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Seasonal abundance of *Epilachna vigintioctopunctata* on *Solanum torvum* in highland area of Sukarami, West Sumatra

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Abstract. The seasonal abundance of *Epilachna vigintioctopunctata* on *Solonum torvum* in highland area of Sukarami, West Sumatra has been studied. In a Sumatran highland (Sukarami, 928 m altitude, annual rainfall 2,900 mm, mean monthly temperature 20.8 - 21.4 ºC), the lady beetle species, *E. vigintioctopunctata* (hereafter abbreviated as EV) commonly occur on the solanaceous host plants such as egg plant and a weed *Solanum torvum*. EV frequently reached a high density to deplete the plants. Seasonal change in abundance and mortality of the EV populations was studied for nine consecutive years (1991 to 2000) in three sites of *S. torvum* fields in Sukarami. The census interval for checking EV was three to four days from the start of study until February 4, 1992 and then seven days until the end of study. The adult beetles found for the first time were sexed and their elytral spot patterns were recorded. Soon after individual beetles were marked in the field with color lacquer, they were immediately released on the same plant. The result of experiment show that: (1) The adult of EV fluctuated synchronously at three study sites; (2) The density index of EV adults on "old" and "new" plants combined varied from 0.13 to 1.25; 3) The fecundity index varied from 0 to 10.33; (3) The average Minimum Length of Residence (MLR) value for females and males was 9.7 days (range from 0 to 170 days, SE = 0.34) and 11.1 days (range from 0 to 161 days, SE = 0.34); (4) An intimate relation was found between changes of *øi* and *Ni*: Drop of *øi* was followed by decrease of *Ni* and rise of *øi* by increase of *Ni*; (5) The survival rate varied from 0.61 to 1.00, and (6) The immature stages also perform several high peaks.
Key Words: Lady beetle, rainfall, fecundity index, generation cycle, population.

Introduction. The long-term dynamics of phytophagous lady beetle *Epilachna* population dynamics under different climatic conditions in Indonesia was studied for several years. In most populations, adult number changed largely with the formation of high peaks from time to time at intervals of 6 - 12 months (Nakamura et al 2001). Nakamura et al (2001) further mentioning that increase and decrease of the EV population its take time around 3 to 5 months and the adult emergence showed dicrete peaks at a fixed interval. During the phase of population increase the generation cycle performed were very clear.

In this article, we aim to ask the same questions again: (1) How the rainfall change, especially strong droughts due to *El Niño*, affected the host plants and populations?; (2) How frequent food depletion occurred?; (3) How large was the amplitude of the fluctuation?; (4) Whether discrete generations occur or not?; (5) Whether adjacent populations fluctuated independently or synchronously?; (6) How are the mortality factors and how large they are?; (7) How and why peaks of adult number were formed?; (8) How are the life table parameters?. We will present the detailed analyses of adult populations and immature stages as well. Especially, we will compare the present results obtained in Sukarami with those of Padang. Padang and Sukarami are only 40 km apart, but habitat conditions are very different in many aspects: elevation (lowland vs. highland), temperature (hot vs. cool), rainfall (torrential heavy rain vs.

drizzling rain with misty fog).

The lady beetle, *Epilachna vigintioctopunctata* Fabricius (Coleoptera: Coccinellida: Epilachninae) (hereafter abbreviated as EV) is a serious pest of solaneceous crops such as eggplants and potatoes over a broad geographical area from Japan (Nakamura 1976; Abbas 1985) to South Asia and Australia (Richards 1983; Kalshoven 1981). This insect found in various kinds of crops and weeds belonging to the Solanaceae such as eggplant (*Solanum melongena*), rimbang (takokak) (*S. torvum*), potato (*S. tuberosum*), and *Centrosema fubescens* (Leguminosae) and *Chromolaena odorata* (Compositae) (Katakura et al 2001). The beetle is also found on *S. jamaicense*, *Pysalis angulata* and on kecubung (*Pseudotaura suateolens*) in the mountains area (Kalshoven 1981). Most important host plants of this species in Indonesia may be eggplant and a weedy shrub, *Solanum torvum* (rimbang [Sumatra] or takokak [Sunda] or pokak [Java] in local languages).

EV in West Sumatra province at a widespread altitude from 0 to 1,400 m it is one of the most abundant epilachnine pests in the province (Katakura et al 1988, 2001). In Sukarami, EV is commonly found with *E. enneasticta* (EN) on *S. torvum*. EV frequently reached a high density to deplete the plants

The field census was conducted in the experimental fields of Sukarami Assessment Institute for Agricultural Technology (SAIAT, formerly Sukarami Research Institute for Food Crops) Sukarami, West Sumatra, Indonesia. It is located on highland area (928 m altitude) about 40 km northeast of Padang (capital city of the province of West Sumatra) and is very wet with drizzling rain almost everyday. The climate data (rainfall and temperature) collected by SAIAT are available. The average values over 22 years (1960 - 1982) are as follows: annual rainfall was 2,917 mm and monthly rainfall fluctuated from 145 mm (July) to 340 mm (November). Mean monthly temperature ranged from 20.8 ºC to 21.4 ºC (Nakamura et al 2001).

