Aggregation in the Broad-Headed Skink (Eumeces laticeps)

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biophysical ecology of the alligator: heat energy budget and climate space. Ecology 53:1094–1102.

Turner, J. S., and C. R. Tracy. 1983. Blood flow to appendages and the control of heat exchange in American alligators. Physiol. Zool. 56:195–200.

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AGGREGATION IN THE BROAD-HEADED SKINK (*EUMECES LATICEPS*).—Small aggregations of scincid lizards of the genus *Eumeces* following the breeding season and in winter have been reported frequently. In *Eumeces fasciatus* small groups gather in hibernacula under the ground or in rotting logs (Hamilton, 1948; Neill, 1948; Fitch, 1954). Similar observations have been made for *E. septentrionalis* (Scott and Sheldahl, 1937; Breckenridge, 1943), *E. gilberti* (Cooper and Vitt, 1986b), and *E. skiltonianus* (Cooper and Vitt, 1985). The broad-headed skink, *E. laticeps,* also forms winter aggregations underground (Neill, 1948; gardeners at Auburn University at Montgomery brought seven adults found hibernating in a cavity about 0.3 m underground among the roots of an ornamental bush to WEC in March 1978). Despite the numerous anecdotal reports of aggregation in *Eumeces* and recent interest in possible sensory mechanisms facilitating it (Duvall et al., 1980; Cooper and Vitt, 1985), there have been no studies of the tendency to aggregate in *Eumeces.* The reported aggregations could reflect either limited availability of hibernacula or attraction to conspecifics for some physical or social advantage. In this note we report a demonstration of aggregation by *E. laticeps* under laboratory conditions eliminating shortage of shelter sites as a factor.

Methods.—Adult *E. laticeps* were captured in Charleston and Barnwell counties, South Carolina in April–June 1984 and were housed at the Savannah River Ecology Laboratory (SREL) until 8 Sept. 1984 when they were transported to the University of Alabama in Huntsville (UAH). While at SREL and until 22 Dec. 1984 at UAH, the skinks were housed individually or in male-female pairs in 30 × 30 × 26 cm high glass terraria with hardware cloth tops. Each terrarium was furnished with a sand substrate and a 10 × 10 cm unfinished plywood square as a refuge. Throughout the study, the skinks were exposed to a natural light cycle in ventilated greenhouses. Water and crickets dusted with vitamins and calcium supplement (Petco) were available ad libitum. For both the isolation period at UAH and the subsequent experimental period, the cages were in a greenhouse attached to a roof-top laboratory; the east and south walls and the roof were glass. Temperatures were regulated only to prevent extremes below 15 C and above 33 C.

On 22 Dec. 1984 the skinks were transferred to the large painted wooden experimental cage (88 × 112 × 60 cm high) containing a sand substrate, a water bowl, and four 40 × 20 cm unfinished plywood rectangles as refuges and potential aggregation sites. These shelter sheets were placed in the centers of the four rectangular floor quadrants of the experimental cage with the long axes of shelter sheets and cage parallel. The water bowl was placed in the center of the cage. At each observation the shelters were individually raised and the skinks counted and removed. After data were recorded for all shelters, lizards, shelter sheets, and bowl were removed, the sand was mixed by hand, and the shelters were turned over and replaced into random quadrants. The water bowl and lizards were then replaced outside the shelters. Observations were made between 0700 and 0830 CST before any morning activity and while temperatures were low enough to minimize lizard movements during recording of data. The experimental cage was placed in the southeast corner of the greenhouse with an initial east–west orientation, and was rotated 90 degrees counterclockwise on 22 Jan. and 5 and 15 Feb.

Observations were begun on 13 Jan. 1986 and continued until 30 March 1985; during this 78 d period, 54 observations were made. The Jan.–March interval was chosen to include periods of normal winter hibernation and early spring activity. Lizards were active in only a very limited way during the winter period; until late Feb. the only activity observed was occasional basking and movement of lizards to and between shelters when returned to the cage following observations. Other activities, including foraging, basking, and agonistic behavior between males in late March, were observed with increasing frequency as the spring progressed.

