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Daily activity patterns in the tarantula *Aphonopelma chalcodes* Chamberlin*

E. W. Minch
Department of Zoology,
Arizona State University,
Tempe, Arizona 85281, USA

Summary

The nocturnal activity period of the tarantula *Aphonopelma chalcodes* begins with the breaking of the silk covering the burrow entrance. Decreasing overhead light intensities and surface temperatures, along with the tarantulas' own biological clocks are factors apparently controlling this. Biotic factors, including ants and larger animals, may delay the start of nocturnal activity. Tarantulas remain within their burrow entrances awaiting prey throughout much of the night. Cessation of nocturnal activity is indicated by retreat of the tarantula into its burrow, or in one instance, the termination of silking over the burrow entrance followed immediately by retreat into the burrow. Increasing overhead light intensity and the internal biological clock of the tarantula probably control this aspect of the daily cycle. Tarantulas are not strictly nocturnal, as indicated in earlier aktograph studies. Field data showing tarantulas to be visible in the upper portions of their burrows, especially in the morning daylight hours, along with indications of burrow entrance silking taking place throughout the diurnal period provide examples of diurnal components in tarantula behaviour.

Introduction

Tarantulas have been considered as examples of nocturnal animals as indicated by Petrunkevitch (1911). This was contradicted by a single observation of Cazier & Mortenson (1964). A detailed field study was undertaken to determine the presence and extent of diurnal activity by the burrowing tarantula, *Aphonopelma chalcodes* Chamberlin. Also it was hoped that this work would provide data on factors controlling the activity patterns of these little-known spiders.

Materials and Methods

Unless stated otherwise, observations were conducted at 1,350 m at Molino Basin in the Catalina Mountains situated in Pima County, Arizona. Individual spiders of the species *A. chalcodes*, indicated by burrow numbers in Tables 1-2, were observed emerging in the field at dusk (39 observations) and retiring at dawn (5 observations), and the time, surface temperature, relative humidity, and lux were measured and recorded. Surface temperatures were measured by a thermometer, and humidity readings were obtained from a hydrometer. Readings in lux were taken by a light meter equipped with a scale in footcandles. Footcandles were converted into lux (10.76 lux = 1 footcandle). The light intensities applied to the overhead sky, as this was what a tarantula looking upward from a burrow would have detected. A table of sunrise and sunset times for each day of the year at Tucson, Arizona, was obtained from the United States Naval Observatory and used for calculating the time after sunset or before sunrise, in minutes, at which individual tarantulas either became active at dusk or retired at dawn.

All nocturnal observations were performed under red light to minimize disturbance to the tarantulas. Observations were made while sitting in a chair. This reduced the area of physical contact with the ground, decreasing the probability of ground vibrations that might have disturbed the spider. Observations were recorded as they occurred, with a pocket flashlight providing illumination during writing. In order to avoid disturbance to the spider, the depth within the burrow occupied by the spider was estimated rather than measured, and was based on the position of the midpoint of the spider's body.

Marked burrows were also checked at approximately 2-hour intervals for any indications of diurnal activity. Care was taken to walk in a manner so as to minimize ground vibrations that might alarm the spider and send it out of sight within its burrow. For each burrow it was recorded whether the spider was visible and also whether the entrance was covered with silk, along with the indication of sunny or cloudy conditions. Data for 12 days distributed from 18 July 1975 to 9 July 1976 were obtained covering at least 2 hours of the morning and extending to 16.00 or beyond in the afternoon, with the number of holes visited ranging from two to 20, depending on the portion of the tarantula activity season included.

