Efficiency of the Dipper in Collecting Immature Stages of *Culex tritaeniorhynchus summorosus*

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ABSTRACT : The efficiency of the dipper (15 cm diameter and 3 cm depth) in collecting immature stages of *Culex tritaeniorhynchus summorosus* was examined experimentally in July, 1971. In each of four water tanks (85 × 85 cm, water depth 10 cm) in which rice plants were growing, 100 each of first, second, third, and fourth instar larvae and pupae of *tritaeniorhynchus* were released, and four persons dipped the water at ten sites in each water tank by the dipper (therefore the number of dips was 160 in total); in each dip the collected larvae were counted by instar, and then returned to the same site as the dip was taken. Based on the figures obtained by the above experiment, the dipping efficiency, which was defined as the probability for one larva in 1 m^2 to be collected by one dip, was established for each instar. By using this dipping efficiency it became possible to estimate the absolute density of *tritaeniorhynchus* larvae from the mean number per dip and the area of the rice field under study.

The dipper is known to be a most convenient and useful device for sampling immature stages of mosquitoes (Hagstrum, 1971; Knight, 1964; Wada *et al.*, 1971 a, b). In our studies on the population dynamics of *Culex tritaeniorhynchus summorosus* started in 1970, the dipper has been widely used to determine the relative density. In the course of the studies, it became necessary to know the efficiency of the dipper in collecting *tritaeniorhynchus* larvae (pupae inclusive) for the estimation of the absolute density in rice fields. Therefore, in July 1971, the known numbers of *tritaeniorhynchus* larvae in different instars, and of *Culex pipiens pallens* larvae for comparison, were released in water tanks in which rice plants were growing, and the numbers of larvae collected by the dipper were recorded. The present paper deals with the results on the efficiency of the dipper obtained by the above experiment.

MATERIALS AND METHODS

The mosquitoes used were *Culex tritaeniorhynchus summorosus* and *Culex pipiens pallens* from the Nagasaki colonies kept in our laboratory. In each of four water tanks, 100 each of first, second, third and fourth instar larvae and pupae of *tritaeniorhynchus* and fourth instar larvae of *pallens* were released carefully so that the mosquitoes were

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distributed without artificial clumps in the tank. The water tank was made of concrete, 85×85 cm in size, and the water depth was 10 cm. In each tank 20 rice plants, of which average height was 65 cm, were growing as shown in Fig. 1. The water temperature averaged 28°C at the time of experiment.

Four persons (A, B, C, and D) dipped the water at ten sites in each of four water tanks (I, II, III, and IV) as indicated in Fig. 1, therefore the number of dips was 160 in total. The field layout of the experiment is shown in Table 1. The dipper used was 15 cm in diameter and 3 cm in depth. In each dip the collected larvae were recorded by species and by instar, and then returned to the same site as the dip was taken. To minimize the disturbance by the previous dip, enough time was taken between the two succeeding dips, and the dipping order of ten sites in each water tank was randomly determined.

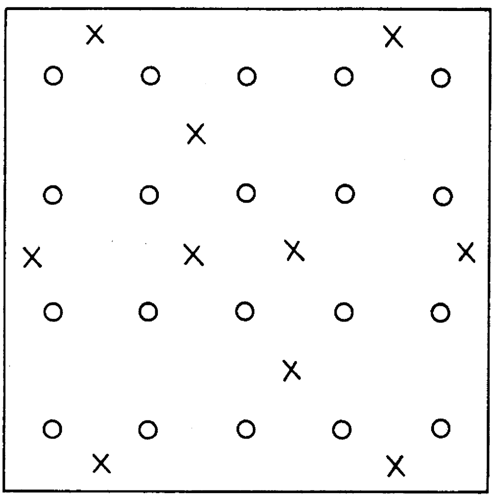

Fig.1. Showing the arrangements of 10 dipping sites (represented by ×) and 20 rice plants (represented by ○) in a water tank.

Table 1. Field layout to examine the efficiency of the dipper to collect mosquito larvae (pupae inclusive), by four persons (A, B, C, and D) in four water tanks (I, II, III, and IV)

Replicate	Water tank			
	I	II	III	IV
1	A	B	C	D
2	D	A	B	C
3	C	D	A	B
4	B	C	D	A

Note: One person dipped ten times in each water tank, therefore the total number of dips was 160.

