柄杓のシナハマダラカ幼虫採集能率

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雑誌名	衛生動物 = Medical entomology and zoology
巻	35
号	4
ページ	367-371
発行年	1984-12-15
URL	http://hdl.handle.net/2297/11688

[Jap. J. Sanit. Zool. Vol. 35 No. 4 p. 367-371 1984]

Efficiency of the dipper in collecting larvae of *Anopheles sinensis* (Diptera: Culicidae) in rice fields

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(Received: March 29, 1984)

Key words: efficiency, dipper, *Anopheles sinensis*, rice field.

Abstract: The efficiency of a dipper (15 cm in diameter and 3 cm in depth) in collecting *Anopheles sinensis* larvae in rice fields was examined experimentally at different larval densities and growth stages of rice plant. Mean number of larvae per dip was proportional to larval density at least within the density range 25–800 of each instar per m^2. The dipping efficiency was not influenced by the growth stages of rice plant.

INTRODUCTION

For obtaining absolute density of immature mosquitoes some methods and devices were proposed by Knight (1964). Ikemoto (1976) used a static quadrat method for sampling immature mosquitoes in rice fields. However, his method is inapplicable to extensive surveys owing to its tedious procedure and much time required. On the other hand, the dipper has been widely used for sampling immature mosquitoes in rice fields owing to its simplicity and effectiveness (Hagstrum, 1971; Nagamine *et al.*, 1979; Takahashi *et al.*, 1982), but it is only useful for estimating relative density. Wada and Mogi (1974) and Chubachi (1976) attempted to convert relative density obtained by the dipper to absolute one on the assumption that mean number of immature mosquitoes per dip is proportional to absolute density. Recently this assumption was tested by Stewart and Schaefer (1983) and Andis *et al.* (1983). They obtained a linear regression equation between dipper counts and absolute densities for each stage and concluded that dipper counts could be converted to the absolute densities by use of the equations.

A problem still remains whether the growth stages of rice plant affect the dipping efficiency or not. If the dipping efficiency is affected significantly by the growth stages, we must obtain the efficiency at every stage of rice plants. In the present study we examined the relationship of the dipper counts with absolute densities of *Anopheles sinensis* Wiedemann larvae and influence of growth stages of rice plant on the dipping efficiency.

MATERIALS AND METHODS

The engorged adult females of *An. sinensis* collected at a cow-shed in the suburbs of Saga City were allowed to oviposit in the insectary (28°C, 15-h photophase). Hatched larvae were reared with powdered mouse-pellets plus dry yeast in the same insectary. To prepare the larvae of all instars on the day of experiments, eggs were obtained over several nights.

Two series of field experiments were

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conducted. The first one was done in August, 1982 to clarify the relation between the dipping efficiency and larval density. With a plastic plate, a sampling enclosure (1×1 m) was set in a rice field. This enclosure contained 24 rice plant hills in 4 rows. After filling the enclosure with well water (about 5 cm in depth), 25 larvae of each instar were released carefully to avoid artificial clumps. Twenty minutes lag was taken between the larval release and onset of dipping to allow them to surface. Then 50 dips were taken with a dipper (15 cm in diameter and 3 cm in depth) from all sites inside the enclosure. Once a dip was taken, larvae were counted, recorded by instars and returned to the same site where dipped. The same procedures were repeated at larval densities of 50, 100, 200, 400 and 800/m^2 of each instar. The experiments of higher densities were made by adding more larvae to the enclosure after completion of the experiments of lower densities.

The second series of experiments was carried out to examine the efficiency of the dipper at 3 different growth stages of rice plant in 1981. In mid-July rice plants were short (*ca.* 30 cm in height) and sparse. Water surface was open between rice plants. In mid-September rice plants were so tall (*ca.* 80 cm in height) and dense that the water surface was hardly seen. In mid-August the condition was intermediate between July and September. Six sampling enclosures, the same type as the first experiments, were set up in the rice field in July.

