Population Parameters of *Cyrtorhinus lividipennis* Reuter (Heteroptera: Miridae) Reared on Eggs of Natural and Factitious Prey[1]

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ABSTRACT

The biology of *Cyrtorhinus lividipennis* was studied on its natural prey, *Peregrinus maidis*, and a factitious prey, *Ceratitis capitata*. The body dimensions of the predators fed on these two types of prey were equal. The duration of egg and nymphal instars were not significantly different; however, the longevity of adults fed on natural prey was much longer than those fed on the factitious prey. The fecundity of *C. lividipennis* on *P. maidis* and *C. capitata* were identical. The predator had equal rates of increase when reared on the natural and factitious prey. Therefore, *P. maidis* and *C. capitata* were equally suitable as prey of *C. lividipennis*, suggesting that *C. capitata* could be used as the prey in the mass rearing of *C. lividipennis*.

The corn delphacid egg sucker, *Cyrtorhinus lividipennis* Reuter, is the most important egg predator of the corn delphacid, *Peregrinus maidis* (Ashmead) in Hawaii (Napompeth 1973). Studies conducted on the numerical relationship of these two species revealed that the predator-prey ratio at the colonization period determined the stability of their interactions (Liquido 1982). This suggests that whenever the initial density of the predator lags behind that of the prey, the outbreak of *P. maidis* could be prevented by inoculative release of *C. lividipennis*. An inoculative release program, however, requires an efficient means of mass rearing the predator.

The mass rearing of *C. lividipennis* on its natural prey, *P. maidis* is very inconvenient and expensive. The use of a suitable factitious prey might be a less expensive and an easier rearing alternative. This consideration makes Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), a very good candidate as a factitious prey because it can be reared in an artificial medium at a very low cost (Mitchell et al., 1965; Tanaka et al., 1969). To determine whether *C. capitata* is as suitable as *P. maidis* for growth and development of *C. lividipennis*, the biology of the predator fed on these two types of prey was studied and compared. This paper discusses the comparative developmental biology, life and reproductive tables, and population growth statistics of *C. lividipennis* reared on eggs of *P. maidis* and *C. capitata*.

MATERIALS AND METHODS

Source of P. maidis *and* C. capitata *Eggs*

The eggs of *P. maidis* fed to the predator were obtained from the stock culture maintained on "Hawaiian Super Sweet Corn #9" in the greenhouse of the Department of Entomology, University of Hawaii. The USDA Tropical Fruit and Vegetable Research Laboratory supplied the eggs of *C. capitata* fed to *C. lividipennis* throughout the study.

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Rearing of C. lividipennis

Gravid females of *C. lividipennis* were collected from "Hawaiian Super Sweet Corn #9" grown at Waimanalo Agricultural Research Station, University of Hawaii. They were released in a cage with a potted one-month-old corn plant which had been previously exposed to gravid *P. maidis*. After one day the plant was removed from the cage and the leaves were cut off. The parts of the midrib laid with predator eggs were cut into 70 mm lengths and placed in 25 × 95 mm, 8-dram glass vials. To prevent the sections of the midrib from desiccating, the base of each was wrapped with cotton soaked in water. The vials were then plugged with non-absorbent cotton and placed on wooden racks inside the rearing chamber at 24.0 ± 2.0°C, 70.0 ± 5.0% relative humidity, with a 12-hour photoperiod.

The emerging nymphs of *C. lividipennis* were kept singly in vials. Eggs of *P. maidis* were fed to one group while eggs of *C. capitata* were fed to the other group. The nymphs were allowed to prey on freshly laid eggs of *P. maidis* in 70 mm long midrib cuttings with wet cotton at the base. Eggs of *C. capitata* were offered to the predator on the surface of 75 × 12 mm gelatin-coated styrofoam. Individual nymphs were provided with 25 eggs every day and were transferred into clean vials every other day. The moisture in the gelatin and the water-soaked cotton wrapped around the base of the midrib cuttings maintained a favorable relative humidity inside the vials.

Upon adult emergence, the predators were paired in vials. The procedure for nymphal feeding was followed in adult rearing. Each pair of adults was provided with 50 prey eggs daily. To obtain eggs of the predator, 3–5 day old sprouted corn seedlings were placed in the vials. Before placing the seedling in the vial, the roots and leaves were removed, the stem cut into 70 mm lengths, and the still intact endosperm covered with wet cotton.

