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ADULT BIOLOGY OF THE ALBIZIA BORER, *XYSTROCERA FESTIVA* THOMSON (COLEOPTERA: CERAMBYCIDAE), BASED ON LABORATORY BREEDING, WITH PARTICULAR REFERENCE TO ITS OVIPOSITION SCHEDULE

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MATSUMOTO, K. & IRIANTO, R.S.B. 1998. Adult biology of the albizia borer, *Xystrocera festiva* Thomson (Coleoptera: Cerambycidae), based on laboratory breeding, with particular reference to its oviposition schedule. Adult survivorship and the oviposition schedule of *Xystrocera festiva* were studied under laboratory conditions. The average adult longevity after emergence from field collected logs was 9.4 days for males and 4.7 days for females. The species was extremely semelparous, laying eggs altogether in one or two clusters, mostly within two days following emergence. The average number of eggs laid per female was 169.2 and the average egg cluster size was 125.6. It was confirmed by dissection that newly emerged females contained an average of 179.3 fully mature eggs, and total egg production per female, calculated as the sum of eggs laid and those remaining in the ovary until death, was 196.8 on average, both representing fecundity. These values varied considerably among individuals, yet power regression of the fecundity as a function of elytral length accounted for most of the variation.

Key words: Stem borer - *Paraserianthes falcataria* - *Acacia mangium* - *Archidendron jiringa* - survivorship - oviposition - Indonesia

MATSUMOTO, K. & IRIANTO, R.S.B.1998. Biologi pengorek albizia dewasa, *Xystrocera festiva* Thomson (Coleoptera: Cerambycidae), berdasarkan pembiakan makmal, dengan rujukan khusus kepada jadual pengoviposiannya. Pemandirian dewasa dan jadual pengoviposian *Xystrocera festiva* dijalankan di bawah keadaan makmal. Kelanjutan umur purata selepas kemunculan daripada balak yang diambil di ladang ialah 9.4 hari bagi pengorek jantan dan 4.7 hari bagi pengorek betina. Spesies tersebut sangat 'semelparous', mengeram telur semuanya dalam satu atau dua kelompok, kebanyakannya dalam masa dua hari selepas kemunculannya. Purata

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supplied in the laboratory, i.e. folded paper, five pieces of cardboard tied up (each 5 × 5 cm), two pieces of albizia bark stapled together (each *c.* 5 × 5 cm). However, it was difficult to count the eggs in most cases, because the eggs were congregated into a multi-layered mass, tightly glued to each other by a yellow female secretion. Each female was therefore supplied with an artificial oviposition site constructed of two transparent plastic plates and two pieces of cardboard (each 5 × 5 cm) tied up and wired together alternately. This devise forced the female to lay an egg cluster in a single layer in the thin gap between the plastic plate and the cardboard, and thus we could count the eggs easily.

Fecundity was assessed by dissecting two groups of females. Firstly, 16 of the above-mentioned 19 ovipositing females were dissected shortly after they died, and the number of eggs remaining in their ovaries plus those they laid were considered to be the fecundity. Secondly, 44 freshly emerged unmated females which had not oviposited were dissected and the number of eggs in their ovaries was recorded as another measure of the fecundity, provided that there would be no additional egg formation and development.

Results

Sex ratio

The number of adults that emerged was variable among the cohorts, ranging from 4 to 149, and the sex ratio in each cohort was also variable, including a significantly male-biased cohort, Pf-5, and a significantly female-biased one, Pf-11 (Table 1). However, the ratio for all individuals of the 15 cohorts together was not significantly different from a 1:1 sex ratio (Table 1), suggesting that the adult sex ratio is basically equal.

Temporal pattern of emergence

The adult emergence period was approximately one month or less in six cohorts, suggesting synchronised immature development (Figure 1). In one cohort (Am-3), however, three males and three females emerged more than two months after the onset of emergence, the latest being a male occurring 101 days later (Figure 1).