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Date	Burrow No.	Time	Temp. (°C)	RH %	Overhead light intensity	Minutes after sunset
10 August 1974	1	19.31	ND	ND	ND	18
30 August 1974	2	19.50	23	39	0	59
31 August 1974	3	19.05	28	37	16	15
1 Sept. 1974	4	18.56	26	55	516	8
14 Sept. 1974	5	19.00	15	77	1	28
15 Sept. 1974	6	19.35	16	70	0	65
4 Oct. 1974	7	18.30	22	52	4	25
10 May 1975	2	19.24	17	38	ND	13
11 May 1975	8	Inact.	ND	ND	ND	ND
26 May 1975	5	20.43	18	39	0	82
27 May 1975	5	20.00	23	ND	ND	38
28 May 1975	5	19.36	17	41	344	13
30 May 1975	7	20.05	18	48	ND	41
31 May 1975	7	19.44	21	42	ND	20
20 June 1975	2	21.26	20	50	0	113
13 July 1975	9	19.44	23	62	172	12
14 July 1975	5	19.52	23	63	43	20
15 July 1975	10	19.41	27	49	129	10
16 July 1975	11	20.11	22	64	0	40
17 July 1975	9	19.41	25	61	344	11
18 July 1975	12	19.37	20	70	1,076	7
7 August 1975	13	19.35	26	43	43	19
8 August 1975	12	19.33	23	60	32	18
9 August 1975	14	19.26	28	46	699	12
29 August 1975	12	19.03	ND	ND	516	11
31 August 1975	15	19.01	27	44	344	11
19 Sept. 1975	16	18.50	ND	ND	5	25
20 Sept. 1975	16	18.29	ND	ND	699	5
10 Oct. 1975	16	18.35	19	43	0	37
11 Oct. 1975	16	18.45	19	42	0	48
12 Oct. 1975	16	Inact.	ND	ND	ND	ND
11 March 1976	17	Inact.	ND	ND	ND	ND
9 May 1976	18	19.26	15	50	86	16
10 May 1976	18	19.21	17	43	344	10
11 May 1976	18	19.39	18	46	5	28
7 July 1976	19	20.05	28	44	1	31
8 July 1976	20	19.56	30	43	22	23
27 July 1976	12	Inact.	ND	ND	ND	ND
28 July 1976	12	19.29	23	70	344	5
30 July 1976	12	19.37	19	71	172	14
16 August 1976	12	19.16	25	50	344	9
17 August 1976	12	19.21	21	71	86	15
17 August 1976	13	Inact.	ND	ND	ND	ND
18 August 1976	12	19.57	21	66	0	52
18 August 1976	13	Inact.	ND	ND	ND	ND

Table 1: Date, burrow number, time of day, surface temperature, relative humidity, overhead light intensity in lux, and time after sunset of silk breaking for given burrows on given nights. ND indicates no data recorded. "Inact." (Inactive) indicates the tarantula failed to break the silk over the burrow entrance.

Results

Initiation of nocturnal activity

Tarantula burrows were usually silked over during daylight hours by a thin, transparent cover. The breaking of this silk cover in the evening provided the logical point on which to base the start of the evening activity period. The front legs and pedipalps were used in breaking the silk cover, which was rapidly folded over onto the collar silk in one continuous motion. Often the spider retreated several centimetres into the burrow for less than one minute and then assumed the waiting position on the collar silk or emerged from the burrow and wandered about for several minutes in the nearby area before returning to assume the waiting position. The moment the silk cover was broken, the time of day, surface temperature, relative humidity, and overhead light intensity were recorded (Table 1). Four individual tarantulas on five nights failed to break the silk covering the burrow (Table 1: 11 May 1975, burrow 8; 11 March 1976, burrow 17; 27 July 1976, burrow 12; 17 and 18 August 1976, burrow 13). The low entrance temperature of 7°C on 11 March 1976 accounted for this on that night. On the other four nights the tarantulas may have been satiated and remained out of sight within the burrows. In addition the spider in burrow 16 had plugged its burrow with a mixture of soil and silk during the previous 24 hours and was not seen on 12 October 1975. Tarantulas remained with such plugged burrows throughout the cooler months, usually October to May (Minch, 1977). The average overhead light intensity for silk breaking, based on 34 observations, was 188 lux and ranged from zero to 1,076 lux, while the average time after sunset for silk breaking, based on 39 observations, was 27 minutes, ranging from 5 to 113 minutes.