Material and Method

Study site. In the experimental field of SAIAT, we established the main study site in December, 1991 by planting ten *S. torvum* seedlings at 9 m interval, and additional six plants were planted in January 1993. Two sub sites (A and B) were established in January 1992, each containing ten *S. torvum* seedlings to compare the seasonal trends of EV populations among the three sites. The main site, the sub sites A, and B are linearly located at about a 900 m interval on a hilly slope on the experimental field of SAIAT. The census for the sub sites A and B stopped at the end of February 1998. On April 1996 ten *S. torvum* seedlings were additionally planted among the old plants in all sites. The area of the study sites were surrounded by bananas (*Musa sapientum*), coffees (*Coffea sp.*), pastures, avocados (*Persea americana*) and red peppers. Soil type is Andosol. To maintain the study sites in a good condition weeds within 1 m of *S. torvum* plants were removed, cow manure was given as fertilizer, and *S. torvum* branches were pruned in order to maintain the plant height around 1.25 m. This maintenance was carried out every two months.

Study period. The study was carried out from 17 December 1991 to 29 March 2000 on the main site and until February 1998 on the sub sites A and B. The census interval for checking EV was three to four days from the start to February 4, 1992 and then seven days until the end of study. The number of host plant leaves, flowers and fruits was recorded once a month.

Routine census

Adult. All adult beetles found for the first time were sexed and their elytral spot patterns were recorded. Soon after individual beetles were marked in the field with color lacquer, they were immediately released on the same plant. The marking was done in order to avoid the double counting and to estimate the adult population parameters such as population size and survival rate using the Jolly (1965) - Seber (1973) method. Unless

specified, the two sexes were jointly processed throughout the Jolly-Seber analysis, because in the most cases the parameters estimated did not show significant sexual differences.

Minimum length of residence (MLR) was determined from the distribution of the interval between the first and last captures. For individuals captured only once, MLR was operationally treated as 0 day.

Immature stages

Egg. Eggs were laid in batches on the undersurface of leaves, stems and flowers of the host plants. All egg masses found were counted and labeled to prevent double counting. The total number of laid eggs was obtained by summing up these data. The number of eggs hatched was assessed by counting the empty shells which remained after hatching. Eggs attacked by parasitic wasps developed black spots and then became dark. All egg masses attacked by parasitism were brought to laboratory to rear the wasps. Egg masses cannibalized by adults were recognized by the basal parts of the chorions remaining on the leaves, early instar larvae also cannibalized eggs. Eggs attacked by predacious bug, *Cazira chiroptera* (Pentatomidae) could be distinguished by specific traces left on the eggs after sucked by the bug, *i.e.*, the eggs became empty and shrunk. The eggs which remain unhatched and shriveled were categorized as "failure to hatch" in the life table. The eggs which disappeared without trace in the following census were referred to as "missing". Egg cannibalism by adults and larvae was observed occasionally. Number of eggs cannibalized was counted only when it was observed in the field.

Larva. The size of larva in early instars was too small to be counted accurately. Therefore only fourth instar larva (hence force abbreviated as L4) were counted on the host plants. Number of larvae attacked by parasitic wasps (*Pediobius foveolatus*) was assessed by direct counting of corpses which became dark brown and remained on the host plants. All the fourth instar larvae attack by parasitism was brought to the laboratory to rear the wasps.

Pupa. The full-grown larva chiefly pupated on the undersurfaces of the host plant leaves. The number of pupa may be largely underestimated, because some fraction of fourth instar larvae pupated on the ground or on grasses near the host plants. All pupae were labeled to prevent double counting. Numbers of pupae attacked by parasitic wasps (*P. foveolatus*) were assessed by direct counting of corpses which became dark and remained on the host plants. All the pupae attack by parasitism was brought to the laboratory for rear the wasps. The pupas which dried up and became dark were categorized as "death" in the life tables.

New adult. The number of newly emerged adults was estimated by direct counting of pupal exuviae. The estimation was largely underestimated, because exuviae tended to be lost soon after adult emergence.

Density index of adults. An index of adult density (ID) was operationally derived as follows:

$$ID = \frac{\text{Adult number at the census when host plant were counted}}{\text{Total number of host plant leaves in the monthly census}}$$

Fecundity index. Direct estimation of the mean fecundity, i.e., the mean number of eggs laid per female, is difficult to measure under natural conditions. Therefore, the fecundity index per female in a month is given by: Ei / Ai, where Ei = total number of eggs laid during the month and Ai = the accumulated number of adults found during the month (we assumed a 1:1 sex ratio).

Separation of successive generations. Compared with fluctuation in the number of adults, those successive immature stages have repetitions of more distinct peaks and toughs as a whole. However, the discreteness becomes less clear at low population density. Various methods so far invented for construction of life tables are applicable only to organisms with discrete or completely overlapping generations (Southwood 1978) and are not suitable when generations are mostly discrete but partially overlap.

