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A STUDY OF FECUNDITY, FERTILITY, AND HATCH IN EUSCHISTUS SERVUS (HEMIPTERA: PENTATOMIDAE) WITH NOTES ON PRECOPULATORY AND COPULATORY BEHAVIOR[1]

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ABSTRACT.--The effects of age and mating on fecundity, fertility, and hatch were studied under laboratory conditions. Precopulatory and copulatory behavior were also investigated. Age and number of copulations had no effect on fecundity, fertility, or hatch. However, when fertilized ♀♀ were compared with virgin ♀♀, fertilized ♀♀ were found to lay significantly more eggs, but have a shorter life span. Mating was initiated by the ♂, and insertion took place with the ♂ facing away from the ♀. Copulation lasted up to 56 hours.

The brown stink bug, Euschistus servus, is common throughout most of the continental United States (Blatchley 1926) and consists of 2 subspecies, E. s. servus (Say) and E. s. euschistoides (Vollenhoven). E. s. servus is common in the southeast and south central United States, E. s. euschistoides across the northern United States and southern Canada. The 2 subspecies intergrade in a wide band from Maryland to Kansas (Sailer 1954). Southern Illinois, the source for animals used in this study, falls within this zone of intergradation.

E. servus attacks a wide range of host plants including cotton (Morrill 1910), goldenrod, thistle (Blatchley 1926), peaches, whitetop fleabane, white campion, horseweed (Woodside 1947), tomatoes, snap beans, southern peas, and okra (Rolston and Kendrick 1961). Information on its life history and rearing under controlled conditions has been published (Woodside 1946, Esselbaugh 1948, Rolston and

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Kendrick 1961), and the eggs (Esselbaugh 1946) and nymphs (DeCoursey and Esselbaugh 1962) described. However, little information is available on fecundity and fertility. Thus, the present laboratory study was conducted to determine the effects of age, mating, and the number of copulations on fecundity, fertility, and hatch. Also, notes were taken on precopulatory and copulatory behavior.

MATERIALS AND METHODS

On April 19, 1974, 8 adult E. servus (5♂♂, 3♀♀) were collected in the LaRue-Pine Hills Ecological Area, Union Co., Illinois, returned to the laboratory, and placed in incubators maintained at 23.9±0.6°C and constant light of ca. 130 ft-c. (Ken-Rad, 15W Daylight, F15T8/D). They were kept in mason jars and fed green snap beans, Phaseola vulgaris L., as described by McPherson (1971). Offspring of these field-collected individuals were reared following the technique of McPherson (1971), and the resulting adult ♂♂ and ♀♀ used to begin the various experiments. The ♀♀ were divided into 4 groups: (1) isolated ♀♀, (2) once-mated ♀♀, (3) twice-mated ♀♀, and (4) mated-for-life ♀♀.

The isolated ♀♀ group consisted of 6 virgin ♀♀, each isolated for its entire adult life. The once-mated and twice-mated ♀♀ groups each consisted of 6 virgin ♀♀ which were allowed to copulate once or twice, respectively, before the ♂ was removed. The mated-for-life group consisted of 12 ♀♀, each paired for its entire adult life with a ♂ (mean number of copulations=2.64, range=1-5); if the ♂ died, it was replaced with one of ca. the same age.

Egg clusters from the 4 groups of ♀♀ were collected daily and placed on filter paper in petri dishes (ca. 9 cm. diam., 2 cm. deep) as described by McPherson (1971). These were kept in the same incubators as the adults. The number of eggs laid/♀, the number which subsequently developed eye spots and, of those, the number which eventually hatched, were recorded.

Although it was originally planned to compare data gathered during the entire life span of each ♀, life spans proved to be highly variable. Several ♀♀ died after ca. 8 weeks, thus greatly weakening comparisons beyond this point. For this reason most comparisons are based on data gathered during the 1st 8 weeks.

The number of egg clusters/♀ was highly variable on a weekly basis. Occasionally, ovipositions of a particular ♀ would be more than 1 week apart. Thus, it was decided to divide the 8 weeks into four 2-week periods to decrease the effect of this variability.

Fecundity, fertility, and hatch were compared within and between the 3-4 groups of ♀♀. Fecundity data for each ♀ began with the first egg cluster. Fertility data began with the first egg cluster containing fertile eggs, determined by the development of eye spots. Hatch, the % of fertile eggs that developed to eclosion, also began with the first cluster containing fertile eggs. Comparisions of preoviposition and interoviposition periods and life spans were also made between groups.

