

Big wigs and small wigs: the roles of size, sex and shelter in spatial distribution patterns in the maritime earwig *Anisolabis maritima*

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Abstract

Animal aggregations can occur for a variety of abiotic factors, such as resource limitation, or biotic factors including sexual selection and predator-prey interactions. Although it is challenging to determine the underlying mechanism of such grouping behavior, we conducted experiments in which we examined the interactions and distribution patterns among pairs of the maritime earwig *Anisolabis maritima* (Order Dermaptera). This insect, found in aggregations under beach debris around the world, is sexually dimorphic regarding its most distinctive feature in that females have straight posterior forceps/pinchers whereas males have asymmetrical, curved forceps. We placed pairs of individuals varying in sex and size and monitored their distribution with and without shelter at 15 min, 12 h and 24 h to determine the roles that these factors may play in spatial patterns and gain insight into the mating system. Overall, we found that females were less likely to cohabitate than males, and they were more tolerant of males than other females. Males, on the other hand, were less aggressive and distributed themselves randomly, except when males were different-sized, in which case they preferred cohabitation. Shelters appeared to play a key role in reducing aggressive interactions, and our results have interesting implications regarding how inter- and intrasexual interactions influence distributional patterns in nature.

Introduction

Animals are often found in nonrandom clusters due to individuals choice to cohabitate (Taylor 1961). Aggregations can form from kin relations (Hamilton 1964), cooperative foraging (e.g. Wiley 1971), and protection in numbers (e.g. Landeau & Terborgh 1986). These aggregations can also be due to exploitation of common

resources and may not indicate gregariousness (Zimmer-Faust & Spainer 1987). All of these factors can contribute to cohabitation of multiple individuals, leading to difficulty in differentiating the driving force.

Groups can also form in correspondence with mate choice, where highly sought after females obtain groups of courters (e.g. Oring & Maxzon 1978), alpha males form harems of females (Kaseda & Khalil 1996), or males showcase their prowess to watching females in leks (Hoglund & Robertson 1990). Mate cohabitation is often mutualistic for all parties involved. Males benefit by attracting more mates from female copying (Gosselin et al. 2003) and thus cohabit with females of high quality to attract more prospective mates (Hill & Ryan 2006). Females in turn have access to high quality males. Sexual dimorphism, resulting from male-male competition (Haley 1994), female choice (Fitze et al. 2010) or a combination of both (Berglund et al. 1996), can often give a clue to sexual selection.

Earwigs display sexual dimorphism, where males have an armament of curved forceps and females are generally larger (Van Lieshout & Elgar 2009). Maritime earwigs, *Anisolabis maritima*, show directional asymmetry in male forceps, which are used to fight for access to food and mates (Munoz & Zink 2012). Females, on the other hand, have straight forceps used for nest defense and prey capture (Miller et al. 2011). Both sexes often use forceps in aggression with one another by quickly closing their forceps around the body of another individual. Female straight forceps act like scissors where males' curved forceps merely pinch. Fights often ensue due to the close living conditions maritime earwigs are found in.

Anisolabis maritima are found in a narrow niche, under driftwood with proper moisture along the high tide line (personal observation; Bennett 1904, Langston 1974). *A. maritima* is globally distributed in coastal habitats of the temperate and tropical regions (Scudder 1876). They were first described in Italy in 1832 although their origin is uncertain as they have a high likelihood of transport (Scudder 1876, Hincks 1952). *A. maritima* is often found in clusters among members of its own species as well as other beach insects. A much higher proportion of these individuals are females. It is still uncertain if the natural sex ratio favors females or if males can be found elsewhere. These aggregations were proposed to be present due to habitat limitations yet it can be hard deciphering between gregariousness and the pressure to share common resources (Miller et al. 2011).

In this study, we studied the behavior of *Anisolabis maritima* in relation to shelter presence, size pairing, and sexual pairing. We expect that 1) opposite sex individuals will choose to cohabitate, and 2) same sex individuals will not cohabitate, 3) size-matched individuals are less likely to cohabitate than different-sized individuals, and 4) more cohabitation will occur without shelters compared to with shelters.

