Life Table of the Corn Earworm, *Heliothis zea* (Boddie), in Sweet Corn in Hawaii.[1]

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In 1931 Swezey first reported corn being attacked by *Heliothis* in Hawaii. Although there are numerous references to "*Heliothis*" in the Hawaiian literature before this date, this record is considered to be the first report of the corn earworm, *Heliothis zea* (Boddie), which was probably introduced about 1930 from North America (Zimmerman and Fletcher, 1956). Since that time this noctuid has been a serious pest of corn in Hawaii.

A practical tool used by ecologists to list the mortality schedule of a population is the life table. The concept of the life table, used in studies of human populations, was first applied to natural populations by Deevey (1947). This technique was adapted to the study of natural insect populations by Morris and Miller (1954) in their studies of the spruce budworm, *Choristoneura fumiferana* (Clemens). Harcourt (1966) in a study of the imported cabbageworm, *Pieris rapae* (L.), developed a life table for insects of field crops. The present paper is concerned with an analysis of mortality of *H. zea* infesting sweet corn, using the life table approach.

MATERIALS AND METHODS

Life table studies were carried out in the laboratory and in the field. In the laboratory the mean air temperature was 24.4°C (range 22.2-26.6°C) and the mean relative humidity 50% (range 45-55%). Forty freshly laid eggs were placed separately in 13 dram plastic vials with small holes in the caps. When the eggs hatched pieces of fresh sweet corn were placed daily in the vials for larval food. Data were taken daily on the number of eggs hatched and the number of larvae that died during each developmental stage.

The field studies were conducted at the University of Hawaii Agricultural Experiment Station, Waimanalo, Oahu. Eight successive crops of sweet corn, variety Supersweet, were planted from April 1976 to June 1977. Each planting consisted of 50 rows, each 40 m long. Cultivation was according to local practices without application of insecticides.

From the first appearance of the silk, samples of 100 ears were randomly collected from the central part of the field at approximately 3 day intervals until harvest. The silks from each ear were clipped off about 2 cm below the tip of the husk, placed in individual containers, and taken to the laboratory for egg and larval counts. If the silk had become dry, the entire ear was collected. The eggs were counted, and the larvae removed from the ears of corn and preserved in 70% alcohol for later counting. The number of larvae that pupated was determined by placing a 16 oz Dixie® cup over each ear just before the time of pupation. A small hole, 1

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cm in diameter, was punched in the bottom of the cup and the ear inserted into the cup through the hole. The cup was held in place with a piece of friction tape (Figure 1). Fully grown larvae burrowed out of the ear and

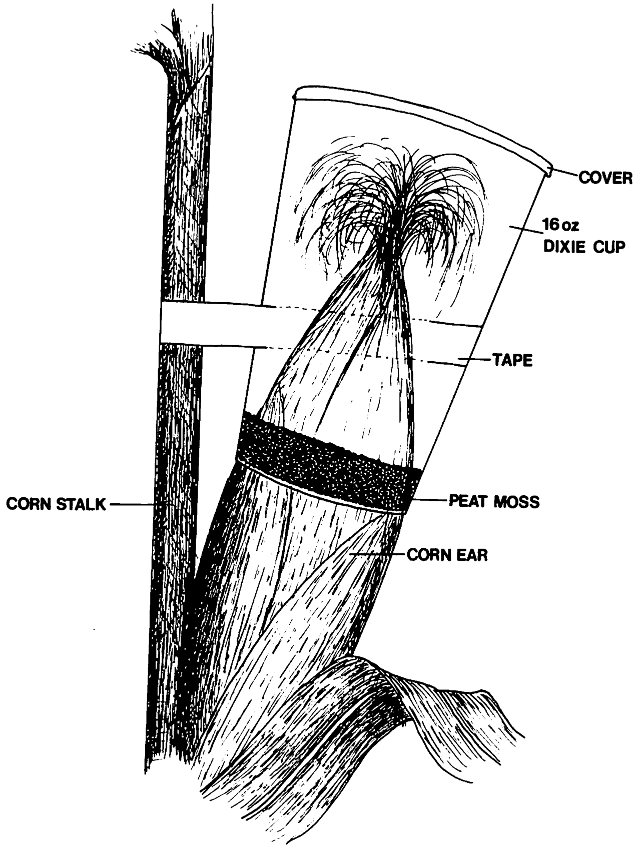

FIGURE 1. Collection cup for *H. zea* pupae attached to a corn plant.

pupated in the paper cup which contained a 3-4 cm layer of peat moss. The cups were removed and the pupae counted when the plants were approximately 85 days old.