It was necessary to analyze the data with non-parametric tests because they consisted of counts. The 0.01 level of significance was chosen because of the small sample sizes and high individual variation between ♀♀.

If a ♀ died during the 8-week period, her data were discarded. If a mated ♀ failed to produce any fertile eggs, these data were not included in comparisons of her group (once-, twice-, or mated-for-life) with others. Any differences between the number of ♀♀ originally selected for the various experiments, and the number used in the analyses, are due to these reasons.

During May 1975, 10 adults (6♂♂, 4♀♀) were collected in the field and returned to the laboratory for observation of precopulatory and copulatory behavior. The 2 sexes were kept in separate mason jars except during periods when notes were taken on sexual behavior.

RESULTS AND DISCUSSION

Fecundity

Intra-group results

Isolated virgin ♀♀ laid an average of 131.83 eggs/♀ (range=12-272), 8.16 eggs/cluster (range=1-25) during their entire life span. The majority of egg clusters (58.76%) consisted of less than 10 eggs (Fig. 1A).

Once-mated ♀♀ averaged 263.25 eggs/♀ (range=204-363), 17.55 eggs/cluster (range=2-38); twice-mated ♀♀, 275.00 eggs/♀ (range=194-353), 18.39 eggs/cluster (range=2-31); and mated-for-life ♀♀, 424.00 eggs/♀ (range=176-654), 20.72 eggs/cluster (range=1-44) during their entire life spans. Three mated-for-life ♀♀ had lifetime fecundities of 628, 645, and 654, and this accounted for this group's high average lifetime fecundity. The most frequent egg cluster sizes were 14 and 28 in each of the mated groups: once-mated (35.71%), twice-mated (42.70%), and mated-for-life (14.76%) (Fig. 1B-D). Rolston and Kendrick (1961) also reported that *E. servus* most frequently laid 14 or 28 eggs/cluster.

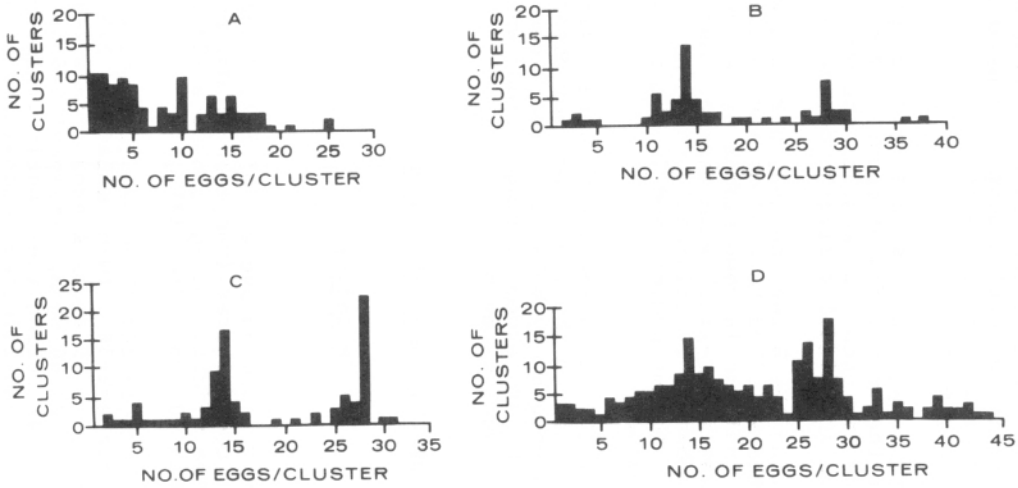

Figure 1. Cluster size frequency of Euschistus servus ♀♀. A, isolated ♀♀; B, once-mated ♀♀; C, twice-mated ♀♀; D, mated-for-life ♀♀.

There was no significant difference between ♀♀ in total fecundity for the 1st 8 weeks of egg production in each of the 4 groups of ♀♀ (Table 1). Also, comparisons within each group of ♀♀, collectively, between 2-week periods showed that age was not a factor (Table 1). This was evident from the original data which showed that ♀♀ were variable in their levels of fecundity for each 2-week period. One ♀ (mated-for-life) laid progressively more, but the remaining ♀♀ fluctuated in fecundity during the 2-week periods (e.g., low during the 1st and 3rd periods, high during the 2nd and 4th periods).

