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Seasonal activity patterns in Sydney funnel-web spiders, *Atrax* spp. (Araneae: Hexathelidae)

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Summary

The dangerously venomous Sydney funnel-web spider *Atrax robustus* O. P.-Cambridge and its close relatives (*Atrax* spp.) are common inhabitants of south-eastern Australia. Despite the formidable reputation of these spiders, there has been little published on either their biology or ecology. This paper presents the first quantitative information on the seasonal activity cycle of *Atrax* spp. There was a significant correlation between *Atrax* density and elevation of the study plot. This relationship probably reflects a moisture gradient, high steep plots were dry and low flat plots were relatively moist. Surface activity was sampled with 160 pitfall traps. Contrary to previously published reports, both adult males and adult females were vagrants. Females were active earlier in the year than males. Juveniles were most frequently captured during summer.

Introduction

The Sydney funnel-web spider (*Atrax robustus* O. P.-Cambridge) is an abundant and well-known inhabitant of south-eastern Australia. The focus of attention has been the fact that the species will readily bite if threatened, and that these bites are occasionally fatal. Much has been written on the venom and medical aspects of the bite (Kaire, 1963; Sutherland, 1972, 1983).

Despite its notoriety, *A. robustus* has been little studied in nature. There exists one published study of its biology in captivity (Levitt, 1961) and it has been described briefly in general works on Australian spiders (McKeown, 1963; Main, 1964, 1976; Mascord, 1970; Scott, 1980; Gray, 1981, 1984). These studies usually mention that the species lives in damp closed forests, or moist micro-habitats in otherwise dry forests, and the fact that adult males are vagrants during the summer months. The focus of the current paper is the quantitative description of activity patterns and habitat relationships of *A. robustus* and its relatives *Atrax* spp. Seasonal activity patterns and spatial patterns are assessed by means of pitfall trapping on 16 replicate plots located in Brisbane Water National Park, NSW. Sexual and age differences in activity are documented.

Methods

The study site was located in the Brisbane Water National Park, near the University of Sydney's Crommelin Biological Research Station at Pearl Beach, NSW, Australia, 33°33′S, 151°18′E (Fig. 1). The habitat is a dry sclerophyll forest with an overstorey dominated by *Casuarina torulosa* Aiton (70% of trees), *Angophora costata* Druce, *Eucalyptus* spp. and *Syncarpia glomulifera* Niedenz. The understorey is relatively open, with numerous small shrubs, mainly *Xanthorrhoea resinosa* Persoon, *Dodonaea triquetra* Wendland, *Livistona australis* Mart., and *Lasiopetalum ferrugineum* Smith. The site is on a north-facing hillside with a few exposed rock outcrops and a dense mat of *Casuarina* litter (5–20 cm deep).

Sixteen 0.023 ha (15 m × 15 m) sampling plots were established and marked on the corners with wooden stakes. The plots were located in an area of uniform habitat approximately 125 × 200 m, and separated by a minimum of 5 m. Ten pitfall traps were installed on each plot, in 2 parallel rows of 5 pitfall traps each, traps separated by 1.5 m. Each trap consisted of a 110 mm (inside diameter) PVC cylinder cut to a length of 150 mm and buried flush with the soil surface (at the interface of the sandy soil and the litter layer). A removable 860 ml plastic cup was slipped into the PVC sleeve. The solid bottom of each cup was removed and replaced with 0.5 mm nylon netting to facilitate drainage. On each sampling date the traps were left open for 24 hours. Samples were taken approximately once per month between August 1984 and February 1986 (no sample for August 1985). All large spiders (> 10 mm) including most *Atrax* spp. were identified and released alive. A few individuals were found dead, these spiders were collected. The remainder of the pitfall sample of arthropods was transferred to 70% ethanol for subsequent sorting and identification. Some juvenile *Atrax* spp. were found during subsequent analyses of these samples. All voucher specimens collected during this study were attributable to *Atrax robustus*. These specimens were deposited in the arachnological collection of the Australian Museum, Sydney. In recent years several closely related and phenotypically similar spiders have been recognised that had previously been referred to as *Atrax robustus* (M.R. Gray, pers. comm.). Thus, it is possible that other cryptic species were confused with this species in the field. For this reason I will use the descriptor *Atrax* spp. in this paper to refer to spiders that were either *Atrax robustus* or closely related congeners. A tree funnel-web species is common in the vicinity of the Crommelin Research Station, but only one was found in a retreat at the study site, and none was found among the voucher specimens.