RESULTS

In Table 2 are given the total numbers in four replicates of each instar larvae (pupae inclusive) of *tritaeniorhynchus* and fourth instar larvae of *pallens*. It was indicated from Table 2 that the numbers collected were not remarkably different by water tank and also by person, but the numbers differed significantly with species and with instars. In *tritaeniorhynchus*, the total number of first instar larvae was 87 by 160 dips, and the number became larger with the advance of instar, 157 pupae having been collected. On the other hand, only 39 fourth instar larvae of *pallens* were obtained by the same number of dips. Such a great difference in the number between *tritaeniorhynchus* and *pallens* is considered to be due to the different behaviors of the two species.

Since the numbers collected by the dipper differed with species and instar as shown in the above, the efficiencies of the dipper to collect each instar larvae of *tritaeniorhynchus* and fourth instar larvae of *pallens* are presented in Table 3. Here, the dipping efficiency was defined as the probability for one larva in 1 m^2 to be collected by one dip. Since the number of each instar larvae released was 100 in each of four water tanks, the total number released was 400. By dividing 400 (total number released) by 4 (number of water tanks), and again by 0.7225 (area in m^2 of a water tank, 0.85×0.85), we have 138.4 as the density per m^2 of the released larvae. The numbers of collected larvae per dip were obtained by dividing the total numbers collected (from

Table 2. Numbers of each instar larvae and pupae of *Culex tritaeniorhynchus summorosus* and fourth instar larvae of *C. pipiens pallens* collected by the dipper according to the layout of Table 1

	No. released in each tank	Number collected								Total*
		water tank				person				
		I	II	III	IV	A	B	C	D	
C. t. s.										
first	100	12	27	18	30	18	25	25	19	87
second	100	17	20	23	35	17	35	18	25	95
third	100	26	27	39	41	31	44	28	30	133
fourth	100	33	31	22	39	16	44	32	33	125
pupae	100	40	56	25	36	38	45	24	50	157
Total	500	128	161	127	181	120	193	127	157	597
C. p. p.										
fourth	100	6	6	17	10	5	14	9	11	39

* Number collected by 160 dips.
Note: Total numbers in four replicates are given by water tank and by person.

Table 3. Efficiencies of the dipper to collect each instar larvae and pupae of *Culex tritaeniorhynchus summorosus* and fourth instar larvae of *Culex pipiens pallens*

	No. released (A)	Density per m^2 (B)	No. collected (C)	No. per dip (D)	Dipping efficiency (D)/(B)	Reciprocal (B)/(D)
C. t. s.						
first	400	138.4	87	0.54	0.0039	256
second	400	138.4	95	0.59	0.0043	235
third	400	138.4	133	0.83	0.0060	167
fourth	400	138.4	125	0.78	0.0056	177
pupae	400	138.4	157	0.98	0.0071	141
Total	2000	692.0	597	3.73	0.0054	186
C. p. p.						
fourth	400	138.4	39	0.24	0.0017	577

(B) = (A) ÷ 4 (No. of water tanks) ÷ 0.7225 (area of a water tank).
(D) = (C) ÷ 160 (total No. of dips).
Dipping efficiency = probability for one larva in 1 m^2 to be collected by one dip.
Reciprocal = No. of larvae per m^2 expected when one larva was collected by one dip.

Table 2) by 160 (number of total dips). The values of the dipping efficiency defined above can be calculated for respective instar larvae by dividing the numbers of collected larvae per dip by the densities per m^2 of the released larvae. The dipping efficiency is naturally proportional to the total number of collected larvae.

The reciprocal of the dipping efficiency is the expected number of larvae per m^2 when one larva was collected by one dip. By using the value of the reciprocal, we can calculate the expected numbers of larvae in a unit area of the rice field from various mean numbers per dip. In Table 4 are presented the expected numbers in 1 m^2 and 1 ha of *tritaeniorhynchus* larvae in all instars together when the mean numbers per dip of collected larvae were 0.1, 0.5, 1.0, 5.0 and 10.0. It is shown from Table 4 that even when the mean number per dip is as small as 0.1 the expected number in 1 m^2 is 18.6, and that in 1 ha 186,000. When the mean number per dip is 10.0, the numbers in 1 m^2 and in 1 ha are respectively expected to be more than 1,800 and more than 18 millions. Since the mean number per dip of 10 is frequently encountered in rice fields in summer, it is apparent that an extremely large number of *tritaeniorhynchus* larvae are breeding in the vast area of rice fields.