The emergence within a cohort was mostly protandrous. In two cohorts with a statistically testable population size (Kolmogorov-Smirnov test), however, significant differences were detected in the timing of emergence between the two sexes in opposite ways: the emergence sequence was protandrous in one cohort ($\chi^2 = 8.922$, df = 2, $p < 0.05$), whereas it was protogynous in the other ($\chi^2 = 8.244$, df=2, $p < 0.05$). The emergence of the 11 cohorts from Ngancar occurred in January, February, March, June, July, August, September, October, November and December, and those of the 4 cohorts from Benakat in January, February, March, April, September, October, November and December. Therefore, it seems that adult emergence occurs continuously throughout the year. This point remains to be further confirmed with field data.

Table 1. Number of male and female adults of *Xystrocera festiva* which emerged from *Archidendron jiringa* (Aj) and *Acacia mangium* (Am-1, -2 and -3) from Benakat, and *Paraserianthes falcataria* (Pf-1, -2...-11) from Ngancar. G-test tests significance of the deviation from a 1:1 sex ratio.

Tree/cohort code	No. of adults			G-value
	Male	Female	Total	
Aj	20	16	36	0.4454
Am-1	17	12	29	0.8664
Am-2	1	3	4	-
Am-3	41	48	89	0.5511
Pf-1	34	32	66	0.0606
Pf-2	10	8	18	0.2227
Pf-3	6	7	13	0.0770
Pf-4	9	7	16	0.2507
Pf-5	22	10	32	4.6119*
Pf-6	14	16	30	0.1334
Pf-7	6	10	16	1.0107
Pf-8	9	12	21	0.4300
Pf-9	0	7	7	-
Pf-10	9	19	28	3.6515
Pf-11	62	87	149	4.2145*
Total	260	294	554	2.0880

*: Significant at 95% level.

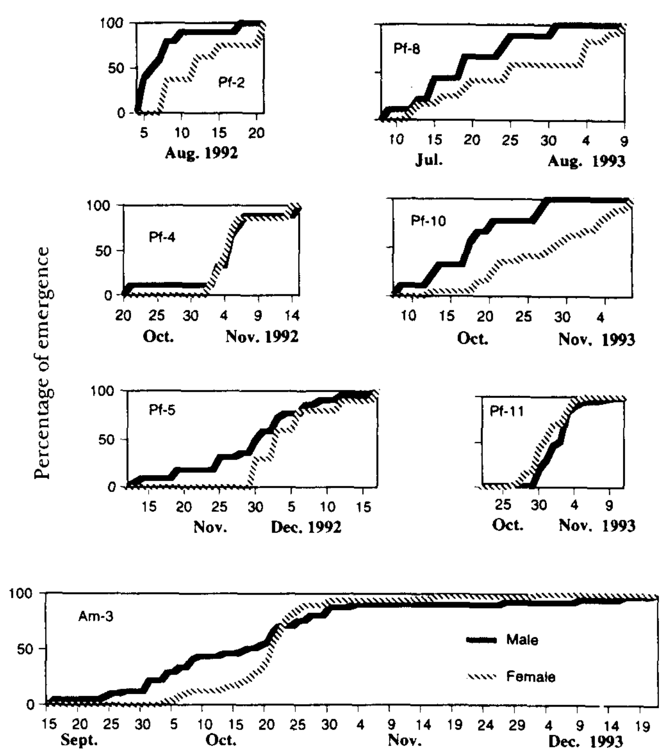

Figure 1. Cumulative emergence curves for male and female adults of *Xystrocera festiva*. The tree/cohort codes given for each graph correspond to those in Table 1.

Longevity

The adults were short-lived, and females lived shorter than males (Figure 2). Average post-emergence longevities (±SE) of males and females were 9.4 ± 0.8 days (ranging from 4 to 15 days) and 4.7 ± 0.6 days (ranging from 1 to 10 days) respectively.