The study was terminated when increased activity precluded accurate counts of the lizards.

Initially, until 22 Jan., sex was not recorded. Number of lizards not under boards was recorded only for the initial 19 observations. Further, sample size was not constant throughout the study; the initial sample size was 40 (23 male and 17 female), but deaths of six skinks during the experiment gradually reduced it to 34 (19 male and 15 female). Thus, statistical analyses included only individuals under boards and expected frequencies used in the statistical tests were adjusted to current sample sizes.

In the absence of aggregation or agonistic behavior a random distribution of numbers of lizards per shelter would be expected. A nonrandom distribution could be produced by agonistic interactions or by aggregation. To distinguish these possibilities lizards were observed for signs of aggressive behavior and for head and neck wounds produced by intraspecific biting (Vitt and Cooper, 1985). We consider a contagious (clumped) distribution without apparent agonistic behavior indicative of aggregation. Data analyzed by chi-square were numbers of lizards under each shelter. Two chi-square tests of randomness were conducted for each day, one assuming equal attractiveness of shelters and the other using the mean observed frequencies per shelter for the entire study as expected values. Position preference was tested by a chi-square test with expected values obtained by assuming that each shelter site was equally preferred. Possible influences of sex on use of shelter sites were examined by comparing numbers of days on which the same shelter covered the greatest numbers of males and of females during the initial two thirds and final third of the experiment. Expected frequencies were too low to allow separate chi-square tests for males and females. All statistical tests were two-tailed with alpha = 0.05.

Results.—Significant aggregation occurred on 26 of 54 d when calculated using equal expected frequencies for each shelter and on 19 of 54 d when the expected frequency for each shelter was its mean observed frequency (Table 1). The latter tests must be considered more meaningful because numbers of days on which 10 or more lizards occupied a shelter sheet (8, 16, 18, and 36) varied significantly (chi-square = 24.63, df = 3, $P < 0.001$) by shelter position. The experimental design eliminated shortage of shelter sites as a possible source of aggregation. Weighting the expected frequencies removed effects of differentially attractive physical conditions.

Aggregation was absent on more days than it was significantly present, probably for several reasons. In part, this was due to the infrequency of aggregation during the last third of the study. It is to be expected that natural aggregations dissolve around the time of emergence from hibernation. Earlier in the study, the failure of lizards to aggregate on some days could have been due to a failure of photothermal conditions in the laboratory to adequately mimic natural stimuli that induce aggregation. Furthermore, the natural frequency of aggregation is unknown. Aggregation could be a probabilistic rather than deterministic response to a set of conditions. Finally, aggregations in nature presumably persist for much of the hibernation interval, whereas in this experiment, they were broken up each day by removing the lizards from the cage and replacing them outside shelters.

Aggregation could have been produced by a few dominant individuals forcing the remainder together in other shelter positions, but no agonistic behavior was observed until after aggregation had declined markedly. Neither did any head wounds indicative of agonistic behavior appear. Agonistic behavior is restricted almost entirely to the breeding season in late spring. At that time males have bright orange heads, the orange coloration being induced by testosterone, the same hormone which activates aggressive behavior (Cooper and Vitt, 1987a, 1987b). In the winter and at emergence from hibernation, male head coloration is dull and agonistic interactions have not been reported. Aggressive behavior is thus highly unlikely to have influenced aggregation in the present study. Therefore, aggregations must form because the skinks are attracted to conspecifics.

Significant aggregation occurred much more frequently early in the experiment than during the final third (Table 1). For the tests with weighted expected frequencies, number of days with aggregation for the three successive 18 d data periods were 10, 7, and 2; for the unweighted tests they were 10, 14, and 2. Clearly, aggregation occurred less frequently during the final third than during the first. The importance of this trend is obvious, but its significance could not be assessed by tests requiring independence of observations among days. We interpret the data as indicating that the tendency