Once-mated vs. twice-mated ♀♀

Once- and twice-mated ♀♀ were compared to determine the effect of one additional copulation on fecundity. There was no significant difference in total fecundity between the 2 groups for the 1st 8 weeks of egg production nor did age affect the groups differently (2-week comparisons) (Table 2).

Once + twice-mated ♀♀ vs. mated-for-life ♀♀

Since no difference in fecundity was found between once- and twice-mated ♀♀, the 2 groups were lumped and compared with mated-for-life ♀♀. No significant difference in total fecundity was found between these groups for the 8-week period nor again, was age a factor (Table 2).

It should be noted that 3 mated-for-life ♀♀ laid over 100 eggs/♀ during weeks 7-8, far above the highest number for either once- or twice-mated ♀♀. This may be the reason why the comparison between the mated-for-life ♀♀ and the lumped once- and twice-mated ♀♀ for this period was closer to being significantly different (> 0.025) than comparisons between the earlier 2-week periods.

All mated ♀♀ vs. isolated ♀♀

Since there was no significant difference between any of the groups of mated ♀♀, they were lumped and compared to the isolated ♀♀ group. The analyses showed that mated ♀♀ laid significantly more eggs during the 8-week period than isolated ♀♀ (Table 3).

Fertility

Intra-group results

Eggs collected from isolated ♀♀ were kept under observation for 5-7 days to detect possible parthenogenesis, but no signs of development were seen. Once-mated ♀♀ averaged 87.27% fertility (range=66.00-97.25%);

Table 1. Comparisons of fecundity between Euschistus servus ♀♀ during the 1st 8 weeks of egg production.

Test Group	Weeks 0-2	3-4	5-6	7-8	χr^2-values (Prob.) Between 2-wk. periods	Between ♀♀
Isolated ♀♀						
1	6	5	0	0		
2	48	10	31	17		
3	2	10	0	0		
4	17	34	0	0		
5	43	0	22	0		
6	12	0	15	0	6.65(>0.05)	7.71(>0.10)
Once-mated ♀♀						
1	56	70	42	55		
2	83	86	85	69		
3	42	28	33	14		
4	28	56	98	20	5.40(>0.10)	7.80(>0.05)
Twice-mated ♀♀						
1	82	84	83	26		
2	63	39	7	43		
3	82	54	31	49		
4	54	83	56	56		
5	84	56	83	28		
6	83	54	67	28	4.25(>0.20)	4.14(>0.50)
Mated-for-life ♀♀						
1	36	102	30	66		
2	26	76	35	47		
3	33	78	98	77		
4	96	55	75	17		
5	28	97	96	66		
6	85	67	86	112		
7	26	30	58	73		
8	135	105	112	108		
9	56	6	33	155		
10	56	49	42	15		
11	56	43	28	40	0.05(>0.99)	16.25(>0.05)

Table 2. Comparisons of fecundity between once-mated, twice-mated, and mated-for-life Euschistus servus ♀♀ during the 1st 8 weeks of egg production.

Weeks	Number of eggs/♀			Mann-Whitney U values(Prob.)	
	Once-mated ♀♀	Twice-mated ♀♀	Mated-for life ♀♀	Once- vs. Twice-mated	Once+Twice vs. Mated-for-life
0-2	28	54	26		
	42	63	26		
	56	82	28		
	83	82	33		
		83	36		
		84	56		
			56		
			56		
			85		
			96		
			135	5.5(>0.08)	43.0(>0.05)
3-4	28	39	6		
	56	54	30		
	70	54	43		
	86	56	49		
		83	55		
		84	67		
			76		
			78		
			97		
			102		
			105	10.5(>0.38)	51.0(>0.05)
5-6	33	7	28		
	42	31	30		
	85	56	33		
	98	67	35		
		83	42		
		83	58		
			75		
			86		
			96		
			98		
			112	8.0(>0.23)	50.5(>0.05)
7-8	14	26	15		
	20	28	17		
	55	28	40		
	69	43	47		
		49	66		
		56	66		
			73		
			77		
			108		
			112		
			155	11.0(>0.45)	29.0(>0.025)
0-8	- -	- -	- -	0.19[a](>0.42)	1.16[a](>0.12)

[a]z-value calculated from Mann-Whitney U value because of large sample size.