Individual *Atrax* spp. were classified into one of 4 groups; adult females (chitinous epigastric plate, size), adult males (presence of tibial apophysis and expanded copulatory organ on palp), subadults (without adult structures, > 15 mm total body length) and juveniles (< 15 mm total body length). The division of immature individuals into 2 size classes is arbitrary, but I believe that they represent 2 annual cohorts, as there is a break in the size distribution near 15 mm. An alternative explanation is that these two groups represent immatures of two different *Atrax* species.

I marked 9 *Atrax* spp. burrows with numbered wood tongue-depressors. These burrows were checked on each sampling date (both day and night) to determine if a spider was waiting near the entrance. Ambush predation from the burrow entrance is a common behaviour among other burrowing spiders on this study area (*Misgolas rapax* Karsch, *Lycosa furcillata* L. Koch, *Lycosa godeffroyi* L. Koch).

Data on capture frequency were analysed using the log-linear models approach but applying a randomisation test

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(Sokal & Rohlf, 1981: 787–795). The log-linear model was fitted to the sparse three-way table of spiders classified by age/sex-class, date and plot. The significance of each two-way interaction was tested using the ordinary likelihood ratio test statistic. The low capture rate (per cell in the matrix) precludes the use of the asymptotic Chi-squared approximations, thus I obtained significance values from 1000 re-randomisations, each stratified for the term being tested (Sokal & Rohlf, 1981). One additional comparison of captures on the high-elevation (dry) plots with the low-elevation (moist) plots was made using a Mann-Whitney non-parametric two-sample test with all dates combined (Minitab: Ryan, Joiner & Ryan, 1985).

Results

No quantitative data were collected on *A. robustus* burrows, but those burrows that were found were under fallen logs, rocks or at the edge of large piles of leaf litter at the edge of tree trunks or shrubs. Of the 9 marked burrows, all appeared active (fresh silk, cleared entrance) throughout the duration of the study (17 months). No *Atrax* spp. were found near the burrow entrance. Several individual funnel-webs were located out on the surface during the day and (more frequently) at night. On one occasion an adult female was observed on top of a leaf in full sunlight, a behaviour never before reported in this species.

There was a great deal of variation in the distribution and abundance of *Atrax* spp. captured in the pitfall samples. A total of 157 individuals were captured on 18 dates (160 pits/date). Analysis with log-linear models revealed that each of the main effects (class, date and plot) was important. There was also a significant statistical interaction between the date and plot factors.

Seasonal variation

Patterns of seasonal variation were highly significant (log-linear model, $p<0.01$). A total of 87 juveniles were captured, mostly between mid-January and the end of April 1985. They began appearing in the pitfall samples again by November 1985 (Fig. 2a). In contrast, few individuals were captured between May and November in either year. Only 19 subadult individuals were captured, and these mainly on 2 sampling dates, 10 January and 12 February 1985 (Fig. 2b). None was captured during the cool months of the year.

A total of 26 adult female funnel-webs were captured, most of these were trapped during early spring and summer in 1984/85, with some appearing during the late spring and summer of 1985/86 (Fig. 2c). Vagrant behaviour of adult female *A. robustus* has been noted before, usually after rainfall or environmental disturbance (Gray, 1981). The largest number of adult females occurred on a day when 149 mm of rain fell at the study site (9 November 1984). This was the heaviest rainfall in 26 months. Most adult male funnel-webs were caught during the summer and autumn of 1985 (Fig. 2d). As was the case with juveniles, adult males appeared earlier at the end of 1985. The pattern of adult male activity was not associated with rainfall (no correlation with rain on capture date or rain during previous week).