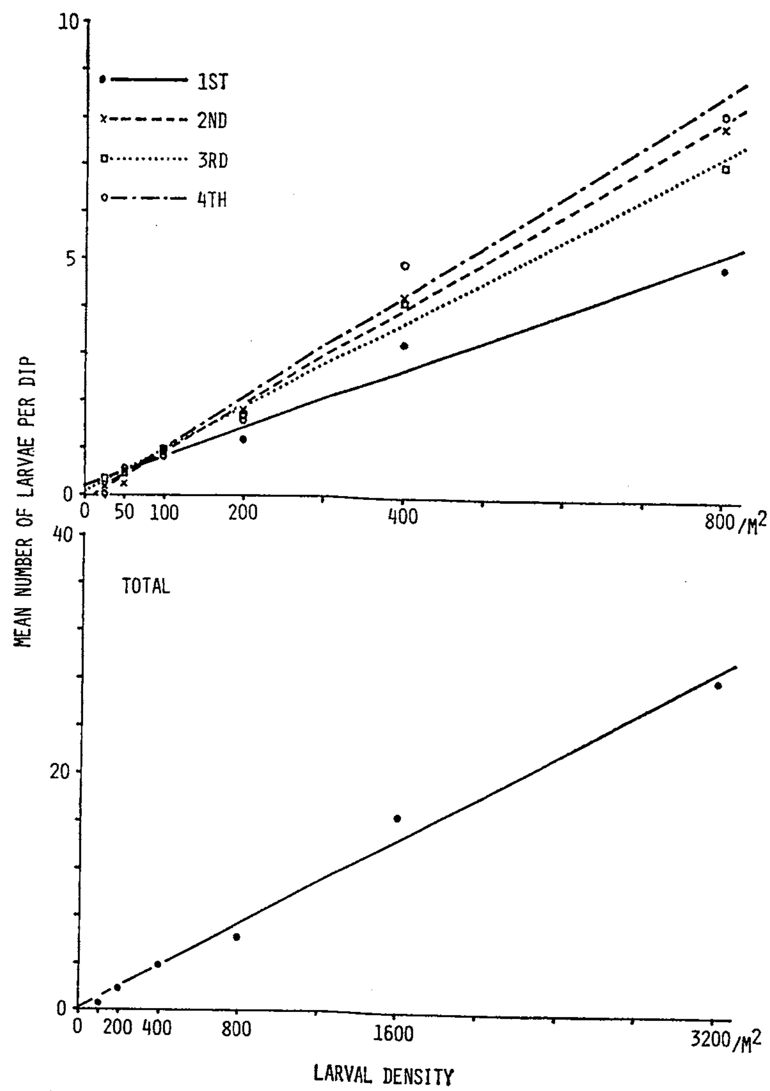

Fig. 1 Relationship between mean number of larvae per dip and absolute larval density.

These enclosures remained set till September for repeated use. After 100 larvae of each instar were introduced, 10 dips were taken from each enclosure. In July the rice field was watered and wild *Anopheles* larvae existed in the enclosures. Therefore 10 dips were taken each before and after the larval release. Numbers of larvae used for analysis were obtained by subtracting the numbers in pre-release dipping from those in post-release dipping. No fishes were found in the enclosures. In August and September the rice field was completely drained, thus contamination of the enclosures with wild larvae was impossible.

Results

Relation between the mean number of larvae per dip and the absolute larval density

Relation between the mean number of larvae per dip and the absolute larval density of *An. sinensis* is shown in Fig. 1. A linear relationship can be seen (r^2: 1st instar, 0.975; 2nd instar, 0.998; 3rd instar, 0.998; 4th instar, 0.981; total, 0.990). The regression equations between the number of larvae per dip (Y) and the absolute density (X) obtained by the method of least squares are as follows:

1st instar $Y=0.0062X+0.2046$
2nd instar $Y=0.0102X-0.1122$
3rd instar $Y=0.0090X+0.0943$
4th instar $Y=0.0107X-0.1146$
Total $Y=0.0090X+0.0720$

Results of *t*-test for common regression coefficients indicated that the regression coefficient for the 1st instar is significantly smaller than those for the other instars (Table 1). The lines crossed with each other at the larval density less than 200/m^2 (Fig. 1). Therefore the difference of number of larvae per dip among instars is relatively small at the lower larval density.

Table 1 Test of common slops for the larval instars.

Instar	1st	2nd	3rd	4th
1st	—	**	**	**
2nd		—	*	
3rd			—	
4th				—

* Difference at 0.05 level.
** Difference at 0.01 level.