Table 3. Comparisons of fecundity between mated and isolated Euschistus servus ♀♀ during the 1st 8 weeks of egg production.

	Number of eggs				
	Mated ♀♀		Isolated ♀♀		
Weeks	N	$\bar{x}$(range)	N	$\bar{x}$(range)	z-values(Prob.)
0-2	21	61.43(28-135)	6	21.33(2-48)	-2.86(<0.003)
3-4	21	62.76(6-105)	6	9.83(0-34)	-2.57(<0.010)
5-6	21	60.86(7-112)	6	11.33(0-31)	-2.54(<0.010)
7-8	21	55.43(14-155)	6	2.83(0-17)	-2.71(<0.004)
0-8	21	240.48(117-460)	6	45.33(11-106)	-6.54(<0.001)

twice-mated ♀♀, 93.76% (range=84.54-99.65%); and mated-for life ♀♀, 85.74% (range=64.69-97.98%) during their entire life spans.

There was no significant difference in fertility between ♀♀ for the 1st 8 weeks of fertile egg production in each of the 3 groups of ♀♀, nor was age a factor (2-week comparisons) (Table 4).

Twice-mated ♀♀, though not significantly different in total fertility for the 8 weeks at the 0.01 level, were at the 0.02 level. The data showed that 2 ♀♀ had 100% fertility for the 8 weeks, whereas the remaining ♀♀ averaged 87.61%. A larger sample size would probably show this difference to be random variation.

Once-mated vs. twice-mated ♀♀

Once-mated ♀♀ were compared with twice-mated ♀♀ to determine if an additional copulation would increase or prolong fertility. However, there was no significant difference in fertility between the 2 groups nor did age affect the groups differently (2-week comparisons) (Table 5).

Once + twice-mated ♀♀ vs. mated-for-life ♀♀

Since no difference in fertility was found between the once- and twice-mated ♀♀, the 2 groups were lumped and compared with mated-for-life ♀♀. Again, no significant differences in fertility were found (Table 5). This was not unexpected since one mated-for-life ♀ was observed

Table 4. Comparisons of % fertility between Euschistus servus ♀♀ during the 1st 8 weeks of fertile egg production.

Test Group	Weeks 0-2	3-4	5-6	7-8	χr^2-values(Prob.) Between 2 wk. periods	Between ♀♀
Once-mated ♀♀						
1	81.08	100.00	100.00	100.00		
2	100.00	100.00	98.82	97.10		
3	97.62	92.86	100.00	92.86		
4	90.00	55.36	87.76	30.00	2.78(>0.30)	5.33(>0.10)
Twice-mated ♀♀						
1	100.00	100.00	100.00	100.00		
2	96.83	82.05	57.14	79.07		
3	97.53	100.00	100.00	100.00		
4	77.78	81.93	80.36	85.71		
5	100.00	100.00	100.00	100.00		
6	100.00	90.74	94.03	78.57	0.20 (>0.99)	13.57(>0.01)
Mated-for-life ♀♀						
1	87.25	96.66	96.96	98.68		
2	68.88	65.38	74.07	83.08		
3	89.17	98.81	82.80	81.00		
4	95.83	100.00	100.00	82.35		
5	83.54	97.33	96.67	88.66		
6	87.18	97.83	99.07	100.00		
7	88.52	93.85	92.59	100.00		
8	99.26	96.19	99.11	96.43		
9	93.04	98.23	98.56	100.00		
10	58.49	88.57	100.00	78.57		
11	100.00	97.67	100.00	100.00	5.15(>0.10)	17.82(>0.05)

in copulo 5 times, but had an overall fertility (94.55%) which fell within the ranges of those for once- and twice-mated ♀♀.

The comparison of fertility for 0-2 weeks between mated-for-life and the lumped once- and twice-mated ♀♀, though not significant at the 0.01 level, was at the 0.05 level. This probably, in part, resulted from the fertilities of 2 mated-for-life ♀♀, which were lower than any in the once- or twice-mated groups during this period.

Table 5. Comparisons of fertility between once-mated, twice-mated, and mated-for-life Euschistus servus ♀♀ during the 1st 8 weeks of fertile egg production.