To distinguish successive generations, the following procedure was tentatively adopted. The number of egg laid per day, fluctuated distinctly, with peaks and valley approximately at definite intervals. This trend, which was traced through the fourth instar larvae and pupa to emergence, was particularly clear during the high density periods, exhibiting a distinct "serration", or discrete generations (Nakamura et al 1990). Distinct valley was considered to be changes of generations. Serration was less clear in the low densities periods in adults.

Results and Discussion

Number of observed adults. On the main site adult number fluctuated widely from 0 to 135 (the highest was observed in late May, 1997) as shown in figure 1.

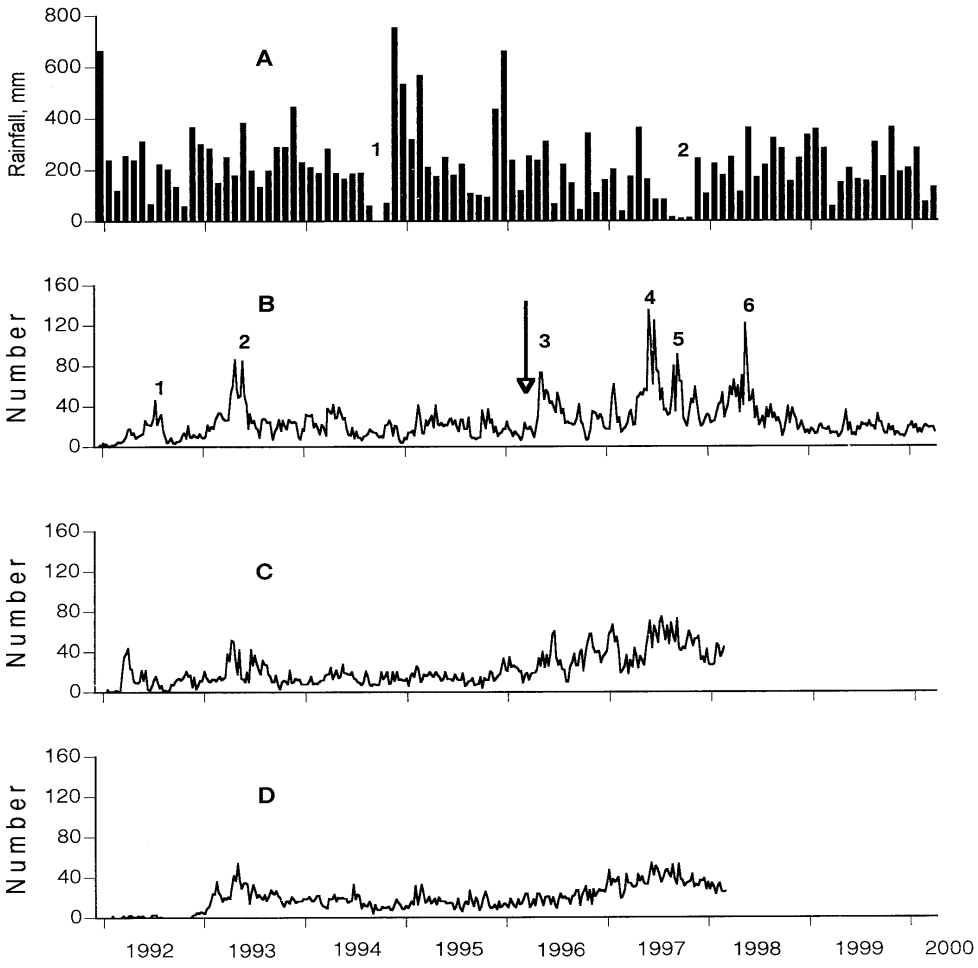

Figure 1. Seasonal change in monthly rainfall (A), and in number of *Epilachna vigintioctopunctata* adults in the main site (B), and sub sites A and B (C and D) during the study period in Sukarami, West Sumatra. Arrow indicates the planting of the "new" plants. Numerical in A main A and B indicates the drought period and major peak, respectively.

Figure 1 above shows that the number of adult of EV fluctuated synchronously between adult EV at the main site (Figure 1B), with the sub site A (Figure 1C) and at the sub site B (Figure 1D). During the study period we observed six major distinct peaks. The highest EV population was observed at the main site in late of May, 1997 with a number of 135 individuals. The result of research was conducted in Padang, the adult number fluctuated

violently and exhibited three major peaks in 3 years. Peak formation increase and decrease was gradual, taking 3 - 5 months or around 3 - 4 generations, just as reported by Nakamura et al (1990) and Inoue et al (1993). In other research conducted in Bogor (Nakamura et al 2001; Kahono 1999), the trends in the population of adult EV was found synchronous among the three sites in Sukarami (each around 900 m apart) and was found not always synchronous between two sites in Bogor (400 m apart).