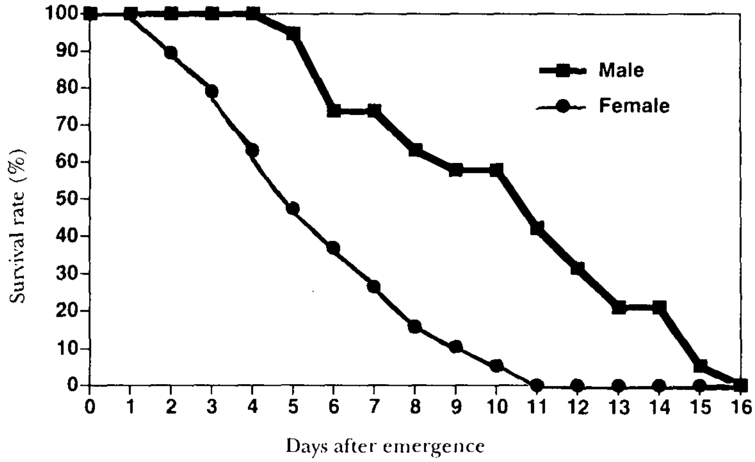

Figure 2. Post-emergence survivorship curves for male and female adults of *Xystrocera festiva* kept under laboratory conditions (n = 19 for both sexes)

Oviposition

Mating always took place immediately after the adult pair was put into the same container. Most females oviposited within 2 days of emergence, and the average preoviposition period (from emergence from the log) was 1.2 ± 0.3 days (Figure 3). The average number of eggs laid per female was 169.2±9.9 (n=19). Most females laid eggs in a single cluster. Only 3 out of the 19 females laid 2 clusters of eggs; 1 female laid them on the same day and the other 2 on different days.

Besides the above 22 egg clusters laid by the 19 experimental females, the numbers of eggs in 11 clusters laid in preliminary experiments were also available for analysis. The egg cluster size was variable, and the average size for the 33 egg clusters was 125.6 ± 11.1 (Figure 4).

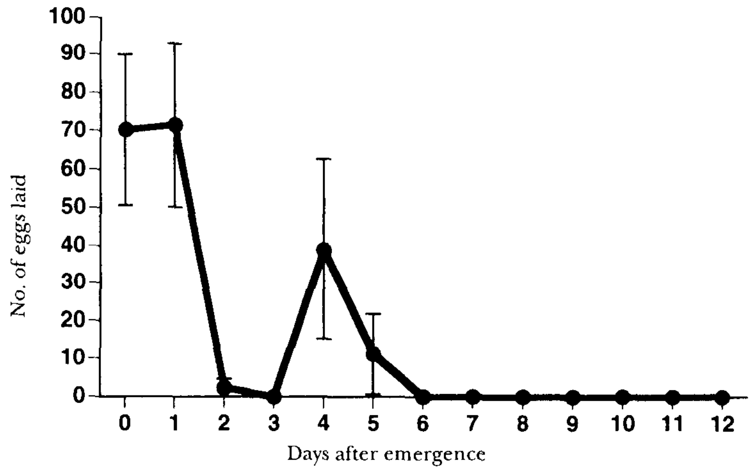

Figure 3. Average number of eggs laid per day per female *Xystrocera festiva* (n=19)

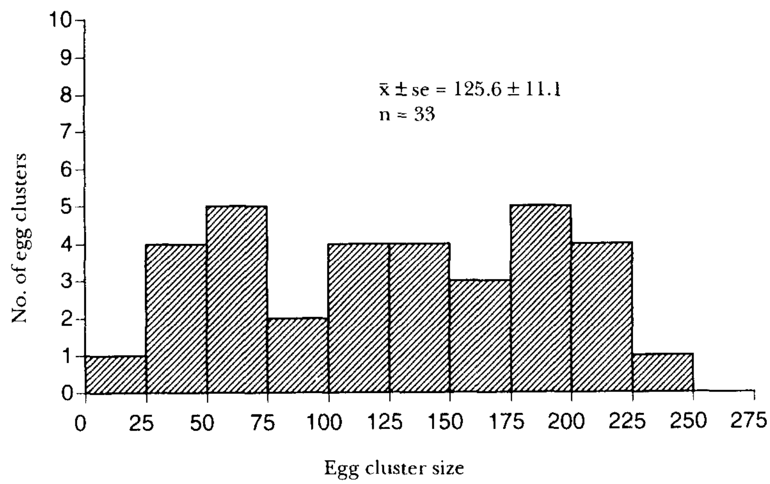

Figure 4. Frequency distribution of egg cluster size of *Xystrocera festiva*

After oviposition, the female abdomen remained hollow throughout the later part of life (as was seen through semi-transparent segments), suggesting that there was no additional egg formation or development. By dissecting 16 out of the 19 females after they died, we found 22.3 ± 7.5 eggs remaining in their ovaries. There were no immature oocytes or degenerated eggs, further indicating that additional eggs did not form and mature eggs were not resorbed. Given this, and that the average number of eggs laid by these 16 females was 174.6 ± 11.4, their fecundity could be 22.3 + 174.6 = 196.9 eggs, of which an average of 88.7% were actually laid.