Weeks	% Fertility			Mann-Whitney U values (Prob.)	
	Once-mated ♀♀	Twice-mated ♀♀	Mated-for-life ♀♀	Once- vs. Twice mated	Once+Twice vs. Mated-for-life
0-2	81.08	77.78	58.49		
	90.00	96.83	68.88		
	97.62	97.53	83.54		
	100.00	100.00	87.18		
		100.00	87.25		
		100.00	88.52		
			89.17		
			93.04		
			95.83		
			99.26		
			100.00	9.5(>0.30)	30.0(>0.025)
3-4	55.36	81.93	65.38		
	92.86	82.05	88.57		
	100.00	90.74	93.85		
	100.00	100.00	96.19		
		100.00	96.66		
		100.00	97.33		
			97.67		
			97.83		
			98.23		
			98.81		
			100.00	12.0(>0.50)	51.5(>0.05)
5-6	87.76	57.14	74.07		
	98.82	80.36	82.80		
	100.00	94.03	92.59		
	100.00	100.00	96.67		
		100.00	96.96		
		100.00	98.56		
			99.07		
			99.11		
			100.00		
			100.00		
			100.00	10.0(>0.38)	50.5(>0.05)
7-8	30.00	78.57	78.57		
	92.86	79.07	81.00		
	97.10	85.71	82.35		
	100.00	100.00	83.08		
		100.00	88.66		
		100.00	96.43		
			98.68		
			100.00		
			100.00		
			100.00		
			100.00	10.5(>0.38)	51.5(>0.05)
0-8	- - -	- - -	- - -	-0.25[a](>0.40)	0.91[a](>0.18)

[a] z-value calculated from Mann-Whitney U value because of large sample size.

Hatch

Intra-group results

The % hatch of once-mated ♀♀ averaged 75.63% (range= 32.24-95.77%); twice-mated ♀♀, 91.66% (range=69.82-98.62%); and mated-for-life ♀♀, 92.12% (range=65.00-99.05%), during their entire life spans.

Age (2-week comparisons) had no significant effect on % hatch within any of the 3 groups of ♀♀, nor were there significant differences between ♀♀ in total % hatch for the 8 weeks within the once- or twice-mated groups (Table 6). However, total % hatch between ♀♀ was close to significantly different in the once-mated group (>0.01). In this group, 1 ♀ had a much lower hatch % (37.18%) than the remaining ♀♀ (90.66%), probably resulting in the high χr^2 value. Larger sample sizes might prove this to be random variation.

Mated-for-life ♀♀ differed significantly in total % hatch. This was probably due to 2 of the 11 ♀♀ which had total % hatches for the 8 weeks of 62.27% and 88.74%, respectively, whereas the remaining 9 ♀♀ averaged 96.44% for the same period.

Failure of fertile eggs to hatch could be predicted during eye spot formation. Fertile eggs which would hatch developed clearly defined red eye spots which could be seen through the opercula. Those which would fail to hatch developed eye spots which appeared blurred, as a red smudge, or were situated on the side of the egg.

Once-mated vs. twice-mated ♀♀

Once- and twice-mated ♀♀ were compared to determine the effect of one additional copulation on % hatch. There was no significant difference in total % hatch for the 8 weeks nor did age affect the groups differently (Table 7).

Though total % hatch was not significantly different at the 0.01 level, it was at the 0.02 level. This probably resulted from one of the once-mated ♀♀ which had an average % hatch of 37.18% for the 8-week period, far below those of the remaining ♀♀ in the once- and twice-mated groups (90.66% and 92.77%, respectively).

Once + twice-mated ♀♀ vs. mated-for-life ♀♀

Since no differences in % hatch were found between once- and twice-mated ♀♀ they were lumped and compared with mated-for-life ♀♀. No significant differences were found in any of the comparisons (Table 7). This indicated that hatch was not affected by age, the number of copulations, or the constant presence of a ♂ during the 8-week period.

Table 6. Comparisons of % hatch between Euschistus servus ♀♀ during the 1st 8 weeks of fertile egg production.