Determination of Biological Attributes

The eggs were observed daily for changes in morphology and time of eclosion. The body length and width of nymphs and adults were measured using a dissecting microscope with a calibrated ocular micrometer. The number and duration of nymphal molts were determined by examining the vials daily for the presence of exuviae. The adults were observed periodically to obtain data on reproductive parameters; i.e., preoviposition, oviposition, and postoviposition periods, fecundity, and longevity. Fecundity was determined by counting the number of eggs oviposited in corn seedlings every other day. Survivorship of individuals in each stage was recorded daily.

Life and reproductive tables for *C. lividipennis* reared on *P. maidis* and *C. capitata* were constructed following Deevey's (1947) and Laughlin's (1965) methods. The population growth statistics were calculated by Birch's (1948) method.

RESULTS

Morphometric Differences

The data on egg, nymph, and adult morphometry, i.e., body length and body width, for individuals reared on *P. maidis* and *C. capitata* were not significantly different ($P>0.05$, T-test) (Table 1).

Longevity and Fecundity

The duration of egg and nymphal instars was not significantly different for individuals reared on natural and factitious prey ($P>0.05$, T-test). However, a significant difference between adult longevity was observed ($P<0.01$, T-test) (Table

1). The adult predators reared on *P. maidis* lived longer than those reared on *C. capitata*. The egg production of *C. lividipennis* was not significantly different with respect to the type of prey used (P>0.05) (Table 2).

TABLE 1. Body measurements and duration of developmental stages of *Cyrtorhinus lividipennis* Reuter when fed on eggs of *Peregrinus maidis* (Ashmead) and *Ceratitis capitata* (Wiedemann).

Prey Species/ Developmental Stage	Number Measured	Body Length (mm) X ± S.E.	Body Width (mm) X ± S.E.	Duration (days) X ± S.E.
P. Maidis				
Egg	30	0.68 ± 0.01	0.16 ± 0.01	5.92 ± 0.20
Nymph				
Instar I	28	0.88 ± 0.08	0.29 ± 0.06	3.05 ± 0.19
Instar II	27	1.23 ± 0.09	0.42 ± 0.07	2.82 ± 0.15
Instar III	27	1.53 ± 0.09	0.59 ± 0.07	3.05 ± 0.22
Instar IV	26	1.98 ± 0.14	0.78 ± 0.08	3.45 ± 0.20
Instar V	25	2.51 ± 0.14	0.88 ± 0.10	3.00 ± 0.23
Adult				
Female	13	3.53 ± 0.12	1.15 ± 0.07	18.64 ± 0.75
Male	12	3.11 ± 0.11	0.99 ± 0.09	20.90 ± 0.76
C. capitata				
Egg	28	0.69 ± 0.02	0.16 ± 0.01	5.96 ± 0.18
Nymph				
Instar I	25	0.76 ± 0.07	0.37 ± 0.06	2.84 ± 0.17
Instar II	25	1.32 ± 0.09	0.49 ± 0.06	3.12 ± 0.16
Instar III	24	1.73 ± 0.09	0.65 ± 0.07	2.79 ± 0.19
Instar IV	24	2.14 ± 0.11	0.79 ± 0.08	2.52 ± 0.17
Instar V	23	2.45 ± 0.09	0.91 ± 0.08	3.29 ± 0.16
Adult				
Female	10	3.39 ± 0.12	1.20 ± 0.10	16.20 ± 0.71
Male	13	3.04 ± 0.11	0.98 ± 0.09	14.77 ± 0.61

TABLE 2. Realized and potential fecundity of *Cyrtorhinus lividipennis* Reuter reared on eggs of *Peregrinus maidis* (Ashmead) and *Ceratitis capitata* (Wiedemann).

Prey Species	Number Observed	Fecundity	
		Realized[a] X ± S.E.	Potential[b] X ± S.E.
P. maidis	11	77.36 ± 1.52	85.36 ± 1.69
C. capitata	10	76.00 ± 2.20	84.40 ± 2.15

[a]Realized fecundity is the number of eggs laid by a female throughout its lifetime.
[b]Potential fecundity is realized fecundity plus the number of developed eggs within ovarioles at the time of death.

Life and Reproductive Tables

The survivorship (1_x) and mortality ($1000q_x$) curves of *C. lividipennis* show semi-convex and semi-concave features (Fig. 1), respectively, indicating that mortality factors acted heavily on adults. This type of mortality curve was designated as type 1 by Slobodkin (1962). Since the predator was reared in the controlled conditions of the laboratory, mortality was attributed to the inherent physiological and genetic limits on its life span.