Table 4. Numbers of *Culex tritaeniorhynchus summorosus* larvae (pupae inclusive) in the rice field expected from various mean numbers per dip (calculated from the reciprocal for the total of *C.t.s.* of Table 3)

Mean No. per dip	Number in 1 m^2	Number in 1 ha
0.1	18.6	186,000
0.5	93	930,000
1.0	186	1,860,000
5.0	930	9,300,000
10.0	1,860	18,600,000

Discussion

By sampling mosquito larvae the relative density is usually determined, however the absolute density is often required to know particularly in detailed ecological studies. The absolute density can be obtained by counting the entire population, but this method is normally applicable only to the species that breed in such small water bodies as cans, ciserns, tree and rock holes, etc. (Knight, 1964).

To estimate the absolute density, instead of counting the entire population, several methods have been developed. The removal method was applied to mosquito larvae in fertilizer pits and in tidewater rock pools to estimate the absolute density (Wada, 1962a, b), but this method is also limited to apply only to the breeder of small water bodies.

The mark-and-recapture method was applied by tagging mosquito larvae with radioactive phosphorus in permanent and temporary pools (Welch, 1960). This method can probably be used effectively in advanced ecological studies, however radioactive isotopes are prohibited to use in the field in Japan and other suitable method to mark mosquito larvae has not been established. An alternative may be to use, as a substitute for marked larvae, other insect which can be distinguished easily from the mosquito species under study. For this reason, *pallens* larvae were examined in the present experiment to know whether they can be used in the rice field as a substitute for marked *tritaeniorhynchus*, however the results indicated that the dipping efficiency for *pallens* was much lower than for *tritaeniorhynchus*, suggesting the different behaviors of the two species in the rice field. Therefore it is perhaps not wise to use *pallens* larvae as a substitute.

A number of static quadrat devices have been developed for evaluating absolute densities of mosquito larvae (see *e.g.* Knight, 1964). However, the density of *tritaeniorhynchus* larvae varies greatly within as well as between rice fields, accordingly very many samples are required to be taken to estimate properly the population density in a whole area with rice fields (Wada *et al.*, 1971b; Mogi and Wada, 1973). Static quadrat devices need usually too much labor in this sense, and it is because of this that we use the dipper to sample mosquito larvae in rice fields. The results of the present experiment demonstrated that the dipper can be used effectively to estimate the absolute density of *tritaeniorhynchus* larvae in the rice field.

The reason for the lower dipping efficiency in young stage larvae than in old stage larvae, as shown by the present experiment and also by Hagstrum (1971) and Shogaki and Makiya (1970), is not clear for the present. However, Hagstrum (1971) stated "Thomas (1950) found with *Culex pipiens quiquefasciatus* Say that instars I, II, III, and IV remained at the surface 5, 10, 40–50, and 80–100% of the time respectively." Since dipping, which is accomplished by submerging the forward edge of the dipper and moving it forward with a skimming motion, relies in principle on the fact that nearly all mosquito larvae sooner or later must come to the water surface (Knight, 1964), the relative deficiency of early stages may be due to the difference in time spent at surface.

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柄杓のコガタアカイエカ幼虫採集能率

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20株の稲（高さ約 65 cm）が植えてあるコンクリート製水槽（85×85 cm，水深 10 cm）4つの各々に，コガタアカイエカの1～4令幼虫及び蛹をそれぞれ 100個体（合計 500個体）ずつ放した．これらの水槽で，柄杓（直径 15 cm，深さ 3 cm）を用いてすくいとって令別個体数を記録した後，すくいとられた幼虫を水槽のもとの位置にもどした．これを各水槽において4人でそれぞれ10回ずつくり返した．このようにして4つの水槽で合計 160回すくいとった結果 597個体（1すくい平均 3.73個体）の幼虫（蛹を含む）が得られた．最初に 85×85 cm の水槽に各令幼虫及び蛹併せて 500個体放したので，$1m^2$ 当り $500/0.85^2=692$ 個体いた水槽からすくいとったことになる．即ち，1すくい当り平均 3.73個体の幼虫が得られる時には，$1m^2$ 当りの幼虫密度は約 692個体と推定される．また，1すくい当り平均1個体が得られたとすると，幼虫密度は $1\ m^2$ 当り $692/3.73=186$ 個体となる．この関係を用いれば，実際に水田ですくいとった柄杓当りの平均幼虫数から，$1\ m^2$ 当りの幼虫数を推定することができ，これに対象とした水田の面積を掛けることによって，そこに生息している幼虫の絶対数の推定値を得ることが可能となる．以上は各令幼虫及び蛹を合計した値を用いた結果であるが，各令別にも同様の計算をすることができる．

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