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DEVELOPMENT AND REPRODUCTIVE POTENTIAL OF *FLORINDA COCCINEA* (ARANEAE, LINYPHIIDAE)

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Abstract. Development and reproduction of the red grass spider, *Florinda coccinea* (Hentz), from South Carolina were studied under laboratory conditions (26 ± 2 °C). Both males and females required five molts to reach maturity, although 10% of the males had one supernumerary molt. Once mature, females lived approximately one month, or nearly twice as long as males. Laboratory–reared females produced as many as six fertile egg sacs, whereas field–collected females produced up to ten sacs. The first sac of laboratory–reared females had the largest average clutch size – about 70 eggs. The reproductive capacity of females mated with unmated males versus those mated with previously mated males was not significantly different.

The red grass spider, *Florinda coccinea* (Hentz), is common throughout southeastern North America. Despite its abundance, biological information on this species, like that of the vast majority of linyphiids, is sparse. The only biological study of *F. coccinea* is an unpublished thesis on territoriality (Ross 1977). Because so little is known about this species, we undertook this study to determine the developmental and reproductive biology under standardized laboratory conditions, and to relate these aspects to our field observations.

MATERIALS AND METHODS

We collected adult females of *F. coccinea* ($N = 34$) from lily turf (*Liriope muscaria*) on the Clemson University campus on 8 May 1989. These spiders and all subsequent offspring were held individually in plastic containers (3.7 cm deep x 5.2 cm diameter) in an environmental chamber (26 ± 2 °C, 65 ± 4% R. H., 14L:10D photoperiod). Field–collected females had live *Drosophila melanogaster* and moist cotton in their containers at all times. All offspring had constant access to moist cotton and were provided approximately ten small leafhoppers or flies per day.

Developmental biology was determined as follows. On 6 June 1989, we removed ten spiderlings from each of the first six clutches produced by the field–collected females, and successfully reared 22 females and 14 males to maturity. These spiders (F_1) were mated, and on 4 July 1989, we removed a total of 60 of their offspring (F_2, 10 spiderlings from each of 6 clutches) and successfully reared 21 females and 25 males to maturity. For F_1 and F_2 spiderlings, we recorded the duration of each post–emergence instar by examining containers daily for exuviae. Occasionally (33.6%, $N = 332$) exuviae were not located, and this caused variation in sample sizes. To test for protandry, we determined the average number of days from the second molt to the final molt for males and females. We used once–mated spiders to compare male ($N = 13$) and female ($N = 29$) longevity from the date of maturity until death.

To determine reproductive capacity of *F. coccinea*, we monitored field–collected females and their F_1 and F_2 offspring. F_1 females ($N = 15$) were mated (8 days after the final molt) with virgin males ($N = 9$, 7 days after final molt) or with once–mated males ($N = 6$, 11–15 days after final molt). F_2 females ($N = 18$, 2–8 days after final molt) were mated with virgin males ($N = 15$, 3–4 days after final molt) or with once–mated males ($N = 3$, 7 days after final molt). We removed females from each of their successive egg sacs within 12 h of construction, and monitored them for production of additional sacs. We recorded the date of construction of each egg sac ($N = 95$), the clutch size (spiderlings plus unhatched eggs) ($N = 93$), and the date of first spiderling emergence from each egg sac ($N = 50$). Oviposition times, clutch sizes, and spiderling–emergence times did not differ significantly between females mated with virgin males and those mated with experienced males (ANOVA, $P >$

Table 1.—Days ($\bar{x}$ ± SE, N) required for development of *Florinda coccinea* in the laboratory (26 ± 2 °C). a = supernumerary molts.

	Intermolt interval			
Generation	2–3	3–4	4–5	5–6
F_1	6.4 ± 0.30, 35	4.6 ± 0.13, 34	5.2 ± 0.12, 35	–
F_2	5.5 ± 0.26, 40	4.0 ± 0.17, 43	5.3 ± 0.11, 44	4.7 ± 0.33, 3^a

0.05), so these groups were combined for subsequent analyses. If there were no significant differences between the F_1 and F_2 generations, data for the two groups were combined.

