Sex Ratios of Wild Populations of *Psylla uncatoides* (Ferris and Klyver) in Hawaii[1 2 3]

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Madubunyi (1967) and Madubunyi and Koehler (1974) found sex ratios favoring the female (2:1) when *Psylla uncatoides* (Ferris & Klyver) were laboratory-reared at a constant temperature of 15°C. At constant temperatures of 20 and 25°C the sex ratios were about 1:1. They suggested that a differential morality factor, favoring female nymphs, exists at lower temperatures. Madubunyi (1967) hypothesized that this would allow for more rapid growth of the psyllid populations once warmer, more favorable temperatures returned. He also hypothesized that a switch in sex ratios, to one favoring males, was an "in-built" natural control mechanism during times of stress due to an unfavorable physical environment, changes in food quality or quantity, intra- and/or inter-specific competition, or other density-geared regulatory mechanisms.

To evaluate Madubunyi's hypotheses, data collected on *P. uncatoides* populations at four locations on Hawaii Island over a period of three years were subjected to chi-square analysis.

MATERIALS AND METHODS

Adult psylla populations were sampled by means of a "D-VAC, Model 24" vacuum collecting apparatus. Three minutes was selected as a suitable time unit for taking D-VAC samples. After the excess debris was removed from samples, the arthropods were killed with ethyl acetate and stored in 70% ethyl alcohol until they could be sorted and the psyllids sexed.

The samples were taken at approximately monthly intervals for over three years, from *Acacia koa* Gray at 1280, 1646 and 2043 m elevation along the Mauna Loa Strip Road, Hawaii Volcanoes National Park and from *Acacia koaia* Hillebrand in the Koaia Tree Sanctuary, 975 m elevation Kawaihae Uka, Kohala Mts.

For practical purposes, not all the samples collected over the three year period were sexed. Samples taken between July 19, 1971 and September 10, 1972 from the 1646 m Mauna Loa Strip Road and the Koaia Tree Sanctuary sites were used in determining population sex ratios. Additional sex ratios were later determined from samples taken at the 2043 m site on the Mauna

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Loa strip road during periods when the mean monthly temperatures were below 9° C, and from the Koaia Tree Sanctuary site after the establishment of the psyllid predator *Harmonia conformis* (Boisduval).

Chi square tests were used to determine whether there were significant deviations from an expected 1:1 sex ratio. For each location, chi square values were obtained for each sample date. For the entire period a double check on the sex ratios was obtained by both adding the chi square values for each sample date, and by adding the raw data and running a chi square test on these totals. Two hundred fifty *P. uncatoides* adults were sexed for each date, except when the sample contained fewer psyllids. Then the entire sample was sexed.

Results and Discussion

The sex ratio fluctuated but, overall, significantly favored the males (Tables 1, 2). The sex ratio significantly favored the females in only one instance (January 7, 1972; 1646 m Mauna Loa Strip Road). This occurred during the month with the lowest mean temperature (9° C) for the site (Bridges and Carey, 1973); however, the following month had the same mean temperature, although the sex ratio significantly favored males. Bridges and Carey (1973, 1974) showed two periods, December, 1971 through February, 1972 and February, 1973, when the monthly mean temperatures at the 2043 m Mauna Loa Strip Road site were below 9° C. Table 3 shows that no significant difference from a 1:1 sex ratio was observed for these periods, and indicates that a differential morality factor, favoring female nymphs, apparently does not exist at lower temperatures in wild populations in Hawaii.

Madubunyi's (1967) hypothesis of an "in-built" natural mechanism controlling the population by sex ratio changes, favoring males when food becomes less abundant, was tested by comparing the sex ratios of the psyllid before and after the establishment of a successful biological control agent at the Koaia Tree Sanctuary (Leeper and Beardsley, 1976). For several years prior to the establishment of the coccinellid, *Harmonia conformis, A. koaia* at this site had a single flushing of new growth per year. This was followed by a psyllid population explosion and a loss of terminal growth within three months due to over-feeding by the psyllid. After the establishment of *H. conformis,* the psyllid populations were controlled enough to allow continued flushing of new growth throughout the year.

The sex ratios prior to the introduction of *H. conformis* (Table 2), when food quality and quantity were reduced, and after the coccinellid's establishment (Table 4), when food quality and quantity were stabilized, both significantly favored the males and therefore did not support Madubunyi's (1967) hypothesis.