Data on the probability of survival (1_x) and age-specific fecundity (m_x) are presented (Fig. 2). The 1_x was based only on the females of the population. The m_x values were the average number of eggs laid/female every two days over the entire reproductive life. The number of eggs was divided by 2 to account for the 1:1 sex ratio. The eggs and nymphs had very high probability of survival as compared to the adults. The probability of survival of females reared on two different prey was identical in early adult life. However, toward the end of the reproductive period, the post-oviposition life expectancy was longer for females reared on *P. maidis* than for those reared on *C. capitata.* The same trend of life expectancy was observed for the males.

The m_x curves show that the fecundity rate increased rapidly during early oviposition period and decreased towards the end of the reproductive life. Furthermore, during the early reproductive period, those females reared on *P. maidis* laid more eggs than those reared on *C. capitata;* the opposite was true during the latter part of the oviposition period.

Population Growth Statistics

The population growth statistics were computed for *C. lividipennis* reared on eggs of *P. maidis* and *C. capitata* (Table 3). The data indicate that *C. lividipennis* will multiply by a factor of 32.15 and 30.07 when reared on *P. maidis* and *C. capitata,* respectively. The mean generation time for individuals of *C. lividipennis* reared on *P. maidis* was a day shorter than for those reared on *C. capitata.* Based on the finite rate of increase (λ), the laboratory population of this predator was expected to multiply by a factor of 1.12 every 2 days regardless of the prey. Furthermore, the predator population was also expected to double its density every 6.5 days regardless of the prey. The values of the population growth statistics were not statistically different between individuals reared on natural and factitious prey.

TABLE 3. Population growth statistics of *Cyrtorhinus lividipennis* Reuter reared in the laboratory on eggs of *Peregrinus maidis* (Ashmead) and *Ceratitis capitata* (Wiedemann).

Population Growth Statistics*	Prey Species	
	P. maidis	*C. capitata*
Ro	32.15	30.07
r_m	0.11	0.11
λ	1.12	1.12
T	30.99	32.23
DT	6.50	6.50

*Ro = net reproductive rate; r_m = intrinsic rate of increase; λ = finite rate of increase; T = mean generation time; DT = doubling time.