On two occasions, ants of the species *Pheidole rhea* Wheeler were observed in large numbers around a burrow entrance at dusk. On 2 September 1974, with observations beginning at 18.24, the ant column reached the burrow entrance at 18.27, passing along the lip. The column was composed of workers together with the distinctive soldier caste, with greatly enlarged heads. Two dried legs of an adult male tarantula were located within 30 cm of the burrow, both of which were investigated by the ants. By 18.46 the ants had begun pulling on the silk cover of the burrow, tearing a third of it away during a 3-minute period. The ants ceased destroying the silk cover at 18.56, leaving only tattered remains. The spider was seen for the first time at 19.16, approximately 7.5 cm within the burrow, with the overhead light intensity at 3 lux. Ants continued to be numerous through 19.30, at which time the spider advanced to within approximately 2.5 cm of the surface. At 19.55 the spider resilked the entrance and by 19.56 withdrew too deeply within the burrow to be visible. The hole was still silked at 20.05 with seven ants within approximately 2.5 cm of the entrance. During the interval (19.56 to 20.05), five other tarantula burrows were checked for activity and all five yielded positive results, indicating that it was the ants and not some more widespread factor that had caused this tarantula to remain deeper within the burrow.

The second observation involved the same species of ants, also accompanied by the distinctive soldiers, on 18 August 1976. These ants did not remain near the burrow for as long as the first group, and the spider emerged briefly from the burrow 52 minutes after sunset. The overhead sky was totally dark except for stars. While the ants were around the burrow, a few of them broke through the silk and wandered several centimetres into the burrow.

Nocturnal activity

Most of the tarantula's activity on or near the ground surface occurred during the hours of darkness. Tarantulas awaited the approach of prey within the entrance of their burrows. The tarsal claws of the first and second pairs of legs and of the pedipalps maintained contact with the silk encircling the burrow entrance. From this position prey could be ambushed and taken within the burrow to be eaten. Strong ground vibrations, such as from foot-tapping, resulted in the tarantula's retreat deep within the burrow for a period that averaged 6.2 minutes in ten observations. Immatures of both sexes and adult females rarely emerged from the burrow even on moonless nights. The farthest an adult female ventured from the burrow entrance was 46 cm. A dragline of silk was left by tarantulas as they walked. Such draglines formed a network on the ground surface around the burrow. Upon termination of surface travel the tarantula returned to the waiting position within the burrow entrance.

Date	Burrow No.	Time	Temp. (°C)	RH %	Overhead light intensity	Minutes before sunrise
28 May 1975	5	05.06	11	ND	430	−13
29 May 1975	5	04.52	7	66	16	−27
30 May 1975	5	05.19	7	67	2,152	0
31 May 1975	14	04.54	10	59	43	−24
17 August 1974	4	05.30	ND	ND	ND	+1

Table 2: Date, time of day, surface temperature, relative humidity, overhead light intensity in lux, and time before sunrise as negative numbers with positive numbers indicating time after sunrise, for entry into the burrow for tarantulas on given mornings. ND indicates no data.

Tarantulas were usually inactive during the night and often went for 1 hour without moving an appendage. Movements usually resulted in small increases of less than 1 cm in depth of the position occupied within the burrow as the night progressed and surface temperature fell. During hours of darkness deeper portions of the burrow retained heat from the day (Fig. 1). Occasionally the spiders partially emerged from the burrow during the night and cleared away any living or dead plant material contacting the collar silk, using the pedipalps and front legs.

On 13 July 1975 a tarantula removed from its burrow at 20.41 was unable to relocate the entrance until placed within 5 cm of it at 21.12. The tarantula then rapidly found and entered the burrow. This indicated location of the burrow entrance to be one function of the web network around it.

Mating was also concentrated in the night and is described by Minch (1977). The only adult male seen searching for females other than during crepuscular or nocturnal periods was on 11 October 1975 at 17.30, 27 minutes before sunset.