Number estimated by Jolly–Seber method, Ni. The number of adults estimated by Jolly-Seber formula (Ni) are plotted together with that of observed (*ni*). The maximum and minimum numbers estimated during the study period were 882 (n = 73) and 4 (n = 6), respectively (Figure 2).

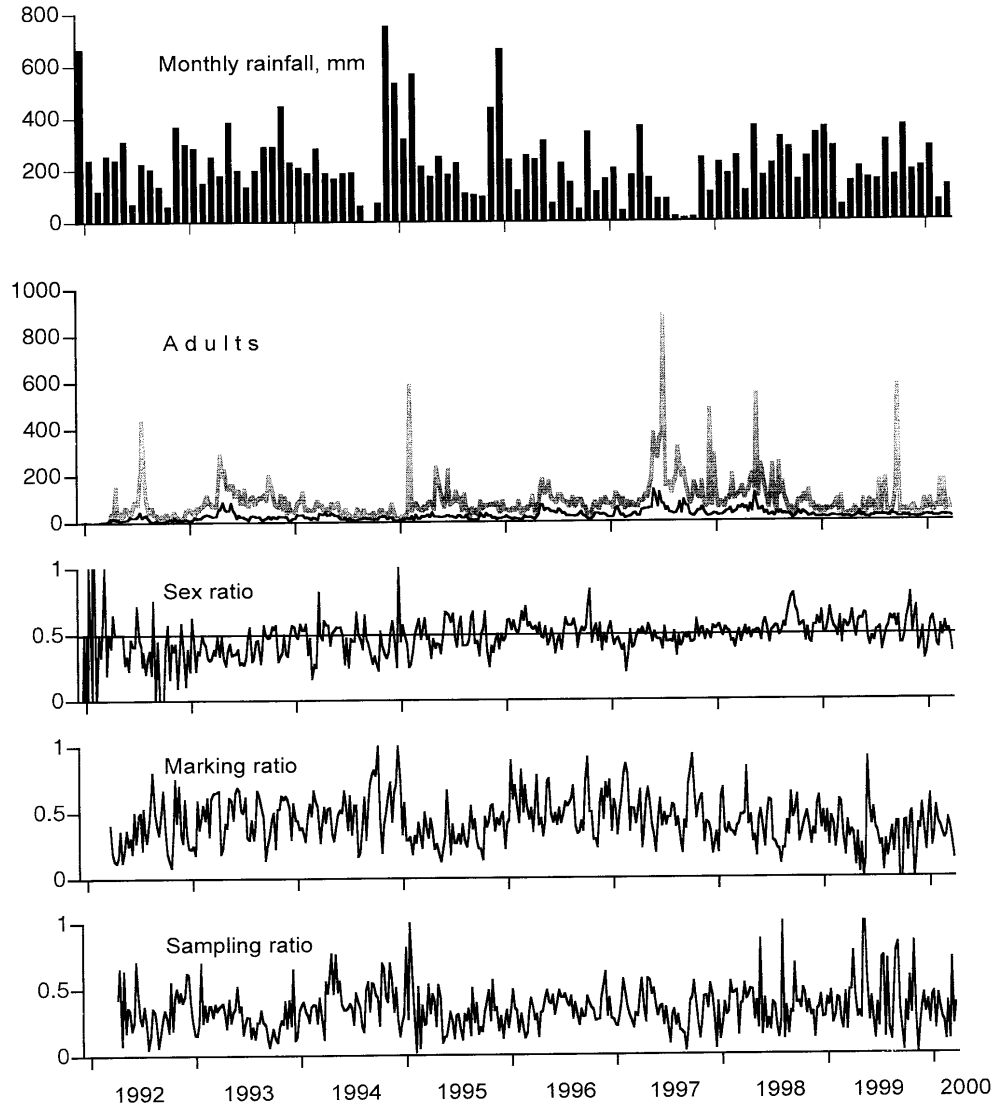

Figure 2. Seasonal fluctuation in the monthly rainfall (top), number of *Epilachna vigintioctopunctata* adults observed (2nd, black) and estimated by Jolly-Seber method (2nd dot line), sex ratio (3rd), making ratio (4th), and sampling ratio (bottom) during the study period in Sukarami, West Sumatra.

Density. The density index of EV adults on "old" and "new" plants combined varied from 0.13 to 1.25 (the average was 0.46). Seasonal change in the density index of EV adults on the "old" and "new" plants as shown in figure 3.