Catling (1973) found the sex ratio of the psyllid *Trioza erythreae* (Del Guercio) to favor the females. Working with the psyllid *Cardiospina albitextura* (Taylor), Clark (1962) found that early in the reproductive period males were predominant, during peak abundance the sex ratio was close to 1:1 and towards the end the females were predominant. The net result was a sex ratio close to unity. Burts and Fischer (1967) obtained data

Table 1. *Chi squares values of sex ratios of* P. uncatoides *collected at 1646 m Mauna Loa Strip Road (F: Female; M: Male; N: No difference).*

Date (+ 4 days)	Number of males	Total sexed	Chi square	Sex favored (P= 0.05)
7-19-71	115	250	1.600*	N
8- 2-71	137	250	2.304	N
9- 1-71	129	250	0.256	N
10- 3-71	134	226	7.805	M
10-31-71	94	163	3.834	N
12- 5-71	103	174	5.885	M
1- 7-72	107	250	5.184*	F
2- 9-72	141	250	4.096	M
3- 5-72	128	250	0.044	N
4- 1-72	131	250	0.576	N
4-30-72	160	250	19.600	M
5-16-72	156	250	15.376	M
6- 1-72	146	250	7.056	M
6-16-72	152	250	11.664	M
7- 2-72	65	110	3.636	N
7-16-72	30	58	0.068	N
9-10-72	9	12	3.000	N
	1937	3993	Sum of the chi squares 80.116	M (P=0.01)
			Chi square of the sum of the sexes 41.558	M (P=0.01)

*These sex ratios favor the female, therefore in summing the chi square values to determine if there are significantly more males, these figures are negative.

Table 2. *Chi square values of sex ratios of* P. uncatoides *collected at the Koaia Tree Sanctuary prior to the introduction of* H. conformis (M: Male; N: No difference).

Date (+ 4 days)	Number of males	Total sexed		Chi square	Sex favored (P =0.05)
7-19-71	119	204		5.020	M
8- 1-71	131	250		0.576	N
9- 1-71	138	250		2.704	N
10- 3-71	154	250		13.456	M
10-31-71	154	250		13.456	M
12- 5-71	167	250		28.224	M
1- 7-72	152	250		11.664	M
2- 9-72	127	250		0.064	N
3- 4-72	127	250		0.000	N
4- 1-72	140	250		3.600	N
4-30-72	157	250		16.384	M
6- 1-72	162	250		21.904	M
7- 2-72	151	250		10.816	M
7-29-72	117	250		1.024*	N
9-10-72	161	250		20.736	M
	2154	3704	Sum of the chi squares	148.604	M (P=0.01)
			Chi square of the sum of the sexes	98.492	M (P=0.01)

*This sex ratio favors the female, therefore in summing the chi squares to determine if there are significantly more males, this figure is negative.

TABLE 3. *Chi square values of sex ratios of* P. uncatoides *collected at 2043 m Mauna Loa Strip Road before, during and after two periods when the monthly mean temperatures were below 9° C (M: Males; N: No difference).*

Date (+ 4 days)	Number of males	Total sexed	Chi square	Sex favored (P = 0.05)
10-31-71	45	75	3.000	N
12- 5-71	9	20	0.200	N
1- 5-72	45	87	0.103	N
2- 3-72	96	165	4.418	M
3- 5-72	80	160	0.000	N
	275	507	Sum of the chi squares 7.521	N (P=0.05)
			Chi square of the sum of the sexes 3.647	N (P=0.05)
11- 2-72	14	26	0.154	N
1- 5-73	95	201	0.620*	N
3- 6-73	133	250	1.024	N
3- 5-73	141	250	4.096	M
	383	727	Sum of the chi squares 5.274	N (P=0.05)
			Chi square of the sum of the sexes 2.092	N (P=0.05)

*These sex ratios favor the female, therefore in summing the chi square values to determine if there are significantly more males, these figures are negative.

TABLE 4. *Chi square values of sex ratios of* P. uncatoides *at the Koaia Tree Sanctuary after the establishment of* H. conformis *(M: Male; N: No difference).*

Date (+ 4 days)	Number of males	Total sexed	Chi square	Sex favored (P = 0.05)
11- 9-73	149	250	9.216	M
12-13-73	121	250	0.256*	N
1-16-73	127	250	0.064	N
2-19-74	139	250	3.136	N
3-17-74	148	250	8.464	M
4-12-74	110	250	3.600*	N
5-16-74	145	250	6.400	M
	939	1750	Sum of the chi squares 27.280	M (P=0.01)
			Chi square of the sum of the sexes 9.362	M (P=0.01)

*These sex ratios favor the female, therefore in summing the chi square values to determine if there are significantly more males, these figures are negative.

similar to Clark (1962) working with the pear psylla, *Psylla pyriocola* Forester, and concluded that differences in psyllid sex ratios reported by various researchers could be due to the period in the psyllid population cycle in which the ratios were taken. My data, which were taken at approximately monthly intervals and entirely from field samples, indicate that this phenomenon does not occur in wild *P. uncatoides* populations. It would appear, therefore, that some factor, such as differential morality or migration, acts to reduce the number of females in wild *P. uncatoides* populations.

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ABSTRACT

Research by Madubunyi and Koehler on laboratory-reared *Psylla uncatoides* (Ferris & Klyver) led to several hypotheses to explain the occurrence of several sex ratio differences and what benefit these differences were to psyllid populations. Data on sex ratios of wild *P. uncatoides* populations failed to substantiate the hypotheses, yet indicated that some factor is regulating the sex ratios in wild populations.

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