TABLE 1. NUMBERS OF LIZARDS OCCUPYING SHELTER SITES AND SIGNIFICANCES OF AGGREGATION BY CHI-SQUARE TESTS ASSUMING EXPECTED FREQUENCIES TO BE EITHER EQUAL (=) OR PROPORTIONAL TO THE MEAN OBSERVED FREQUENCY (OBS) FOR EACH SHELTER SITE ARE PRESENTED FOR ALL EXPERIMENTAL DAYS. The day column gives the number of days subsequent to 12 Jan. rather than the observation number. n.s. = not significant, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

	Shelter				Significance			Shelter				Significance	
Day	1	2	3	4	=	obs	Day	1	2	3	4	=	obs
1	6	2	15	14	**	*	39	3	3	15	11	**	n.s.
2	11	8	22	0	***	**	42	6	1	18	8	***	*
3	8	8	17	7	n.s.	n.s.	43	7	2	12	13	*	n.s.
4	2	7	27	5	***	***	45	6	2	16	9	**	n.s.
5	12	6	13	4	n.s.	n.s.	46	7	1	19	7	***	*
6	10	5	18	4	**	n.s.	48	9	1	14	10	*	n.s.
7	10	15	12	3	n.s.	**	52	10	4	10	10	n.s.	n.s.
10	2	15	17	6	**	***	53	13	3	10	8	n.s.	n.s.
11	3	5	16	16	**	*	54	8	5	16	5	*	n.s.
12	4	6	9	19	**	***	55	7	7	13	7	n.s.	n.s.
13	7	4	22	1	***	**	56	8	10	5	5	n.s.	*
15	11	3	17	8	*	n.s.	57	7	6	13	6	n.s.	n.s.
16	9	2	12	16	*	*	59	12	4	6	12	n.s.	n.s.
17	12	8	9	9	n.s.	n.s.	61	2	8	14	10	*	n.s.
18	13	7	11	7	n.s.	n.s.	62	9	8	9	8	n.s.	n.s.
20	11	3	8	7	n.s.	n.s.	63	10	6	13	5	n.s.	n.s.
24	8	8	12	6	n.s.	n.s.	64	7	10	11	6	n.s.	n.s.
25	6	13	5	5	n.s.	***	65	8	7	13	6	n.s.	n.s.
26	8	6	18	3	**	n.s.	66	10	8	8	7	n.s.	n.s.
27	11	7	6	8	n.s.	n.s.	68	11	10	5	8	n.s.	n.s.
29	3	6	13	1	**	*	69	6	7	6	4	n.s.	n.s.
30	1	7	16	10	***	*	72	12	6	9	7	n.s.	n.s.
31	2	17	1	13	***	***	74	10	6	8	10	n.s.	n.s.
34	6	3	13	3	*	n.s.	75	8	9	11	6	n.s.	n.s.
35	7	7	10	4	n.s.	n.s.	76	11	8	8	7	n.s.	n.s.
36	4	4	1	19	***	***	77	9	5	8	12	n.s.	n.s.
38	10	0	3	21	***	***	78	3	13	12	6	*	**

to aggregate is strongest during the winter and decreases in late winter to early spring. Because the field observations of aggregation cited above have been primarily in cold weather, it seems likely that aggregation may be favored by low temperatures or short photoperiods. The low frequency of aggregation in March suggests that higher temperatures or increasing photoperiods in spring may break up winter aggregations.

Discussion.—Restriction of aggregation to low temperatures is consistent with the interpretations of Duvall et al. (1980) and Cooper and Vitt (1985) regarding possible temperature-dependent responses to aggregation pheromones. In *E. laticeps* the preferred body temperature is 32.5–33.7 C (Pentecost, 1974). The lizards are rarely active below 20 C and are sluggish at temperatures below the mid-twenties (Cooper and Vitt, 1986a). At these low temperatures tongue-flicking rates are much lower than at 30 C. Vomeronasal olfaction, important in detecting female sex pheromones, following conspecific scent trails, and detecting species-identifying odors (Cooper et al., 1986a; Cooper and Vitt, 1986c), appears to be used to detect contact pheromones in agonistic and sexual contexts. However, the vomeronasal system might be less important than primary olfaction in detecting airborne conspecific odors in relation to aggregation. Nevertheless, the high tongue-flick rate of males approaching female airborne odors (Duvall et al., 1980) argues for vomeronasal participation.