Cessation of nocturnal activity

Tarantulas were observed in the early morning on five occasions (Table 2), in order to gather data on the termination of their nocturnal activity period. On four occasions the spiders emerged from their burrows near sunrise and stationed themselves nearby for periods of 15, 13, 24, and 9 minutes. Each then retired out of sight within the burrow, despite the absence of any apparent disturbance by the investigator. (Later observations showed that the spiders often return later in the day to silk over the entrance (Table 3)). The time at which the spider first withdrew into the burrow was selected as the time of termination of its nocturnal activity period. The remaining spider was observed silking in the early morning. This was on 17 August 1974, from 05.43 to 05.50, after which the spider immediately withdrew into the burrow. The time when silking terminated was used to indicate the end of nocturnal activity in this instance. Another burrow visited on 31 May 1975 at 05.00 was already silked. The overhead light intensity when spiders retreated into their burrows, based on four observations, averaged 660 lux, ranging from 16 to 2,152 lux, and the time for this event averaged 13 minutes before sunrise, ranging from 27

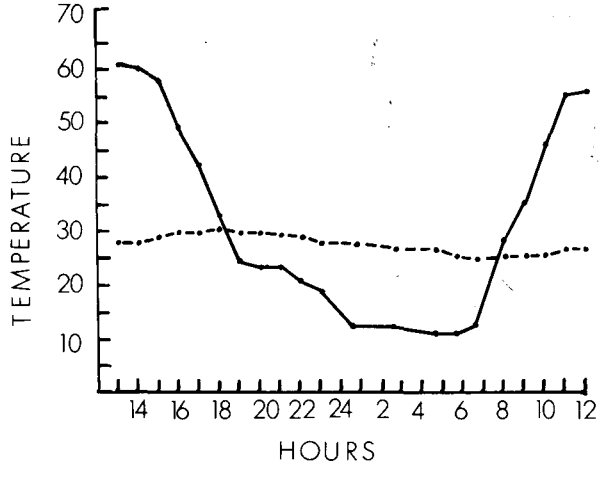

Fig. 1: The 24-hour temperature cycle for the soil surface and 23 cm depth within an open tarantula burrow taken on a clear day, 27-28 May 1975. Temperatures in °C. Surface temperatures connected by solid line; temperatures 23 cm deep connected by broken line. Sunset was at 19.22 and sunrise at 05.10.

minutes before sunrise to 1 minute after sunrise.

Diurnal activity

That tarantulas were not strictly nocturnal was indicated by observations of several tarantulas being seen outside their burrows in daylight. A presumed adult female was outside her burrow at an altitude of 950 m, approximately 5 km from the study area, after a summer afternoon thundershower. The time was not recorded. Another presumed adult female was collected on 16 August 1976, at Molino Basin in sunlight at approximately 17.25, apparently wandering, as no burrow could be located and the spider made no attempt to seek out a burrow when approached. This specimen remained alive beyond the duration of this study.

Marked tarantula burrows were investigated for indications of diurnal activity. Table 3 indicates the number of tarantulas visible and the number of tarantula burrows silked during daylight hours. All burrows included were known to contain live tarantulas. Since the silk covering the burrows was thin, it was possible to see tarantulas even within silked burrows. For selected observations performed under cloud cover, the overhead light intensity in lux was measured. On 16 July 1975, under overcast skies, two spiders out of 15 were near the entrances of their burrows at 16.00. The overhead light intensity was approximately 172,000 lux, with an air temperature of 27°C. In another instance, four spiders out of nine were near their burrow entrances on 10 August 1975 at 17.15 under cloudy skies after a 1-hour period of light rain with the overhead light intensity at approximately 43,000 lux. At noon on 11 August 1975, with clouds having obscured the sun since dawn, two out of nine tarantulas were positioned near the tops of their burrows under an overhead light intensity of approximately 344,000 lux.

After heavy rains on 29 July 1976 at 09.00, two tarantulas out of 19 were seen at their burrow entrances using their bodies to block the openings. Abandoned burrows were often plugged by washed-in dirt after the first heavy rain, so this blocking behaviour may be one method employed by tarantulas to protect their burrows.