To estimate egg mortality, field samples of 100 eggs were taken daily during the first 4 days of silking. Each egg was placed separately in a glass vial and held until either the larva or a parasite emerged. Samples of larvae were also collected and reared on sweet corn until the pupal and adult stages to determine larval and pupal mortality. Although cannibalism and predation by the anthocorid bug, *Orius inidiosus* (Say), were observed, no attempt was made to quantify larval and pupal mortality caused by these specific mortality factors. Predators in the silk were sampled by means of a small shaker sampler (Nishida and Takara, 1979) which separated predators.

In constructing the life table the following symbols proposed by Morris and Miller (1954) and by Morris (1963), were used, with the addition of a column for the cumulative percent surviving.

x = Age interval (development stage).
lx = Number living at the beginning of the stage noted in the x column
dx = Number dying within the age interval in the x column.
dxf = Mortality factor responsible for dx.
100qx = Percent mortality based on lx.
100rx = Cumulative percent surviving.

The number entering a given age interval was calculated using a graphical integration method described by Southwood (1966). The developmental time of each stage necessary for the use of this method was determined in the laboratory. The developmental times in days for the egg and six larval instars were 3.0, 3.4, 2.9, 2.6, 2.3, 2.3, and 3.2, respectively.

Results

Table 1 summarizes a life table for the corn earworm under laboratory conditions. In the laboratory the highest mortalities of 7 and 11% occured during the egg stage and second instar, respectively.

TABLE 1. *A life table for* H. zea *reared in separate vials at 24.4°C and 50% relative humidity.*

x Age interval	lx Number alive at beginning of x	dx Number dying during x	100qx dx as a percent of lx	100rx Cumulative percent surviving
Eggs	1000	75	7	93
Larva 1	925	50	5	88
Larva 2	875	100	11	77
Larva 3	775	25	3	75
Larva 4	750	0	0	75
Larva 5	750	25	3	73
Larva 6	725	25	3	70
Pupa	700	0	0	70
Adult	700			70

Table 2 summarizes a life table under field conditions. The total mortality during the egg stage was 62%. The major mortality factor was parasitism by the trichogrammatid wasp, *Trichogramma confusum* Viggiani, which accounted for 39% mortality. However, egg parasitization was observed to be as high as 92% depending on age of silk and locality. The most abundant predator in the silk known to feed on eggs was *O. insidiosus*. This predator, and other unknown factors, caused the remaining 23% of the egg mortality. These data show that combined mortality caused by *O. insidiosus* and other factors was less than that of the egg parasite. The 100qx values during the larval stage varied from 1 to 49%. The major factors affecting larval mortality were the combined mortality due to disease, parasitism, and cannibalism. The mortality caused by each of these factors was not determined for each of the stages. However, throughout the study period it was estimated that during the larval stages mortality due to virus disease was not greater than 11% and that due to parasitism not greater than 5%. The disease symptoms observed corresponded to those given by Steinhaus (1949) for the nuclear polyhedrosis virus of *Heliothis armigera* (Hübner). The parasites involved were two tachinids *Eucelatoria armigera* (Coquillet) and *Lespesia archippivora* (Riley). Cannibalism and intraspecific interactions may be important mortality factors during larval development. Often dead and partially destroyed carcasses were noted in the silk tubes. Data on pupae indicated a mortality of 33% in this stage. The causes of this mortality are unknown.

Survivorship data in the laboratory and the field for all stages of *H. zea* are shown in Figure 2. Mortality in the field was higher than that in the laboratory where cannibalism, parasitism, and other mortality factors found in the field were not present. The mortality in the laboratory may have been due in part to the daily handling of the larvae and to inherent weakness of certain individuals. The total mortality per generation was 30% in the laboratory and 94.8% in the field.