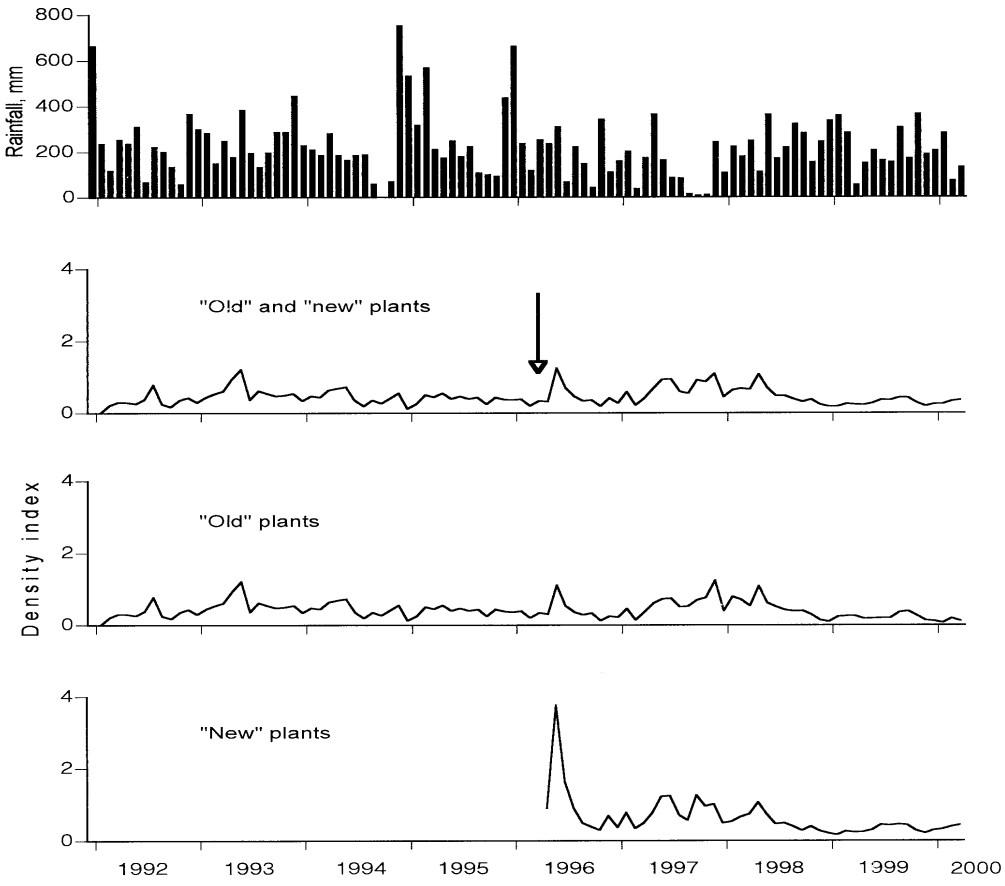

Figure 3. Seasonal change in monthly rainfall (top), and density index of *Epilachna vigintioctopunctata* adults on the "old" and "new" plants combined (2nd), "old" plants (3rd) and "new" plants (bottom) during the study period in Sukarami, West Sumatra. Arrow in 2nd figure indicates the planting of the new host plants.

Figure 3 above shown that, the "new" plants (adult density index was 3.77) indicating that were clearly preferred compared to the "old" plants only on May, 1996 (one month after planting the "new" plants). Thereafter, adult density on both kinds of plants changed synchronously at the same level.

Fecundity index. The fecundity index varied from 0 to 10.33 (the average was 1.01) on the main site during the study period. The highest peak fecundity index was observed on February, 1992 (10.33), when the host plants were still young (Figure 4).

Figure 4 shown that the fecundity index was rather constant during the rest of the study period (9 years).