We also dissected 44 females just after emergence from logs. Their abdomens were full of mature eggs, and immature oocytes were rare. Only 8 and 20 immature oocytes were found among the many mature eggs in just two females, indicating that maturation of eggs occurred before emergence of females. An individual female had 179.3 ± 10.5 eggs on average, but the number of eggs varied among individuals, ranging between 62 and 320.

The fecundity measured in the above two ways was correlated with female body size as expressed by the length of elytra (Figure 5). The power regression of the total number of eggs (Y) on the elytral length (X; in mm) was

$$Y = 0.0313X^{2.803} \qquad (r = 0.733),$$

for the 16 females dissected after oviposition, and a similar regression equation for the 44 females dissected before oviposition was

$$Y = 0.0211X^{2.899} \qquad (r = 0.958).$$

The above two regression equations were not significantly different (t - test: $df = 56$, $t = 0.125$, ns for the power; $df = 57$, $t = 0.183$, ns for the coefficient). This again supports the fact that maturation of the eggs occurs before emergence and eggs are not added or resorbed afterward. Therefore, the counts of eggs in the above two ways are both good measures of fecundity. The regression equation for the combined data for females which oviposited and for those females which did not was

$$Y = 0.0192X^{2.928} \qquad (r = 0.924).$$

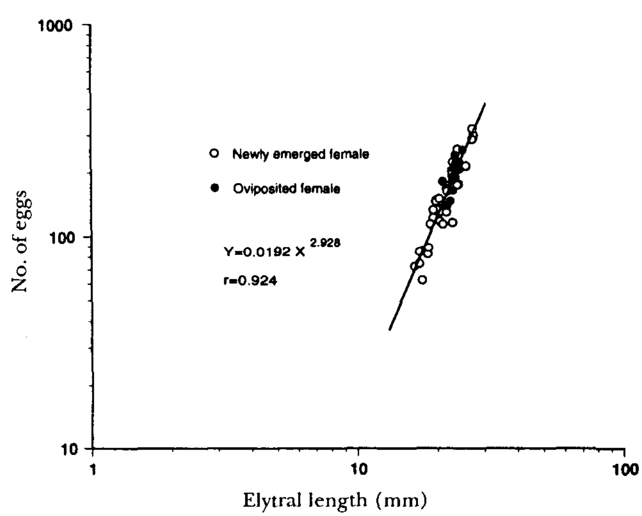

Figure 5. Total number of eggs in the ovaries of newly emerged females or total number of eggs laid plus those remaining in the ovaries of females of *Xystrocera festiva*, plotted against their elytral lengths on a log-log scale. The regression line and equation for the two groups of females combined together are also given.

Discussion

As mentioned previously, original works on the adult biology of *X. festiva* have been rather few, with quantitative data of longevity and fecundity briefly given by Franssen (1937) and Notoatmodjo (1967) based on materials from Java, and by Abe (1983) based on those from Sabah, Borneo.

The average female longevities (4 or 5 day) recorded in these previous studies are similar to that obtained in the present study. However, the average male longevity in the present study (9.4 days) is somewhat longer than the 7 days reported by Franssen (1937) and Notoatmodjo (1963). Abe's (1983) recorded male longevity of 2 to 3 days is much shorter than those in the other studies. In these previous studies, whether the adult beetles were supplied with water was not mentioned, but if not, we suspect that a lack of water or dry conditions may reduce male longevity. The short longevity of the females is reasonable, because most of them finish oviposition within two days of emergence, and after that they have no reproductive value.