We deposited voucher specimens of both sexes in the Clemson University Arthropod Collection.

RESULTS

Developmental biology.— Both males and females required five molts to reach maturity, although four males (10.2%) had one supernumerary molt (Table 1). The first of these five molts occurred within the egg sac. Approximately 70% of second-instar spiderlings (N = 120) constructed webs after emergence from the egg sac; the remainder, which did not construct webs, died before the next molt. The number of days required to reach maturity was not significantly different ($F = 0.89$, $df = 1$, $P = 0.3475$) between males ($\bar{X} = 15.8$, SE = 0.41, $N = 36$) and females ($\bar{X} = 15.2$, SE = 0.30, $N = 40$), although longevity of adult females ($\bar{X} = 27.8$, SE = 2.66 days, $N = 29$) exceeded that of adult males ($\bar{X} = 16.1$, SE = 3.15 days, $N = 13$) (t–test, $df = 40$, $P = 0.013$).

Reproductive biology.— Of the laboratory–reared females that produced egg sacs ($N = 32$), more than half produced at least three sacs, with the maximum number of sacs being six (Table 2). Intervals between production of the second through fifth sacs did not differ significantly. The first sac had a significantly larger average clutch size than successive sacs (Table 3). Field–collected females produced up to ten egg sacs ($\bar{X}$ = 4.4, SE = 0.46, $N = 25$); however, these values are minima because females might have oviposited prior to collection. Egg sacs were not retained in the web, but were constructed in the bottom of the container, suggesting that in the field they are deposited at the base of vegetation.

Spiderling–emergence times from successive egg sacs ($\bar{X} = 12.8$, SE = 0.23, $N = 51$) did not differ significantly between generations ($F = 0.31$, $df = 1$, $P = 0.5836$) or among successive sacs ($F = 0.97$, $df = 2$, $P = 0.3858$). Of the sacs in which spiderlings were produced (74.2%, $N = 93$), young were unable to emerge from 30.4%. The remaining sacs, including all fifth and sixth sacs, contained only eggs.

DISCUSSION

Our study of *F. coccinea* is the first study of a North American linyphiid to address developmental rates within each stadium in males and

Table 2.—Days ($\bar{x}$ ± SE) between sequential ovipositions of *Florinda coccinea* in the laboratory (26 ± 2 °C). Times were not significantly different between the F_1 and F_2 generations ($F = 0.23$, $df = 1$, $P = 0.6354$). Adjusted means followed by different letters are significantly different ($P < 0.05$; LSMeans procedure, SAS Institute 1985).

Oviposition events	No. days between oviposition events	N
Sac #1–Sac #2	4.8 ± 0.21a	25
Sac #2–Sac #3	5.7 ± 0.66a	19
Sac #3–Sac #4	5.3 ± 0.21a	10
Sac #4–Sac #5	6.1 ± 0.76a	6
Sac #5–Sac #6	9.7 ± 2.19b	3

Table 3.—Clutch sizes ($\bar{x}$ ± SE) of consecutive egg sacs constructed by *Florinda coccinea* in the laboratory (26 ± 2 °C). Clutch sizes were not significantly different between the F_1 and F_2 generations ($F = 2.96$, $df = 1$, $P = 0.0893$). Adjusted means followed by different letters are significantly different ($P < 0.05$; LSMeans procedure, SAS Institute 1985).

Egg sac number	Clutch size	N
Sac #1	70.5 ± 2.71a	32
Sac #2	61.6 ± 3.06b	23
Sac #3	62.0 ± 2.13b	19
Sac #4	59.6 ± 3.03a	10
Sac #5	50.2 ± 7.75b	6
Sac #6	48.5 ± 9.96b	3

females. Shorter developmental times for *F. coccinea* observed in our study relative to the few developmental studies of Old World linyphiids (Turnbull 1962; De Keer & Maelfait 1987a, 1987b), might be due to higher rearing temperatures and unlimited food in our study. Although male spiders are generally smaller than females and, therefore, require fewer molts (Foelix 1982), male and female linyphiids are approximately the same size and have the same number of molts or, as in *F. coccinea*, males sometimes have supernumerary molts.