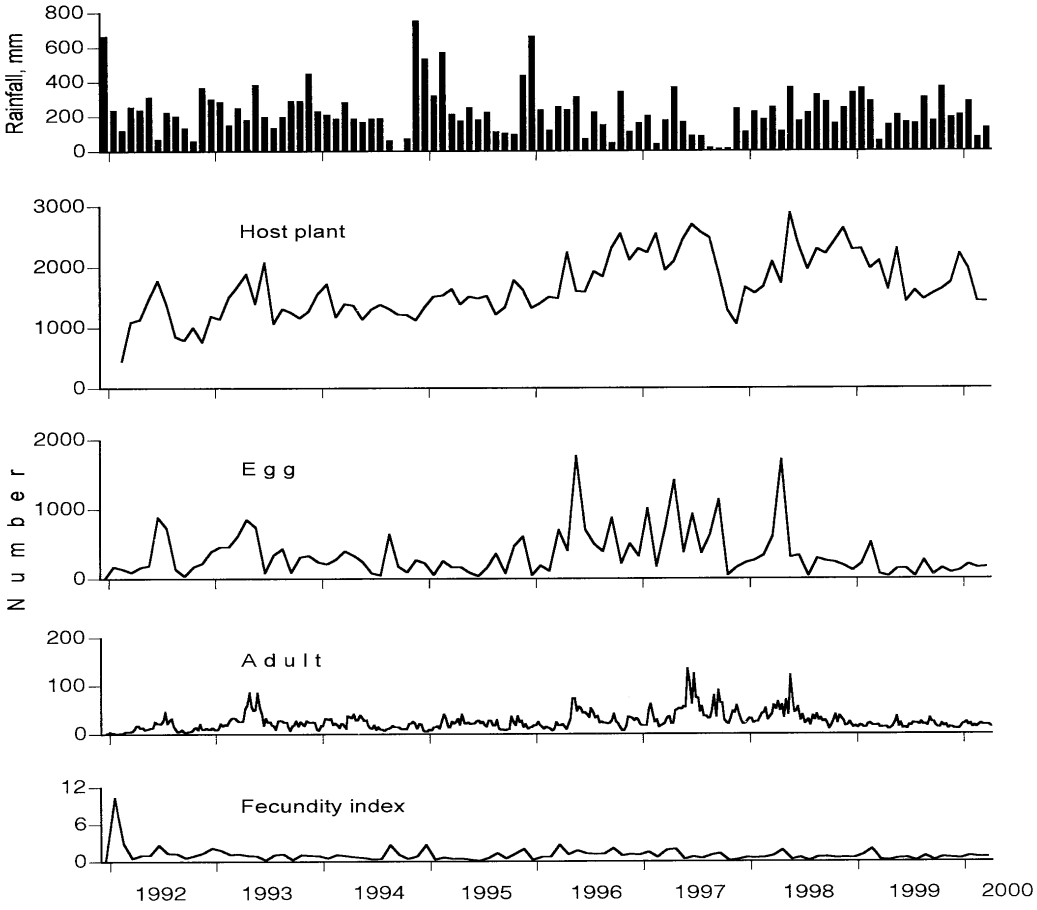

Figure 4. Seasonal change in monthly rainfall (A), total number of *Solanum torvum* leaves (2nd), total number eggs laid per month (3rd), total number of adults (4th) and fecundity index (bottom) of *Epilachna vigintioctopunctata* during the study period in Sukarami, West Sumatra.

Survival rate

Minimum length of residence (MLR). Figure 5, shows the frequency distribution of minimum length of residence time (MLR) of EV adults.

From the Figure 5 above shown that, the average MLR value for females and males was 9.7 days (range from 0 to 170 days, SE = 0.34) and 11.1 days (range from 0 to 161 days, SE = 0.34), respectively. The average number of captures per individuals 1.69 (female, SE = 0.02) and 1.79 (male, SE = 0.02). The percentage of individuals captures only once for males was 56.5 % and 60.1 % for female, and there was no marked sexual difference in seasonal.

Total number of adults marked during the study period was 6,302 in which males and females were 3,214 and 3,088, respectively. There was no significant deviation from expected 1:1 ratio.

Estimation of survival rate by Jolly-Seber method, øi. Since study site were relative small to flying activity of EV adults emigration and death could not be separated as the causes of loss. Consequently a term "residence" instead of "survival" is used for *øi* values derived by the Jolly-Seber formula. Value of *øi* fluctuated between 0.8 and 1.0 in most parts of the study period. An intimate relation was found between changes of *øi* and *Ni*: Drop of *øi* was followed by decrease of *Ni* and rise of *øi* by increase of *Ni* (Figure 6).

The survival rate varied from 0.61 to 1.00 (the average was 0.94) as shown at figure 6.

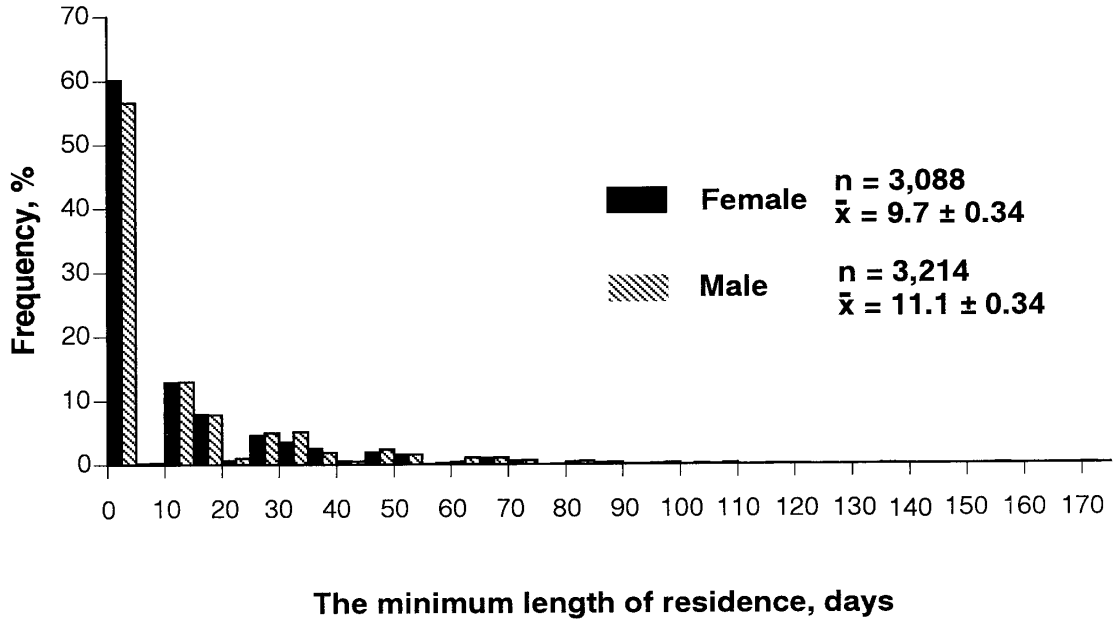

Figure 5. Frequency distribution of the minimum length of residence seasonal change of adult *Epilachna vigintioctopunctata* during the study period in Sukarami, West Sumatra.

