Sciences, University of Cape Town, Private Bag UCT, Rondebosch 7701, South Africa

E-mail: chersastus@gmail.com

Received 28 September 2014; Accepted 12 October 2014; Published online 1 December 2014



### Abstract

Three hypotheses exist for explaining climbing behavior in millipedes: 1) waterlogging, 2) detritus limiting, and 3) mate avoidance. Data of sex ratios, mating frequency and relative abundance are provided to suggest an alternative explanation for the pattern in sympatric forest millipedes. Sex ratio differences - from equality - were tested using a G-test comparing millipedes on and above ground. Mating frequencies were calculated based on the percentage of paired individuals. Relative abundance may correlate with male-biases in the sex ratios. All three factors suggest *Chersastus inscriptus* has a higher reproductive potential than *C. anulatus*. This is evidence for mating hotspots.

**Keywords** sex ratio; mating frequencies; millipedes; climbing behavior; *Chersastus inscriptus*; *Chersastus anulatus*.

Arthropods  
ISSN 2224-4255  
URL: <http://www.iaees.org/publications/journals/arthropods/online-version.asp>  
RSS: <http://www.iaees.org/publications/journals/arthropods/rss.xml>  
E-mail: [arthropods@iaees.org](mailto:arthropods@iaees.org)  
Editor-in-Chief: WenJun Zhang  
Publisher: International Academy of Ecology and Environmental Sciences

### 1 Introduction

Climbing behavior in millipedes is hypothesized due to water-logging, accessing additional food sources, and mate avoidance (Telford and Dangerfield, 1996). Data are given for relative abundance, mating frequency, and sex ratio of sympatric *Chersastus inscriptus* Attems, 1928 and *C. anulatus* Attems, 1934, morphologically identifiable by yellow flashes, red legs and red heads compared to discrete red-black annulations and no yellow flashes, with black legs and black heads (Lawrence, 1967). These species differ in copulation duration (Cooper and Telford, 2000), however are similar in sexual size dimorphism (SSD = 0.2) (Cooper, unpublished).

### 2 Materials and Methods

Millipedes were hand collected in coastal forest habitat at Mtunzini (28° 55' S; 31° 45' E) during the summer season (1995-1996). Individual millipedes were identified to species and sexed based on the presence of gonopods in males and their absence in females. Individuals were counted as either on or above ground (>30cm but <3m above ground surface). The number of mating pairs was recorded. The total number of adults

was used to estimate the relative abundance. Intercalary males were excluded from the counts. Sex ratio was calculated as ([number of males] / [males + females]) (Kvarnemo and Ahnejö, 1996). Copulation frequency was calculated as ([number of copulating pairs] / [males + females]) and converted into percentiles.

### 3 Results

Swarms of both species were pure (> 95% adults). The *C. inscriptus* sex ratio was male-biased on the ground ( $G = 10.48$ ,  $0.001 < P < 0.005$ ,  $DF = 1$ ) and above ground ( $G = 26.67$ ,  $P < 0.001$ ,  $DF = 1$ ); overall male-bias ( $G = 34.11$ ,  $P < 0.001$ ,  $DF = 1$ ) (Table 1, 2). The *C. anulatus* sex ratio was not biased ( $G = 10.48$ ,  $0.001 < P < 0.005$ ,  $DF = 1$ ). The mating frequency of *C. inscriptus* was 12% (31% on the ground and 69% above ground) compared to 3% for *C. anulatus* which was only found above ground. The relative seasonal abundance of *C. inscriptus*: *C. anulatus* differed by an order of magnitude (9.41: 1).

**Table 1.** Sex ratios measured above ground (SR T) and on the ground (SR G) in sympatric *Chersastus inscriptus* and *C. anulatus*. G-tests were performed against equal sex ratios: \*  $0.001 < P < 0.005$ , \*\*  $P < 0.001$ .

| Species              | SR G (n)    | SR T (n)     | SR (n)       |
|----------------------|-------------|--------------|--------------|
| <i>C. inscriptus</i> | 55 % (101)* | 62 % (445)** | 65 % (546)** |
| <i>C. anulatus</i>   | (0)         | 55 % (58)*   | 55 % (58)*   |

**Table 2.** Sex ratios (%) recorded early (SRI) and late (SR II) in the mating season in sympatric millipedes *Chersastus inscriptus* and *C. anulatus*. G-tests were performed against equal expectation (1: 1): \*  $0.05 < P < 0.025$ ; \*\*  $P < 0.001$ .

| Species              | SR II (n)         | G       | SRI (n)            | G       |
|----------------------|-------------------|---------|--------------------|---------|
| <i>C. inscriptus</i> | 60%<br>(480: 320) | 21.88** | 33 %<br>(45: 90) - | 27.42** |
| <i>C. anulatus</i>   | 2%<br>(47: 28)    | 4.07*   | 57 %<br>(26: 20)   | 14.98** |

### 4 Discussion

The spatiotemporal distribution of *C. inscriptus* / *C. anulatus* suggests mating hotspots (Rowe et al., 1994). Knowledge on the reproductive biology of millipedes is powerful for ecological rehabilitation programmes. The three factors recorded here (sex ratio, mating frequency, relative abundance) indicate that *C. inscriptus* has a greater potential reproductive rate than *C. anulatus*.

The mating hotspots suggested by the 3 factors imply more intensive male-male competition for mates and this may be the reason why millipedes become arboreal. This is not like the savanna millipedes as the soil in the forest was sandy and did not become waterlogged. Feeding on additional food sources such as lichen and bark (personal observation) implied detritus cannot be ruled out as a competing hypothesis. Complete mate avoidance is not possible as males were seen on terminal branches of trees.

Ideally, an experiment needs to experimentally manipulate the sex ratios in situ. Mate avoidance and mating hotspots are not mutually exclusive hypotheses and both need testing. Additional knowledge on millipede reproductive systems can be useful in forest regeneration plans.

**Acknowledgements**

The Wildlife and Environment Society of South Africa made their facilities available. This research was supported by the Author's family.

**References**

- Cooper M, Telford SR. 2000. Copulatory sequences and sexual struggles in millipedes. *Journal of Insect Behaviour*, 13: 217-230
- Kvarnemo C, Ahnesjö I. 1996. The dynamics of operational sex ratios and competition for mates. *Trends in Ecology and Evolution*, 11: 404-408
- Lawrence RF. 1967. The Spiroboloidea (Diplopoda) of the eastern half of southern Africa. *Annals of the Natal Museum*, 18: 607-646
- Rowe L, Arnqvist G, Sih A, Krupa JJ. 1994. Sexual conflict and the evolutionary ecology of mating patterns: water striders as a model system. *Trends in Ecology and Evolution*, 9: 289-293
- Telford SR, Dangerfield JM. 1996. Sexual selection in savanna millipedes: products, patterns and processes. In: *Acta Myriapodologia. – Mémoires du Muséum National d'Histoire Naturelle*, 169: 565-576