Test Group	Weeks 0-2	3-4	5-6	7-8	χr^2-values(Prob.) Between 2 wk. periods	Between ♀♀
Once-mated ♀♀						
1	50.00	46.51	28.57	23.64		
2	87.95	97.67	94.12	95.59		
3	95.12	100.00	100.00	100.00		
4	88.89	58.06	87.21	83.33	0.30(>0.95)	11.10(>0.01)
Twice-mated ♀♀						
1	71.95	67.85	67.47	73.08		
2	86.89	96.88	100.00	100.00		
3	93.67	100.00	87.10	91.67		
4	100.00	100.00	100.00	97.92		
5	98.81	100.00	97.59	100.00		
6	97.59	97.96	100.00	100.00	1.65(>0.50)	11.00(>0.05)
Mated-for-life ♀♀						
1	100.00	100.00	100.00	89.33		
2	87.10	88.24	95.00	98.15		
3	99.07	100.00	98.70	98.77		
4	93.48	100.00	93.33	92.86		
5	96.97	94.52	97.70	91.86		
6	100.00	100.00	99.06	100.00		
7	96.30	98.36	84.00	91.11		
8	100.00	100.00	94.59	100.00		
9	98.13	99.10	100.00	96.30		
10	61.29	69.35	63.89	54.55		
11	98.04	95.24	64.71	96.97	4.96(>0.10)	24.61(<0.01)

Table 7. Comparisons of % hatch between once-mated, twice-mated, and mated-for-life Euschistus servus ♀♀ during the 1st 8 weeks of fertile egg production.

Weeks	% Hatch			Mann-Whitney U values(Prob.)	
	Once-mated ♀♀	Twice-mated ♀♀	Mated-for-life ♀♀	Once- vs. Twice-mated	Once+Twice vs. Mated-for-life
0-2	50.00	71.95	61.29		
	87.95	86.89	87.10		
	88.89	93.67	93.48		
	95.12	97.59	96.30		
		98.81	96.07		
		100.00	98.04		
			98.13		
			99.07		
			100.00		
			100.00		
			100.00	7.0(>0.10)	33.5(>0.05)
3-4	46.51	67.85	69.35		
	58.06	96.88	88.24		
	97.67	97.96	94.52		
	100.00	100.00	95.24		
		100.00	98.36		
		100.00	99.10		
			100.00		
			100.00		
			100.00		
			100.00		
			100.00	6.5(>0.10)	46.0(>0.05)
5-6	28.57	67.47	63.89		
	87.21	87.10	64.71		
	94.12	97.59	84.00		
	100.00	100.00	93.33		
		100.00	94.59		
		100.00	95.00		
			97.70		
			98.70		
			99.06		
			100.00		
			100.00	8.5(>0.20)	52.0(>0.05)
7-8	23.64	73.08	54.55		
	83.33	91.67	89.33		
	95.59	97.92	91.11		
	100.00	100.00	91.86		
		100.00	92.86		
		100.00	96.30		
			96.97		
			98.13		
			98.77		
			100.00		
			100.00	7.5(>0.10)	53.0(>0.05)
0-8	- -	- -	- -	-2.21[a](>0.01)	0.74[a](>0.20)

[a]z-value calculated from Mann-Whitney U value because of large sample size.

Preoviposition and Interoviposition Periods and Life Spans

Preoviposition period

A comparison of preoviposition periods between mated-for-life and isolated ♀♀ showed that there was no significant difference between the 2 groups (Table 8). An insufficient number of ♀♀ were available at the time ♀♀ used in the once- and twice-mated experiments emerged for establishment of all pairs simultaneously. Also, these ♀♀ emerged over an extended period of time and were of different ages when they were eventually paired. Thus, they could not be used in this comparison.

Interoviposition period

There was no significant difference in interoviposition periods between once- and twice-mated ♀♀, nor when these groups were lumped and compared with mated-for-life ♀♀ (Table 9). When the 3 groups of mated ♀♀ were lumped and compared with isolated ♀♀, there was again no significant difference. However, they were different at the 0.025 level suggesting a trend toward isolated ♀♀ having longer interoviposition periods. Larger sample sizes are needed to clarify this point.

Life span

There was no significant difference in life span between once- and twice-mated ♀♀, nor when these groups were lumped and compared with mated-for-life ♀♀ (Table 9). However, when the 3 groups of mated ♀♀ were compared with isolated ♀♀, the life span of isolated ♀♀ proved to be significantly longer (Table 9).

That virgin ♀♀ have a longer adult life span than mated ♀♀ has been shown in a number of other studies. For example, Bilewicz (1953) found that mating and subsequent egg laying decreased the life span of *Drosophila melanogaster* Meigen. Maynard Smith (1958) and Lener (1967) reported that virgin ♀♀ of *Drosophila subobscura* Collin and the large milkweed bug, *Oncopeltus fasciatus* (Dallas), respectively, lived significantly longer than did normal mated ♀♀. Mitchell and Mau (1969) found that mating activity significantly shortened the life of both sexes of the southern green stink bug, *Nezara viridula* (L.).