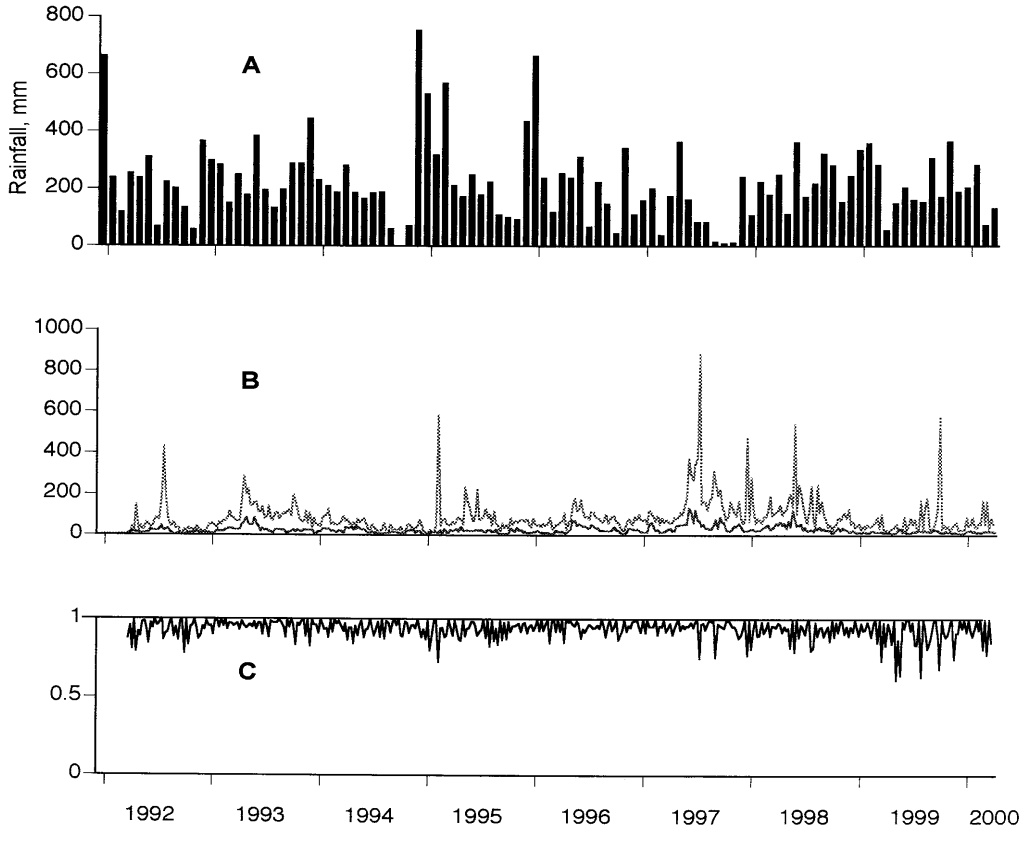

Figure 6. Seasonal fluctuation in monthly rainfall (A), number of adult *Epilachna vigintioctopunctata* observed (B, solid line) and the number estimated by Jolly-Seber method (B, doted line) and daily residence rate (C) during the study period in Sukarami, West Sumatra.

Immature stages. Compared with fluctuation in number of adults (Figure 2), number of immature stages fluctuated more distinctly as shown at Figure 8 below.

Figure 7 shown that, the seasonal change in number of eggs laid per day, fourth instar larvae, pupae per day and emergence of new adults, indicating the generation cycles. The immature stages also perform several high peaks that support the high peaks of adult population of EV.

Egg. The number of eggs per day varied from 0 to 106.14 (the average was 7.81), the high peaks were observed in mid of June, 1992 (62.29), late April, 1993 (63.14), late August, 1994 (68.14), early May, 1996 (106.14), mid of June, 1997 (88.67), and mid of April, 1998 (82.29).

Larva. The number of fourth instar larvae varied from 0 to 113 (the average was 15.37), the high peaks were observed in mid July, 1992 (81), late March, 1993 (70), early October, 1994 (44), early April, 1995 (47), early October, 1996 (94), early May, 1997 (88), and mid April, 1998 (113).

Pupa. The number of pupae per day varied from 0 to 4.14 (the average was 0.31), the high peaks were observed in early July, 1992 (3.25), late March, 1993 (2.29), early May, 1996 (2.14), late April, 1997 (1.71) and early May, 1998 (4.14).