Life cycles of linyphiids have been described as either univoltine (Schaefer 1976; Christophe 1977), bivoltine (Baert 1978), polymorphic (Wise 1974, 1976), or diplochronic (Toft 1976; Wise 1984). *F. coccinea* in upstate South Carolina is apparently multivoltine. However, the short generation time and overlapping cohorts from multiple egg sacs make it difficult to determine the number of generations per year. We have found all instars and adults of both sexes throughout the year in South Carolina.

The developmental and reproductive biology of *F. coccinea* is similar to that of other spiders. For instance, a general trend among spiders is for females to live longer than males (Foelix 1982), and for the first egg sac to have the largest clutch size (Preston–Mafham & Preston–Mafham 1984). The production of six to ten egg sacs by *F. coccinea* falls within the range found in other linyphiids, although the clutch size of *F. coccinea* was larger than that of *Oedothorax fuscus* (De Keer & Maelfait 1987a) and *Frontinella pyramitela* (Austad 1982), perhaps because *F. coccinea* was provided more food.

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LITERATURE CITED

Austad, S. N. 1982. First male sperm priority in the bowl and doily spider, *Frontinella pyramitela* (Walckenaer). Evolution, 36:777–785.

Baert, L. 1978. Influence de la photo périodicité sur la maturation ovarienne chez *Gongylidium rufipes*. Rev. Arachnol., 2:23–27.

Christophe, T. 1977. Etude démographique d'une population de l'araignée *Macragus rufus* (Wider) (Linyphiidae). Bull. Soc. Zool. France, 102:187–196.

De Keer, R. & J. –P. Maelfait. 1987a. Laboratory observations on the development and reproduction of *Oedothorax fuscus* (Blackwall, 1834) (Araneida, Linyphiidae) under different conditions of temperature and food supply. Rev. Ecol. Biol. Sol., 24:63–73.

De Keer, R. & J. –P. Maelfait. 1987b. Life history of *Oedothorax fuscus* (Blackwall, 1834) (Araneae, Linyphiidae) in a heavily grazed pasture. Rev. Ecol. Biol. Sol., 24:171–185.

Foelix, R. F. 1982. Biology of Spiders. Harvard University Press, Cambridge, Massachusetts. 306 pp.

Preston–Mafham, R. & K. Preston–Mafham. 1984. Spiders of the World. Facts on File, Inc., New York. 191 pp.

Ross, J. W. 1977. Evidence for territoriality in the line–weaving spider, *Florinda coccinea* (Hentz). M. S. Thesis, University of Tennessee.

SAS Institute. 1985. SAS User's Guide: Statistics, 5th ed. SAS Institute, Cary, North Carolina.

Schaefer, M. 1976. Experimentelle Untersuchungen zum Jahreszyklus und zur Uberwinterung von Spinnen (Araneida). Zool. Jb. Syst., 103:127–289.

Toft, S. 1976. Life–histories of spiders in a Danish beech wood. Natura Jutlandica, 19:5–40.

Turnbull, A. L. 1962. Quantitative studies of the food of *Linyphia triangularis* Clerck (Araneae: Linyphiidae). Can. Entomol., 94:1233–1249.

Wise, D. H. 1974. Role of food supply in the population dynamics of the spider *Linyphia marginata*. Ph.D. Thesis, University of Michigan, Ann Arbor.

Wise, D. H. 1976. Variable rates of maturation of the spider *Neriene radiata* (*Linyphia marginata*). Am. Midl. Nat., 96:66–75.

Wise, D. H. 1984. Phenology and life history of the filmy dome spider (Araneae:Linyphiidae) in two local Maryland populations. Psyche, 91:267–288.

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