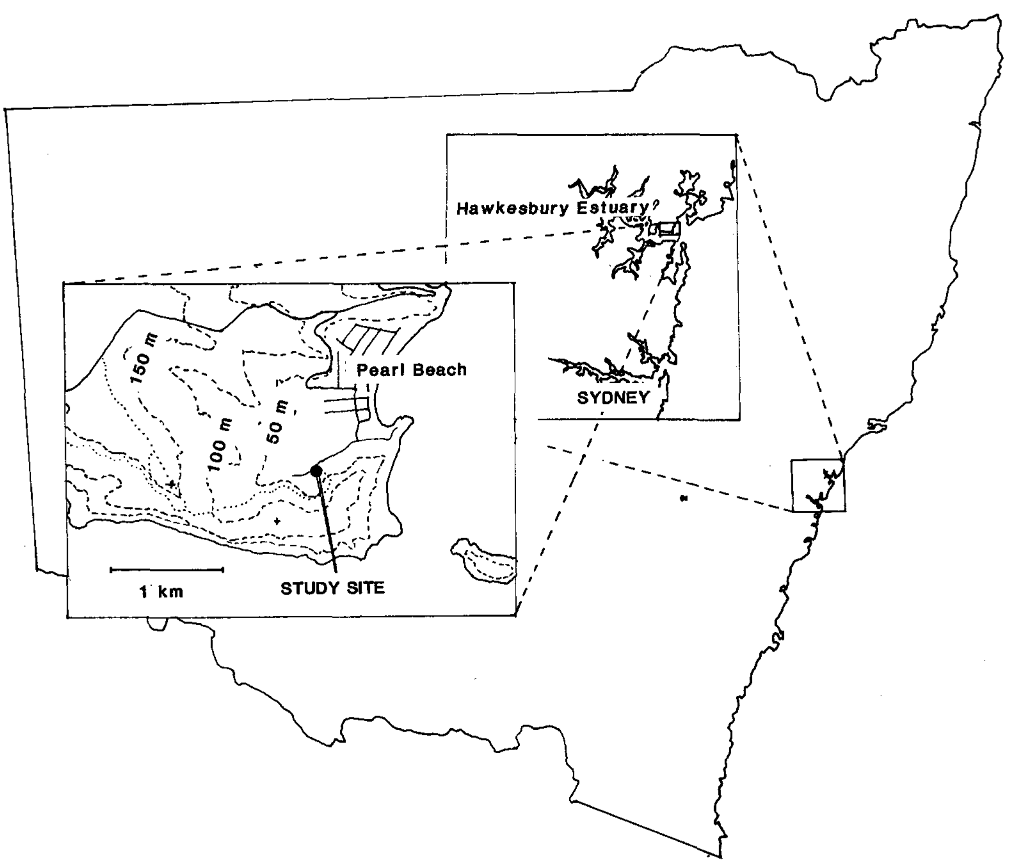

Fig. 1: The location of the study site. The outline map is of the state of New South Wales, Australia. The two included maps focus on the study site locality.

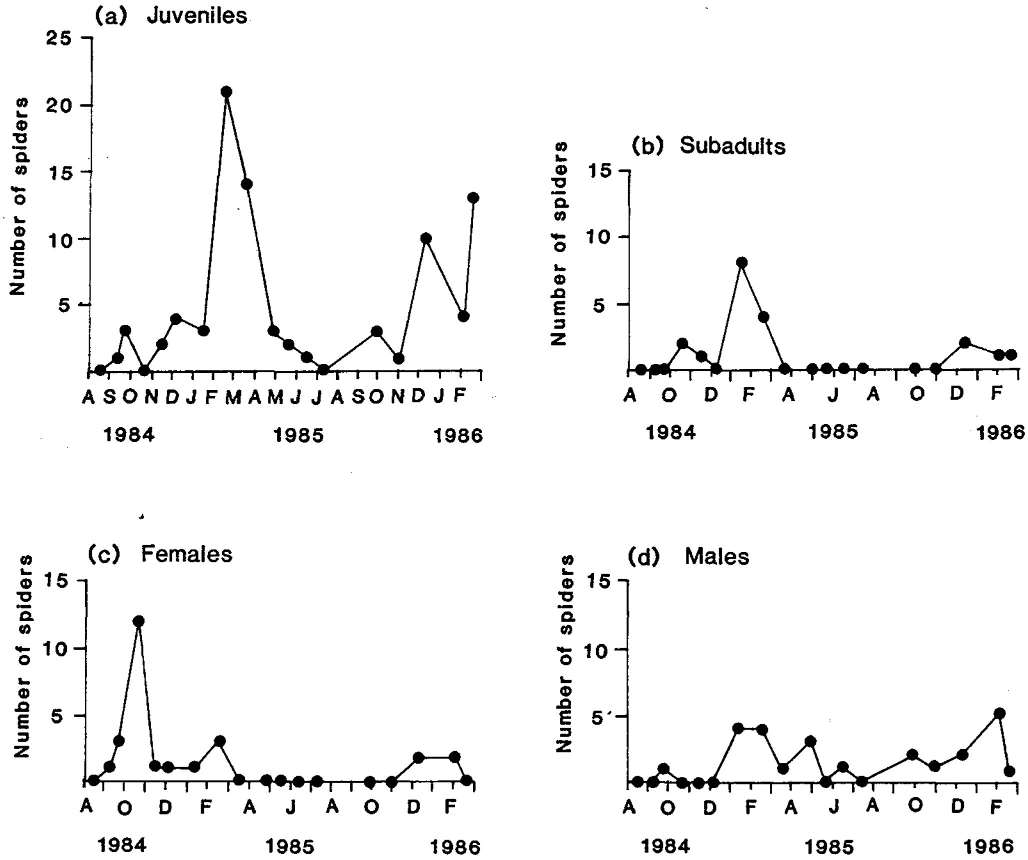

Fig. 2: The seasonal distribution of *Atrax* spp. captures in pitfall traps at Brisbane Water National Park, NSW, Australia. For each sampling date all of the pitfall trap samples (160) have been combined.