Materials and Methods

Collection and Care of Study Organism

Earwigs were collected from under driftwood on San Juan Island in Washington between 19 June and 3 August 2013. Earwigs were kept on a 16:8 hour light:dark photoperiod, which was the natural summer cycle. Size matched individuals were refrigerated for 40 mins to slow movement to allow for application of colored bee tags (3mm in diameter) with Duro Quick Gel.

Arenas were created using transparent tupperware containers (15 x 21 x 10 cm) with 1.5 cm deep moist sand collected from False Bay, San Juan Island, Washington. Two uniform indentations, on either side of the container, were made in all of the arenas. Ditches were covered by a red tinted square (5 x 5 cm) to create shelters in some containers that allowed for visual monitoring without disturbance. A thread was taped to the top of all containers to divide the arena into two equal halves. Containers and red tinted covers were rinsed with warm water and dried after every trial and replaced with new sand.

Measurements and Data

Trials were between (1) size matched males, (2) different-sized males, (3) size matched females, (4) different-sized females, and (5) same-sized male and female. All trials were conducted with and without shelters. Recordings were taken between 9 and 12, morning and night, with use of a red light to maintain photoperiod cycles. Locations of each earwig were recorded and photographed after 15min, 12 and 24 hours with a Canon Power Shot SD1200IS. After each trial, individuals were frozen overnight in numbered Eppendorf tubes. Chi-squared goodness-of-fit tests were performed for each trial, and we also conducted Chi-squared tests of independence to determine the role of shelter, sex, and relative size on cohabitation. All data were analyzed using JMP 10.0.

Results

Male-Male Trials

The only instance of cohabitation was among different-sized males at 15 min when no shelter was present (n=24, $\chi^2=6.28$, DF=1, p=0.0122; Table 1). Although, they preferred not to cohabitate when shelter was present at 12 hours (n=28, $\chi^2=5.313$, DF=1,

p=0.02). Interactions were dependent on the presence ($\chi^2=5.609$, DF=1, p=0.02) and lack of shelter ($\chi^2=6.024$, DF=1, p=0.014), respectively. Size matched male match-ups had no preference whether or not to cohabitate, both with and without shelters, for all time periods.

Female-Female Trials

There was no preference among individuals at 15 min regardless of shelter presence (Table 1). Females preferred not to cohabitate at 12 hours due to the presence of shelter regardless of size category. All categories preferred not to cohabitate at 24 hours with the exception of different sized females without shelter (n=42, $\chi^2=0.86$, DF=1, p=0.35).

Male-Female Trials

Only size matched male-female pairs preferred not to cohabitate at 12 hours (n=50, $\chi^2=3.97$, DF=1, p=0.046) due to the presence of shelters ($\chi^2=5.555$, DF=1, p=0.0184). In all other cases, there was no preference for or against cohabitation (Table 1).

Sex and Size Comparisons

Females are more likely than males to not cohabitate when they are different sized ($\chi^2=4.6$, DF=1, p=0.0312) but are just as likely when they are size matched ($\chi^2=2.36$, DF=1, p=0.123). Females are also more likely to not cohabitate when with other females ($\chi^2=7.816$, DF=1, p=0.0052) than when placed with males ($\chi^2=0.029$, DF=1, p=0.8654).

Discussion

We found that cohabitation is rare among *Anisolabis maritima* with a tendency to favor not cohabitating (Table 1). Preference against cohabitation was shelter dependent at 12 hours but not at 24 hours. Shelters also played a significant factor in the only instance of cohabitating, in different sized males at 15 min.