TABLE 2. *A life table for* H. zea *in sweet corn October 10 1976-November 20 1976, University of Hawaii Agricultural Station, Waimanalo, Oahu (mean air temperture = 24.5°C and rainfall = 3.65 cm).*

x	lx	dx F	dx	100qx	100rx
Age interval	Number alive at beginning of x	Factor responsible for dx	number dying during dx	dx as % of lx	cumulative %surviving
Egg	1000	*Trichogramma confusum*	386	39	61
		Orius insidiosus and unknown	232	23	38
			Total 618	62	38
Larva 1	382	*O. insidiosus*, cannibalism and unknown.	90	24	29
Larva 2	292	Cannibalism and unknown.	59	20	23
Larva 3	233	Cannibalism and unknown.	34	15	20
Larva 4	199	Cannibalism, disease, parasitism, and unknown.	59	30	14
Larva 5	140	Cannibalism, disease, parasitism, and unknown.	69	49	7
Larva 6	71	Cannibalism, disease, parasitism, and unknown.	1	1	7
Pupa	70	Disease and unknown.	18	33	5
Adult (28 ♂♂; 24 ♀♀)	52				

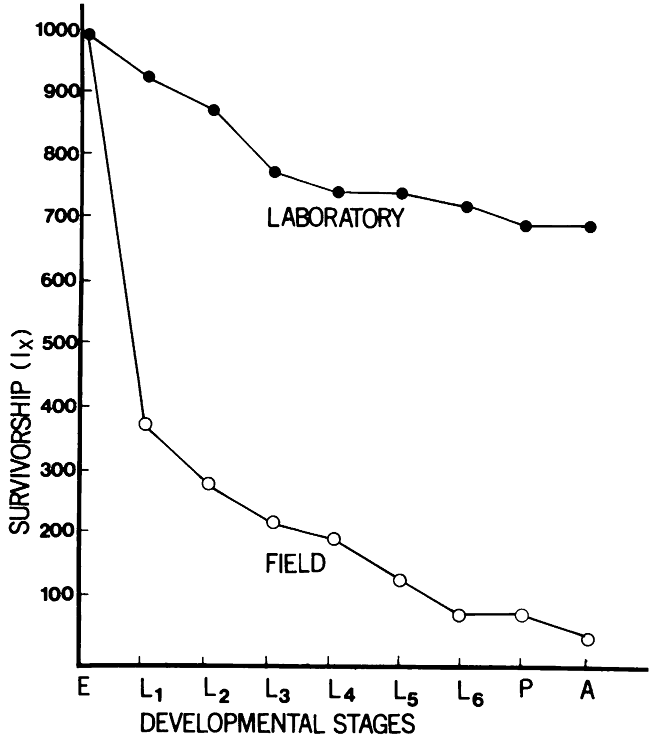

FIGURE 2. Survival curves for field and laboratory populations of *H. zea.* Symbols: E = egg, L = larva, P = pupa, A = adult.

Discussion

Our data showed that in Hawaii *T. confusum* was a very important egg mortality factor. Under favorable summer conditions it was observed to parasitize as high as 92% of the eggs by the 4th day of silking. In California during a 3 year study the average parasitization of corn earworm eggs on silks by *Trichogramma pretiosum* Riley was found to be 38% (Oatman, 1966). Quaintance and Brues (1905) reported *T. pretiosum* parasitization of eggs on silks to be 63%.

O. insidiosus was the most abundant predator on the corn silks. Barber (1936) found that numbers of *O. insidiosus* adults reached a peak during the first week of silking when silks were moist and exposed, while nymphs reached a peak the following week. Results of this 2 year study showed that 51% of the earworm eggs in the silks were destroyed by *O. insidiosus.* McColloch (1920) estimated that *O. insidiosus* may destroy 25-50% of the corn earworm eggs.

The present study showed that there was a large difference between the number of larvae of *H. zea* that entered the corn ear just after silking and the number that reached maturity at harvest. This reduction was attributed primarily to cannibalism. In the laboratory Barber (1936) showed that larvae readily fed on each other, and regardless of starting density, the larval population was reduced to an average of one per container. Our study showed that larvae infesting corn in the field were reduced to an average of a little less than one per ear. Examination of survival curves showed that the highest mortality occurred in the egg and newly hatched larvae.

The 94.8% mortality per generation reported in this paper was probably lower than that occurring under actual field conditions because the pupal collecting cups were used. These cups protected the pupae from parasites, predators such as birds and mice, and from adverse physical factors.

Summary

Studies on the field mortality of the corn earworm, *Heliothis zea*, infesting sweet corn were conducted at the University of Hawaii Agricultural Experiment Station, Waimanalo, Oahu, during 1976 and 1977. Factors contributing to the mortality of the corn earworm are presented in a life table. The egg parasite, *Trichogramma confusum*, was the major mortality factor during the egg stage. *Orius insidiosus* contributed to the mortality of the eggs and early larval instars. Cannibalism was the major mortality factor during the larval stages. Parasitization by *Eucelatoria armigera* and *Lespesia archippivora* was of relatively minor importance.

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