This study was not designed to detect sex differences in tendency to aggregate. However, no tendency of segregation of the sexes by shelter site was apparent. Sample sizes were too small to test for aggregation separately for males and females, but both sexes clearly aggregated. In males (initial N = 23, final N = 19), 10 or more individuals were found under a single shelter sheet on 13 of 47 d on which data were recorded by sex. For females (initial N = 17, final N = 15), eight or more individuals occupied the same shelter on 12 d. These data are rather arbitrarily chosen, but 10 and eight represent 0.43 and 0.42 of the initial sample sizes for males and females, respectively. The close match suggests that the sexes aggregate equally. On four of the days on which 10 or more males were found under a single shelter sheet, eight or more females occupied the same shelter. Although proof is needed, it is likely that winter aggregations form randomly with respect to sex.

The present study suggests that the anecdotal reports of winter aggregation by *E. laticeps* cited above were not based on chance events, but the adaptive significance of the aggregation remains unknown. Shortage of overwintering sites cannot be a proximate mechanism forcing aggregation because ample sites were available. Nevertheless, limited availability of suitable overwintering sites could have selected for aggregation in evolutionary time. Social advantage on emergence seems highly improbable because the lizards disperse and do not fight or mate until 6 wk later (Vitt and Cooper, 1985). Potential physical advantages of aggregation such as reduced heat loss or reduced evaporative water loss cannot be evaluated without further study.

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LITERATURE CITED

Breckenridge, W. J. 1943. The life history of the black-banded skink *Eumeces septentrionalis* (Baird). Amer. Midl. Nat. 29:591–606.

Cooper, W. E., Jr., and L. J. Vitt. 1985. Responses of the skinks, *Eumeces fasciatus* and *E. laticeps*, to airborne conspecific odors: further appraisal. J. Herpetol. 19:481–486.

———, W. R. Garstka and L. J. Vitt. 1986a. Female sex pheromone in the lizard *Eumeces laticeps*. Herpetologica 42:361–366.

———, and L. J. Vitt. 1986b. Thermal dependence of tongue-flicking and comments on use of tongue-flicking as an index of squamate behavior. Ethology 71:177–186.

———, and ———. 1986c. Tracking of female conspecific odor trails by male broad-headed skinks (*Eumeces laticeps*). *Ibid.* 71:242–248.

———, and ———. 1987a. Intraspecific and interspecific aggression in lizards of the scincid genus *Eumeces*: chemical detection of conspecific sexual competitors. Herpetologica. 43:7–14.

———, and ———. 1987b. Induction of orange head coloration and activation of courtship and aggression by testosterone in the male broad-headed skink (*Eumeces laticeps*). J. Herpetol. 21(2).

Duvall, D., R. Herskowitz and J. Trupiano-Duvall. 1980. Responses of five-lined skinks (*Eumeces fasciatus*) and ground skinks (*Scincella lateralis*) to conspecific and interspecific chemical cues. *Ibid.* 14:121–127.

Fitch, H. S. 1954. Life history and ecology of the five-lined skink, *Eumeces fasciatus*. Univ. Kansas Publ. Mus. Nat. Hist. 8:1–156.

Hamilton, W. J., Jr. 1948. Hibernation site of the lizards *Eumeces* and *Anolis* in Louisiana. Copeia 1948: 211.

Neill, W. T. 1948. Hibernation of amphibians and reptiles in Richmond County, Georgia. Herpetologica 4:107–114.

Pentecost, E. D. 1974. Behavior of *Eumeces laticeps* exposed to a thermal gradient. J. Herpetol. 8:169–173.

Scott, T. G., and R. B. Sheldahl. 1937. Black-banded skink in Iowa. Copeia 1937:192.

Vitt, L. J., and W. E. Cooper, Jr. 1985. The evolution of sexual dimorphism in the skink *Eumeces laticeps*: an example of sexual selection. Can. J. Zool. 63:995–1002.

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ORIGIN OF THE STIMULUS FOR MUSCULAR SPASMS AT THE CRITICAL THERMAL MAXIMUM IN ANURANS.—Several different methods have been used to