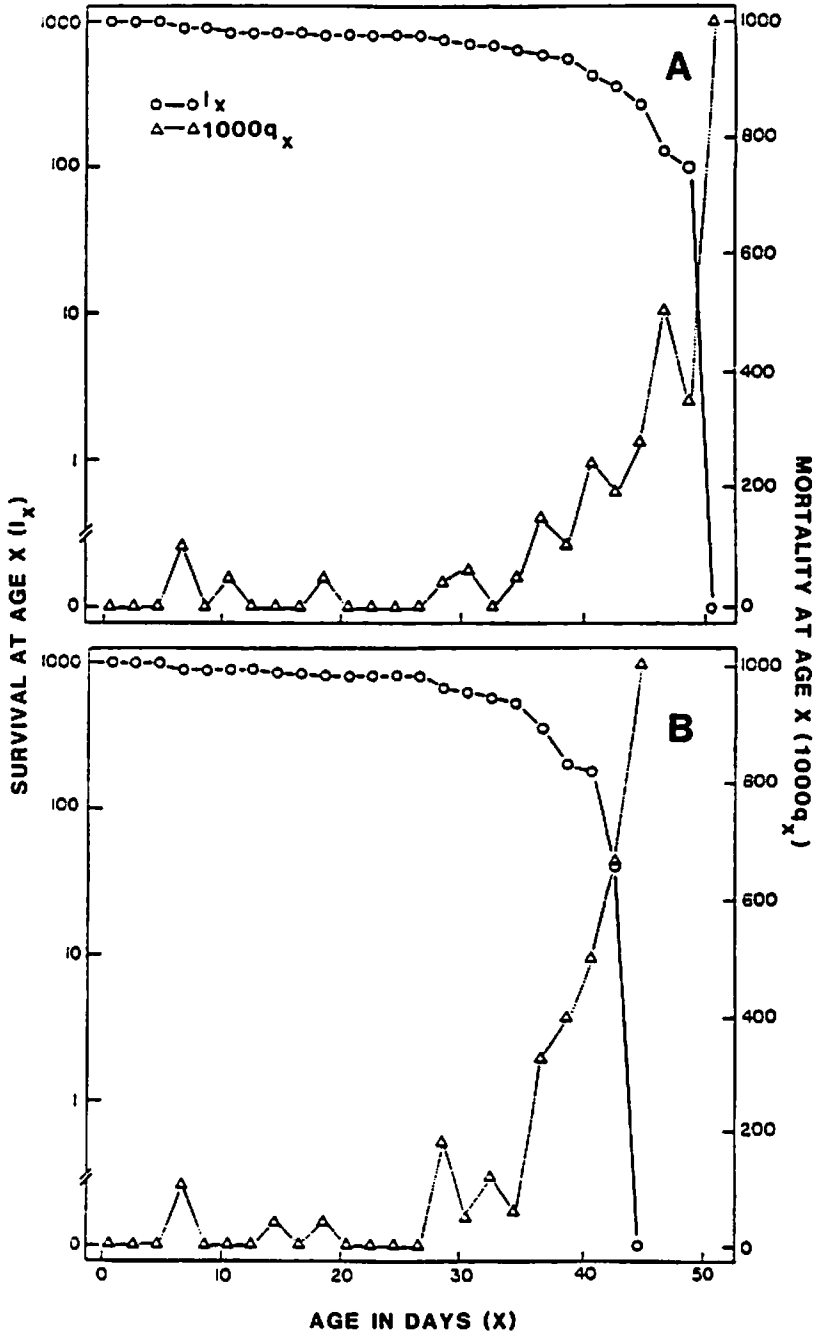

FIGURE 1. Survivorship (1_x) and mortality ($1000q_x$) curves of *Cyrtorhinus lividipennis* Reuter reared on eggs of (A) *Peregrinus maidis* (Ashmead) and (B) *Ceratitis capitata* (Wiedemann).

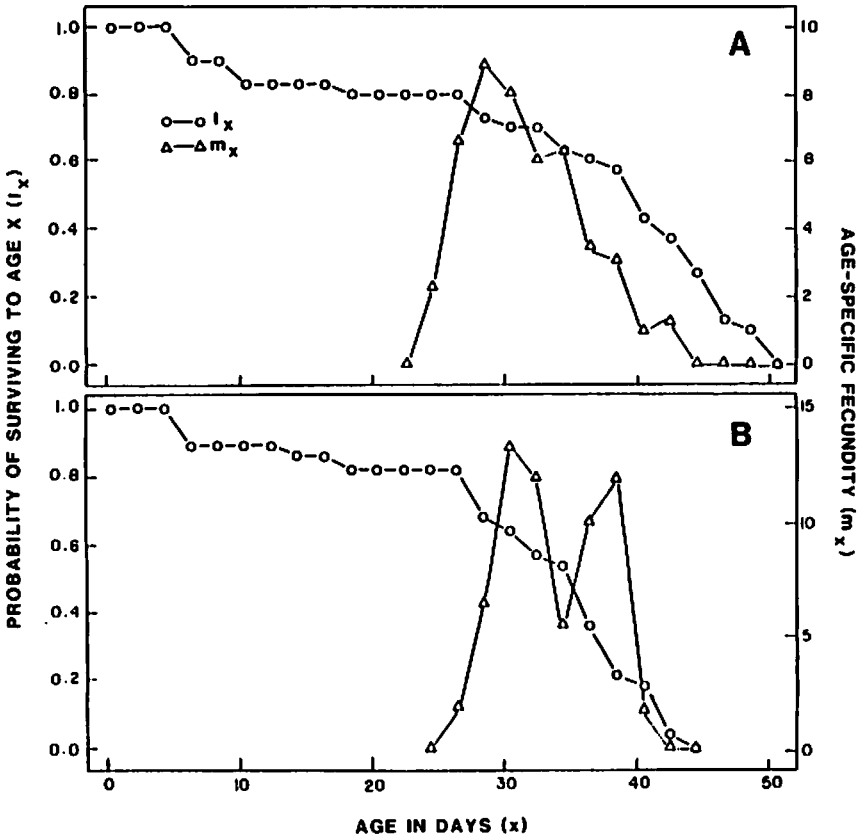

FIGURE 2. Probability of survivorship (l_x) and age-specific fecundity (m_x) of *Cyrtorhinus lividipennis* Reuter reared on eggs of (A) *Peregrinus maidis* (Ashmead) and (B) *Ceratitis capitata* (Wiedemann).

DISCUSSION

A successful biological control program may depend on the amenability of the parasite or predator to laboratory rearing. The preferred laboratory host or prey is the pest species targeted for control. However, if the intended natural host or prey is not amenable to laboratory rearing or difficult to handle under mass-culture conditions, a factitious host or prey is usually used. The utilization of factitious hosts in colonizing parasites has been well studied (Coppel and Mertins 1977). Several parasitic species have been reared on artificial holidic and meridic diets (Hagen 1964, Simmonds 1966). Rearing on artificial diet has been reported only among general, facultative predators; i.e., the adults or other stages of development are phytophagous (e.g., Hagen 1950) or predators extending their polyphagy to plant feeding irrespective of the stage of development (e.g., Tamaki and Weeks 1972).