Discussion

Initiation of nocturnal activity

Few studies have been made on this aspect of tarantula biology. Petrunkevitch (1911) noted that the destruction of the silk covering the burrow entrance separated the diurnal from the nocturnal activity period. Den Otter (1974) found hairs present

Date	No. of active burrows visited	1	2	3	4	5	6	Inclusive times
18 July 1975	14	14–ND(S)	6–11(S)	7–11(S)	5–7(S)	6–6(C)	4–6(C)	08.45 to 17.45
8 August 1975	9	3–5(S)	0–4(S)	0–5(S)	0–3(C)	ND–ND	ND–ND	09.45 to 16.00
9 August 1975	9	3–3(S)	0–6(S)	0–7(S)	0–6(S)	ND–ND	ND–ND	08.45 to 16.30
10 August 1975	9	1–6(S)	0–8(S)	1–4(C)	4–4(C)	ND–ND	ND–ND	09.30 to 17.15
30 August 1975	13	5–6(S)	4–4(S)	1–7(S)	1–7(S)	1–7(S)	2–8(S)	08.30 to 18.00
31 August 1975	13	1–9(S)	2–10(S)	1–10(S)	2–8(S)	5–7(S)	ND–ND	10.00 to 18.00
1 Sept. 1975	15	4–9(S)	0–9(S)	1–12(S)	4–10(C)	12–6(C)	ND–ND	10.00 to 18.00
10 May 1976	4	0–1(S)	1–2(S)	0–0(S)	0–0(S)	0–0(S)	ND–ND	09.30 to 16.00
11 May 1976	5	1–1(S)	2–1(S)	0–2(S)	0–2(S)	3–2(S)	ND–ND	09.00 to 18.45
29 May 1976	2	0–1(S)	0–1(S)	0–1(S)	0–1(S)	0–1(S)	ND–ND	10.00 to 18.00
8 July 1976	17	1–15(S)	0–16(S)	0–16(S)	0–17(S)	1–17(C)	1–17(C)	08.45 to 18.30
9 July 1976	20	0–18(C)	0–19(C)	0–19(C)	0–19(C)	0–19(C)	ND–ND	10.00 to 18.00

Table 3: Dates and number of tarantulas visible within their burrows from surface observation (first number) and number of burrow entrances silked (second number), during given days for the given number of active burrows visited. Inclusive times refer to the times of the first and last checks, with columns 1–6 denoting individual checks, column 1 being the earliest and the others running in chronological order at approximately 2-hour intervals. S indicates sun, with C indicating clouds. ND indicates no data.

on the tarsi that responded only to a rise in temperature and the absence of receptors sensitive to humidity in *Sericopelma rubronitens* Ausserer. Buchli (1969) observed in the family Ctenizidae that, if the night-day cycle was inverted, so was the hunting cycle, and concluded that the eyes served as synchronizers. Cloudsley-Thompson (1967) found two tarantulas of apparently different species of *Aphonopelma* (= *Eurypelma*) from the Sonoran Desert to be strictly nocturnal. Aktograph studies indicated the presence of an internal clock governing activity periods.

Concerning biotic factors controlling activity periods, Baerg (1958) noted that ants invaded tarantula burrows and devoured young as they emerged from the egg-sac, while Den Otter (1974), working with *S. rubronitens*, located club-shaped tarsal organs that gave action potentials in response to ground vibrations. Both of the above observations indicate influences on the daily activity cycle of tarantulas.

My field observations show, in agreement with Cloudsley-Thompson (1967) that *Aphonopelma* is most active at night. However, in the field, there is not a total cessation of activity by *Aphonopelma* during daylight hours as is indicated by the aktograph studies. The biological clock is probably timed to coincide the start of nocturnal activity with the time of sunset when surface and overhead light intensity play roles in initiating activity. Tarantulas tended to be more active on cool afternoons even with the overhead light intensity at 344,000 lux, indicating that favourable surface temperature alone could bring about some increase in activity. With cooler surface temperature the tarsal receptors described by Den Otter (1974), sensitive to temperature elevations, would not be activated as the spider surfaced. This would have been true also at sunset, according to the data presented in Fig. 1. Tarantulas above ground or in the burrow entrance in daylight tended to be extremely wary and difficult to approach, much more so than at night. Many tarantulas remained out of sight within their burrows even when the surface temperature was lowered due to clouds or rain. Thus for maximum tarantula surface activity, not only must the surface temperature be favourable, but also the overhead light intensity must be low.