Female preference to avoid same-sex individuals increased over time as the likelihood of encounters increased (Table 1). Female pairs with shelters, regardless of size category, set up dominance between the 15 min and 12 hr period, noted by the preference to not cohabitate. While without shelter, this was delayed until the 24 hour period. Non-shelter environments are unnatural for *A. Maritima* and may have caused excessive chaos and confusion, delaying the determination of dominance among pairs. Size matched females would be equally matched in combat while different-sized pairs may be more tolerant of significantly smaller individuals or benefit from having a larger conspecific in close proximity. Females are more aggressive towards one another due to the higher abundance compared to males (Bennett 1904) leading to a competition for nest space and mates. Female aggression has also been shown to increase egg survival during nesting (Miller et al. 2011) and thus may be due to the time of collection during the breeding season.

Males, on the other hand, partake in less aggressive displays that involve pinches instead of strikes (Munoz & Zink 2012). Direct combat is a way for males to assess one another and are not likely to inflict injury during these interactions (Munoz & Zink 2012). Size matched males had no preference for or against cohabitation as contests were equal. The instance of cohabitation among different sized males without shelter may be due to the larger male's tolerance of a competitor too small to waste energy on (Enquist & Leimar 1983). Since no shelter was present, the small male would choose to seek a larger male for protection from conspecifics and as a more appealing victim, if discovered by predators. Cohabitation may not continue if the larger male becomes agitated of the smaller male's presence. Conversely, different sized males with shelters

preferred not to cohabit at 12 hours but lost interest in maintaining segregation at 24 hours (Table 1).

Size matched male-female pairs with shelter behaved like different sized male-male pairs, indicating females are the ones changing their behavior (Table 1). Females acted significantly different in size matched female-female trials compared to intersexual trials ($\chi^2=7.816$, DF=1, $p=0.0052$) while males maintained a random distribution ($\chi^2=0.029$, DF=1, $p=0.865$). Females may show less aggression towards potential mates compared to other females that are just competition. Males, conversely, maintain better relations with other males than with aggressive females that often put up a fight before allowing copulation.

While only size matched male-female pairs were used for trials, more work on the differing interactions among different-sized male-female match ups needs to be analyzed to fully understand intersexual interactions in regards to size. Size matched male trials should also be further studied since interactions vary among small versus large pairs. Small males with asymmetric forceps have shown to have an advantage over more symmetric forceps in male dominance battles, while this does not stand true for large males (Munoz & Zink 2012). Video recordings of the first 15 minutes may also aid in determining the time dominance was settled. *Anisolabis maritima*'s mating system and natural distribution cannot be fully understood until further studies are made on their interactions, cohabitation preferences, and mate choice.

Table 1. Cohabitation of maritime earwigs of differing size and sex at 15min, 12hrs, and 24hrs. Preference for or against cohabitation was determined by location on either side of a split arena with or without shelter.

		Cohabitation at 15 min (yes/no)	X ² at 15 min	p-value at 15 min	Cohabitation at 12 hrs (yes/no)	X ² at 12 hrs	p-value at 12 hrs	Cohabitation at 24 hrs (yes/no)	X ² at 24 hrs	p-value at 24 hrs
size matched males	no shelter	16/14	0.133	0.71	14/18	0.501	0.48	18/14	0.501	0.48
size matched males	shelter	10/18	2.318	0.13	14/14	0	1	14/14	0	1
different sized males	no shelter	18/6	6.279	0.01	16/10	1.397	0.24	12/12	0	1
different sized males	shelter	10/14	0.67	0.41	8/20	5.313	0.02	12/12	0	1
size matched females	no shelter	30/32	0.065	0.80	34/30	0.250	0.62	18/36	6.116	0.01
size matched females	shelter	20/22	0.095	0.76	10/36	15.600	<0.0001	14/30	5.954	0.01
different sized females	no shelter	32/28	0.267	0.61	26/30	0.286	0.59	18/24	0.86	0.35
different sized females	shelter	22/28	0.722	0.40	8/38	21.262	<0.0001	10/32	12.119	0.0005
size matched MF	no shelter	12/16	0.573	0.45	20/12	2.021	0.16	20/12	2.021	0.16
size matched MF	shelter	18/26	1.463	0.23	18/32	3.97	0.046	26/24	0.080	0.78

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