Spatial variation

The patterns of spatial occurrence were also statistically significant (log-linear model, $p<0.01$). Consistently fewer funnel-webs were captured on the relatively hot and dry plots located high on the hillside (plots 5, 7, 8, 11, 15), and more on the low moist plots (Table 1). This difference is significant (Mann-Whitney U-test, $p<0.0001$). The elevation on the study area varies from 42 m at the top of plot 7 to 34.7 m at the bottom of plots 1 and 2. Funnel-web abundance in the pitfall samples was negatively correlated with mean elevation on each plot ($r=-0.63$, $p<0.01$). It may not be elevation itself that is the crucial factor, but rather the level of soil moisture, which is probably inversely related to elevation on the study area. I have no quantitative information on average soil moisture on the study area, but lower plots were characterised by plant species which prefer moist soils, and the litter in these areas was usually moist just under the surface. This is in striking contrast to the dry litter on the higher plots.

Discussion

Juvenile funnel-webs appeared earlier in the summer of 1985 than in 1984. It was both cooler and drier than in 1984 (Crommelin Biological Research Station, weather records). Most of the individuals classified as juveniles were either in their second or third instar. As the second instar is the first to appear on the surface and disperse, the appearance of these spiderlings can be used as a crude measure of recruitment. If this assumption is reasonable, it appears that recruitment of funnel-webs during 1984/85 was considerably higher than in 1985/86. Another possible explanation for the small number of juveniles captured during 1985/86 is that the peak of movement may have occurred later than in 1984/85, after the end of sampling (March 1986).

Few subadult individuals were captured during the spring of 1985. This is surprising because this cohort was common as juveniles during the summer/autumn of 1984/85. While it seems unlikely, it is possible that the

	Plot number															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Elevation (m)	35.1	35.1	36.3	36.3	37.5	37.5	41.5	37.5	37.5	37.8	38.7	37.5	37.2	36.9	38.4	36.3
Juveniles	7	10	9	5	6	4	2	2	1	6	1	11	7	10	0	6
Subadults	0	2	1	0	0	4	1	0	5	0	1	0	2	2	0	1
Females	2	4	2	2	0	2	0	2	1	4	0	0	2	3	0	2
Males	2	3	3	1	0	1	2	2	1	0	0	2	1	3	3	1
Total	11	19	15	8	6	11	5	6	8	10	2	13	12	18	3	10

Table 1: Distribution of *Atrax* spp. captures on the 16 study plots, data for all 10 pitfalls/plot and all sampling dates combined.

destructive sampling of juveniles during 1984/85 depleted the cohort.

Only 25 mature males were captured, even though these are known to wander extensively in search of females during the mating season. It is possible that samples were not taken frequently enough to catch the main activity period. There was little relationship between the seasonal surface activity of males and females (Fig. 2c,d). Perhaps the most surprising finding was that 26 mature female *Atrax* spp. were captured in the pitfall traps. Such mature females were thought to be sedentary, and none was expected in the pitfall samples (McKeown, 1963). Females of other species of hexathelids are known to be vagrants, especially the "tree funnel-webs" in the genus *Hadronyche* (M.R. Gray, pers. comm.). The vulnerability to predation and desiccation of female *A. robustus* was thought to restrict vagrancy. The wandering of female *Atrax* spp. observed during this study may be attributable to temporary forays in search of prey or ejection from the retreat because of environmental disturbance. The largest individual sample of adult females can be attributed to environmental disturbance (rainfall), but the other captures of adult females did not correspond to heavy rainfall events.

As was the case for juveniles, fewer adult females were captured during the 1985/86 season. Since adult females were released alive at the site of capture, I cannot use the depletion argument to explain their low abundance during 1985/86. It is possible that samples were not taken frequently enough to detect short-term pulses of activity.

The present study confirms many natural history observations on funnel-web spider seasonal activity (e.g. male vagrancy: Gray, 1981; Main, 1976; McKeown, 1963). It is also clear that there is much to be learned about the behaviour and ecology of the Sydney funnel-web spiders. For example, a longer term or larger scale pitfall trapping study would probably reveal important spatial and temporal variation. Such information could be helpful in preventing unpleasant interactions between this species and humans.

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