Ants delayed the start of activity well past the time when light intensity and surface temperatures became favourable. Ground vibrations interrupted activity at any time during the night or day. The few cases in which the tarantula failed to break the silk covering during the night may have resulted from concealed feeding within the burrow as a result of successful diurnal hunting or, in one instance, the onset of winter plugging (Table 1, 12 October 1975, burrow 16).

Nocturnal activity

The low level of nocturnal activity exhibited by tarantulas has previously been discussed. Tarantulas captured prey from ambush rather than actively seeking it out. The surface network of webbing around the burrow entrance resulted from the tarantula's silking as it wandered near the burrow. The tarantula, in clearing away debris from the collar silk, ensured proper contact between the web and tarsi. The web network aided the tarantula in relocating its burrow entrance.

Cessation of nocturnal activity

No dawn observations of any tarantula species were found in the literature, but the background information of Buchli (1969) and Den Otter (1974), presented in connection with the start of nocturnal activity, may be relevant. I found that *A. chalcodes* exhibited diurnal activity, to be discussed in the next section, making the determination of the point when nocturnal activity ceased more subject to judgement on the part of the investigator than when nocturnal activity began after sunset. Since surface temperatures were lower than temperatures deeper within the burrow until well past sunrise (Fig. 1), overhead light intensity was considered the major factor involved in terminating nocturnal activity. As indicated in the Results section, tarantulas retired within their burrows in the morning under higher overhead light intensities than when they broke the silk over the burrow entrance in the evening. Tarantulas did not always remain out of sight within their burrows throughout the day (Table 3).

Diurnal activity

It had generally been assumed that tarantulas were exclusively nocturnal, as described by Petrunkevitch (1911). The first investigators who indicated the

existence of diurnal components of tarantula behaviour were Cazier & Mortenson (1964), who worked in Portal, Arizona, possibly on *A. chalcodes*. They noted that a tarantula had resilked its burrow during the interval between 09.00 and noon on 9 July 1963, the spider having been disturbed by a hunting female *Pepsis mexicana* (Lucas) at 08.40 that same morning. Gabel (1972), working with tarantulas from Stanislaus County, California, observed tarantulas using their bodies to block the burrow entrances after a stream of water had been introduced into their burrows. Similar behaviour was exhibited by *A. chalcodes* at Molino Basin after heavy rain.

The presumed adult female found on the surface in the sun must have suffered some unknown event disastrous to her burrow. The male collected in October at Molino Basin appeared after the sun had gone behind a mountain, but 27 minutes before sunset, thus surface heat was not intense. Rain and clouds resulted in daytime surface cooling (Geiger, 1965), which also resulted in increased activity by tarantulas.

During early and mid-morning periods up to about 10.00, a few tarantulas were visible in the upper parts of their burrows on all but a few days (Table 3). Some tarantulas may have perceived vibrations generated from my footsteps and withdrawn out of sight into their burrows before being noticed. They were scored as not being visible, resulting in an underestimate of the degree of morning activity near the surface. From noon until shortly after sunset it was rare to see tarantulas, unless afternoon cloud cover developed, which resulted in an increase in tarantula activity near the surface. One day was cloudy throughout, but the clouds were thin and no diurnal sightings of tarantulas were made. Tarantulas moved gradually into deeper portions of their burrows only as forced by solar heating, in a manner similar to that observed by Hadley (1970) for burrowing scorpions.

Changes in the number of burrow entrances silked were detected during daylight hours, indicating that something was passing through some of the burrow entrances. Such changes were evident even in early afternoons under high solar intensity. Whether the tarantula's burrow was being invaded or the tarantula was capturing prey, or a combination of both factors was involved, was not determined, but the observations indicated that *A. chalcodes* was not as restricted to nocturnal activity as had generally been supposed.

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