New adult. The number of emergence of new adults varied from 0 to 3.43 (the average was 0.21), the high peaks were observed in early July, 1992 (1.88), late March, 1993 (1.43), late April, 1996 (1.86), late October, 1997 (1.57) and early May, 1998 (3.43).

Conclusions

1. The number of adult EV fluctuated synchronously between at the main study site with the sub site study A and B.
2. The density index of EV adults on “old” and “new” plants combined varied from 0.13 to 1.25
3. The fecundity index varied from 0 to 10.33 (the average was 1.01) on the main site during the study period.
4. The average MLR value for females and males was 9.7 days (range from 0 to 170 days, SE = 0.34) and 11.1 days (range from 0 to 161 days, SE = 0.34), respectively
5. An intimate relation was found between changes of *øi* and *Ni*: Drop of *øi* was followed by decrease of *Ni* and rise of *øi* by increase of *Ni*. The survival rate varied from 0.61 to 1.00 (the average was 0.94).
6. The immature stages also perform several high peaks that support the high peaks of adult population of EV.

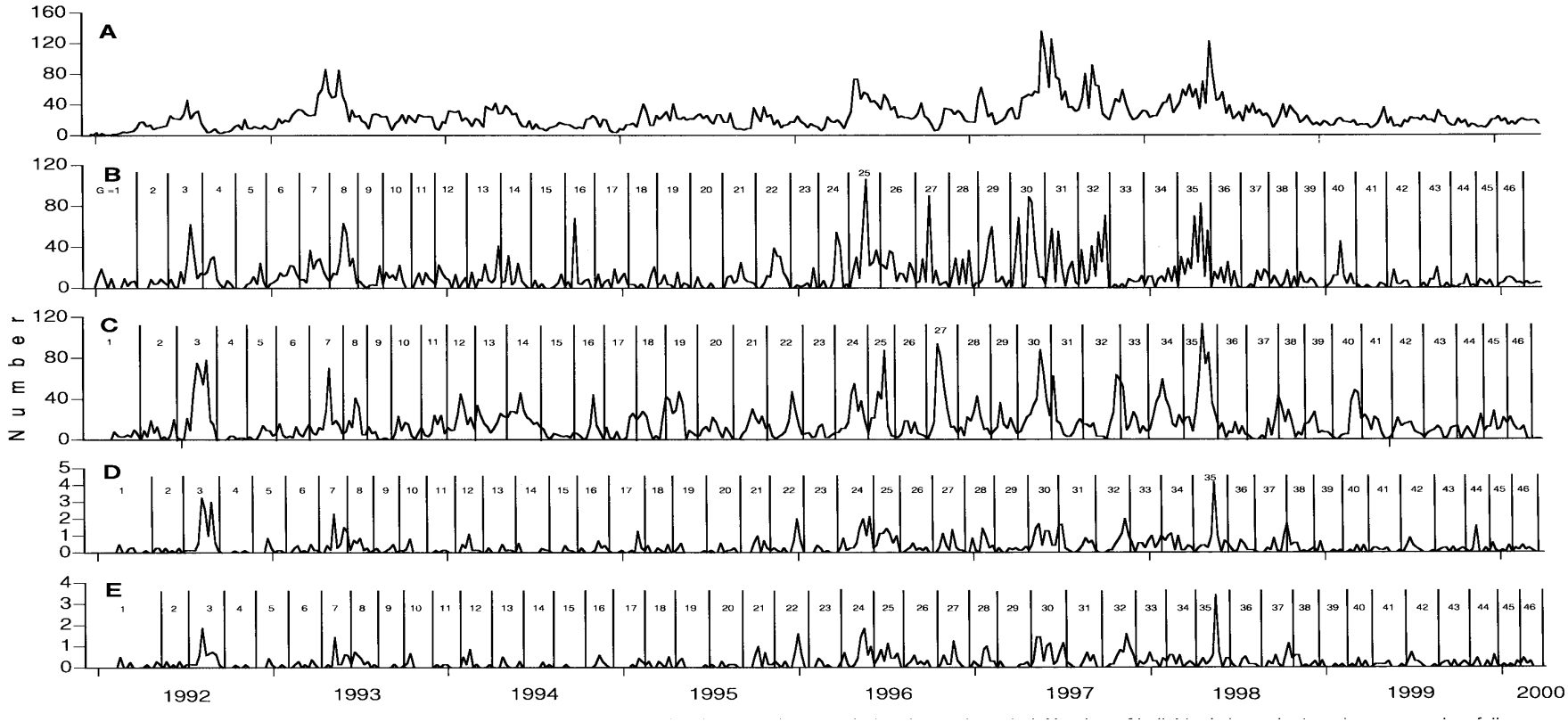

Figure 7. Seasonal fluctuation in number of *Epilachna vigintioctopunctata* in successive developmental stages during the study period. Number of individuals in each stage is expressed as follows: adults (A), number directly counted egg (B), number laid per day; 4th instar larva (C), number directly counted pupa (D), number of new pupa per day; new adult (E), number of pupal exuviae collected per day.

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