Life and reproductive tables were originally constructed to describe the mortality and natality patterns of a population. In the present study, life table analysis is used to predict the comparative age-specific survivorship and mortality of the mirid

predator on natural and factitious prey. The reproductive table provides data on net reproductive rate (Ro) and rate of increase (r_m) of the predator on these two types of prey. These tables, therefore, form a convenient method of evaluating the suitability of the factitious prey for the predator's growth and developement. The results of the present study strongly suggest that the eggs of *P. maidis* and *C. capitata* are equally suitable as prey of *C. lividipennis*. Since the rate of development, survivorship, and reproduction of the predator on natural and factitious prey were not significantly different, it appears that *C. lividipennis* could be mass-propagated on eggs of *P. maidis* or *C. capitata* with equal success.

The use of factitious prey in biological control programs is not only useful for mass rearing but can also be used during transport of the predator. For instance, Stephans (1975) fed *Tytthus mundulus* Breddin with eggs of the housefly, *Musca domestica* L. during transport from New South Wales to Sydney, Australia.

In Hawaii, predaceous Heteroptera which have been reared on the eggs of a factitious tephritid prey, *Dacus dorsalis* Hendel, are *Orius insidiosus* (Say), *Paratriphleps laevisculus* Champion, and *T. mundulus* (Takara and Nishida 1981). In Australia, *T. mundulus* has been successfully reared on eggs of *M. domestica* (Stephans 1975). It is possible that other entomophagous species with similar feeding habits could also be reared on eggs of fruit flies and other insects commonly cultured in the laboratory.

REFERENCES CITED

Birch, L.C. 1948. The intrinsic rate of natural increase of an insect population. J. Anim. Ecol. 17:15–26.

Coppel, H.C. and J.W. Mertins. 1977. Biological Insect Pest Suppression. Springer-Verlag, New York. 314 pp.

Deevey, E.S. 1947. Life tables for natural populations of animals. Quart. Rev. Biol. 22:283–314.

Hagen, K.S. 1950. Fecundity of *Chrysopa californica* as affected by synthetic foods. J. Econ. Entomol. 43:101–104.

———, 1964. Nutrition of entomophagous insects and their hosts, pp. 356–380. *In* DeBach, P. [ed.], Biological Control of Insect Pests and Weeds. Chapman and Hall Ltd., London. 844 pp.

Laughlin, R. 1965. Capacity for increase: a useful population statistic. J. Anim. Ecol. 34:77–91.

Liquido, N.J. 1982. Population Ecology of *Cyrtorhinus lividipennis* Reuter (Heteroptera: Miridae). Ph.D. Dissertation, University of Hawaii, Honolulu, Hawaii. 175 pp.

Mitchell, S., N. Tanaka and L.F. Steiner. 1965. Methods of mass culturing melon flies and Oriental and Mediterranean fruit flies. USDA-ARS 30–104. 22 pp.

Napompeth, B. 1973. Ecology and Population Dynamics of the Corn Planthopper, *Peregrinus maidis* (Ashmead) (Homoptera: Delphacidae), in Hawaii. Ph.D. Dissertation, University of Hawaii, Honolulu, Hawaii. 257 pp.

Simmonds, F.J. 1966. Insect parasites and predators, pp. 489–499. *In* Smith, C.N. [ed.], Insect Colonization And Mass Production. Academic Press, New York. 618 pp.

Slobodkin, L.B. 1962. Growth and Regulation of Animal Populations. Holt, Rinehart and Winston, New York. 184 pp.

Stephans, G.S. 1975. Transportation and culture of *Tytthus mundulus*. J. Econ. Entomol. 68:753–754.

Takara, J. and T. Nishida. 1981. Eggs of the Oriental fruit fly for rearing the predaceous anthocorid, *Orius insidiosus* (Say). Proc. Hawaii. Entomol. Soc. 23:441–445.

Tamaki, G. and R.E. Weeks. 1972. Biology and ecology of two predators, *Geocoris pallens* Stål and *G. bullatus* (Say). USDA Tech. Bull. 1446. 46 pp.

Tanaka, N., L.F. Steiner, K. Ohinata and R. Okamoto. 1969. Low-cost larvae rearing medium for mass-production of Oriental and Mediterranean fruit flies. J. Econ. Entomol. 62:967–968.