Additional Comments

Four ♀♀ in the 3 groups of mated ♀♀ were never observed *in copulo* and never laid fertile eggs. The data

Table 8. Comparison of preoviposition periods between mated-for-life and isolated Euschistus servus ♀♀.

Test Group	N	Days $\bar{x}$(range)	Mann-Whitney U-value(Prob.)
Mated-for-life ♀♀	11	23.18(12-46)	
Isolated ♀♀	6	19.83(17-24)	30.00(>0.05)

Table 9. Comparisons of interoviposition period and of life span between once-mated, twice-mated, mated-for-life, and isolated Euschistus servus ♀♀.

Test Group	N	Days $\bar{x}$(range)	Mann-Whitney U values(Prob.) Once- vs. Twice-mated	Once+Twice vs. Mated-for-life	All mated vs. Isolated
		Interoviposition Period[a]			
Once-mated ♀♀	4	5.40(3.67-8.00)			
Twice-mated ♀♀	6	5.18(3.39-7.00)	10.0(>0.30)		
Mated-for-life ♀♀	11	4.41(3.24-7.13)		33.0(>0.05)	
Isolated ♀♀	6	8.42(3.57-34.00)			24.0(>0.01)
		Life Span			
Once-mated ♀♀	4	100.00(84-140)			
Twice-mated ♀♀	6	93.67(69-115)	11.5(>0.45)		
Mated-for life ♀♀	11	118.45(81-182)		30.0(>0.025)	
Isolated ♀♀	6	175.67(143-244)			7.0(<0.001)

[a]Based on average interoviposition period for each ♀ during the 1st 8 weeks of egg production.

from these ♀♀ were compared with fertile and isolated ♀♀. The analyses showed that their fecundities and life spans were comparable to those of the isolated ♀♀ (Table 10). This suggests that the mere presence of a ♂ has no stimulatory effect on the ♀, but that copulation, fertilization, or both are necessary for high fecundity.

Mating Behavior

Precopulatory and copulatory behavior were observed in the laboratory between 4 pairs of animals. Courtship was initiated by the ♂ who began by palpating the ♀'s head, antennae, and pronotum with his antennae. He then moved posteriorly, palpating along her side. Then while palpating the underside of her abdomen, he attempted to raise her posterior end by nudging movements of his head. If the ♀ was receptive, she raised her abdomen until her body formed ca. a 35° angle with the substrate. He then pivoted 180° and, with aedeagus extended, backed toward the ♀. He raised his abdomen until it was approximately at the same angle as the ♀'s, and upon contact with her abdomen, he moved his abdomen slightly from side to side until his aedeagus entered her genital opening. There was a slight jerking of his body during insertion. During copulation, the ♂ rested his hind legs on hers, their bodies forming ca. a 40° angle with the substrate. An unreceptive ♀ did not raise her abdomen and often kicked at the courting ♂. An unsuccessful courtship could last up to 10 minutes. If the ♀ was receptive, copulation was initiated in as little as 3 minutes. Pairs remained in copulo from 3 to 56 hours and were observed feeding during this time.

CONCLUSIONS

The results of our experiments showed that: (1) neither the number of copulations beyond 1 nor age had an effect on fecundity, fertility, or hatch during the 1st 8 weeks of egg production, and (2) virgin ♀♀ lived longer than mated ♀♀ but laid fewer eggs.

These results are not unexpected when viewed from a possible selective advantage standpoint. It would seem advantageous to the species if 1 fertilization could provide a ♀ with enough sperm to maintain a high fertility level for most or all of her adult life. Also, it would be advantageous for copulation and/or fertilization to result in higher fecundity since eggs of virgin ♀♀ are non-productive. Finally, it would appear beneficial for virgin ♀♀ to live longer than mated ♀♀, thus increasing their chance of copulation.

Table 10. Comparisons of fecundity and of life span between isolated and infertile mated-for-life Euschistus servus ♀♀.

Variable	Isolated ♀♀	Infertile mated-for-life ♀♀	Mann-Whitney U values(Prob.)
Fecundity (eggs/♀)	12	47	
	64	125	
	89	210	
	174	250	
	180		
	272		10.0(>0.38)
Life span (days)	143	139	
	146	144	
	148	202	
	177	236	
	196		
	244		11.0(>0.45)

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