Maximum egg production of up to 400 per female reported by Franssen (1937) has been frequently cited and is supported by Notoatmodjo's (1963) observed maximum of 457 eggs per female. However, we are of opinion that these values are rather rare. In the present study the maximum fecundity recorded was 320 eggs, and fecundity was a function of elytral length. The regression equation indicated that a female capable of producing 400 eggs must be unusually large, with an elytral length of 29.9 mm, and in the case of a female capable of producing 457 eggs, her elytra must be as long as 31.2 mm. Although we had collected over 300 females from the field, the maximum elytral length recorded was only 28.5 mm. In addition, Franssen (1937) and Notoatmodjo (1963) did not mention whether they kept the insects separately in their experiments, but if not, it must be noted that different females may cumulatively oviposit at the same site. We even found an extremely large cluster of eggs, amounting to over 1000 in the holding cage, due to cumulative oviposition by several females under crowded conditions. Abe (1983) dissected five emerged females and found 92 to 143 eggs in their ovary. He probably dissected relatively small individuals.

Species of the subfamily Cerambycinae to which the genus *Xystrocera* belongs, tend to be more semelparous compared to the iteroparous laminine species (Matsumoto *et al.* 1996; see also Adachi 1988, for a review of laminine oviposition schedules). In the congeneric *X. globosa*, for example, females also have fully mature eggs at emergence, and they oviposit several times during the one week or less of their oviposition period (Matsumoto *et al.* 1996). *Xystrocera festiva* is particularly unique in that females mostly lay eggs altogether in a single cluster, representing an extreme case of semelparity in the Cerambycidae.

Since the females are so semelparous and oviposit shortly after emergence, they have a limited chance to distribute their offspring over the forest. Although detailed study on their dispersal by flight is lacking, the full batch of mature eggs may be a heavy load and limit the female pre-oviposition flight. Natawiria (1972/

1973) mentioned that the adults fly only 3 - 4 m at once. In addition, the insect takes 6 to 8 months (Franssen 1937) or 4 to 7 months (Notoatmodjo 1963) from oviposition to adult emergence. As a consequence of these factors, the population would spread rather slowly, even though the population density can increase locally. This coincides with the real conditions in the field. In a commercial plantation of *P. falcataria* in Sabah, the infestation rate was higher in the compartments near an adjoining secondary forest than further away, and the secondary forest was supposed to be the "hot bed" of the insect (Abe 1983). In the Benakat Trial Plantation, the infestation of *Paraserianthes falcataria, Acacia mangium* and *A. auriculiformis* was concentrated in the compartments near two adjoining villages, the older habitats where the insect was found infesting traditionally planted *Archidendron jiringa* as well as introduced *P. falcataria* and *Albizia chinensis* (Matsumoto 1992, Matsumoto *et al.* 1994).

The semelparous cluster oviposition and the gregarious feeding habit maintained throughout the larval period provide useful bases for demographic analysis of the field population of *X. festiva*. In the field, colonies of middle instar larvae and later stages within an area can be easily counted, because of their conspicuous feeding damage, and the count represents the number of cohorts that originated from respective egg clusters, a good measure of population. Fortunately, since the larval colonies are only one or a few on a tree and different colonies seldom join each other, we can simply count the number of currently infested parts as that of colonies. The average number of adults emerged per cohort can be known by counting the emergence holes which they leave on the bark (and also the number of individuals reaching the pupal stage can be known by counting their boreholes, if necessary). Given this, and counting the number of colonies with emergence holes, we can estimate the total number of adults emerged in a given area. Furthermore, in most cases, an egg cluster is the only one and therefore total reproductive output of a female. Therefore, we can also estimate the number of females of the previous generation contributing to the present generation. In practice, the number may be slightly fewer than the number of colonies they produced, because of the presence of a small portion of females which lay 2 egg clusters. In the present study, 22 egg clusters were laid by 19 females including 3 females which oviposited twice, hence the number of females could be 86.4% (=19/22) of the number of colonies they produced, or 27.3% (=6/22) of the colonies could be from the females which laid 2 egg clusters. With some additional data, such as sex ratio and egg cluster size, further deduction is also possible for survival rate, female reproductive success, population change, etc., and thus field population studies in combination with the laboratory results presented here should be promising.

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