2. *Influence of different growth stages of rice plant on dipping efficiency*

Table 2 shows the numbers of larvae collected by 10 dips at the density of 100/m^2 of each instar at the 3 different growth stages of rice plant. The analysis of variance in three-way classifications indicated that the difference caused by the 3 factors, growth stages of rice plant, enclosures and instars, was not significant at 0.10 level (Table 3). The difference caused by the interaction of

Table 2 Numbers of *Anopheles sinensis* larvae collected by 10 dips at the density of 100 larvae of each instar per m^2 at 3 different growth stages of rice plant.

Quadrat	Growth stages of rice plant: Young (July) Instar 1st	2nd	3rd	4th	Middle (August) Instar 1st	2nd	3rd	4th	Matured (September) Instar 1st	2nd	3rd	4th
I	4	20	3	16	11	12	8	13	14	19	8	11
II	7	11	8	11	5	13	8	6	3	13	12	4
III	17	18	10	2	10	9	3	12	10	10	11	12
IV	9	11	3	9	10	3	3	5	11	9	9	6
V	6	5	7	7	7	13	13	7	13	7	14	8
VI	2	1	3	5	8	11	10	14	13	11	17	7
Total	45	66	34	50	51	61	45	57	64	69	71	48

Table 3 Analysis of variance in three-way classifications for Table 2.

Factors	Sums of squares	Degree of freedom	Variance	Ratio, F
Total	1330.65	71		
Growth stage	70.19	2	35.10	2.12*
Instar	72.82	3	24.04	1.46*
Quadrat	139.57	5	27.91	1.68*
Growth stage × Instar	94.47	6	15.75	0.95*
Instar × Quadrat	332.93	15	22.20	1.34*
Quadrat × Growth stage	240.14	10	24.01	1.45*
Residuals	497.41	30	16.58	

* No difference at 0.10 level.

2 factors was also not significant at the same level.

Discussion

The linear relationship between the mean number of immature mosquitoes per dip and the absolute density in rice fields was observed for *Culex tarsalis* Coquillett by Stewart and Schaefer (1983) and for *Psorophora columbiae* (Dyar and Knab) and *An. crucians* Wied by Andis *et al.* (1983). The present study confirmed similar linear relationship for *An. sinensis.* This suggests the feasibility of dipper counts for estimation of absolute population density as Stewart and Schaefer (1983) concluded.

Further it was observed that the dipping efficiency was not affected by the difference of growth stages of rice plant. Dipper counts from rice fields at various growth stages of rice plants can be directly compared. This is a great advantage to the dipper for sampling immature mosquitoes, especially those in Japanese rice fields. There rice stubbles are arranged at a regular interval and water depth is well managed, so that the conditions of rice fields are fairly uniform throughout locality. Once the efficiency of the dipper is determined for one mosquito species in a rice field under standard conditions, it can be applied to other rice fields unless the water depth is extremely low.

Lower efficiency of dippers for young larvae than for old ones was reported in the preceding studies (Hagstrum, 1971; Wada and Mogi, 1974; Chubachi, 1976; Stewart and Schaefer, 1983; Andis *et al.,* 1983). Also lower efficiency for 1st-instar larvae of *An. sinensis* was observed at high larval density. The cause of this phenomenon has not been clarified yet. Probably differential microdistribution and behavior of each instar are related to dipping efficiency.

Wada and Mogi (1974) pointed out the interspecific difference of dipping efficiency. Between 2 mosquito species, *An. sinensis* and *Cx. tritaeniorhynchus* Giles which are abundant in Japanese rice fields, difference was found. For *Cx. tritaeniorhynchus* the efficiency of the same type dipper as used in the present study was obtained by Wada and Mogi (1974) at the larval density of 138.4/m^2. The present results showed the dipping efficiency for *An. sinensis* to be about twice higher in all larval instars than that for *Cx. tritaeniorhynchus.* According to laboratory observations, *Cx. tritaeniorhynchus* larvae seem to be more sensitive to disturbance and more speedy in movement than *An. sinensis.* This may partly explain the lower dipping efficiency for *Cx. tritaeniorhynchus.*

Acknowledgements

We wish to express our cordial thanks to Prof. T. Shozaki and Mr. H. Tanaka, Agriculture Experimental Station, Saga University, for admitting us to use the rice fields. We are also grateful to Miss K. Noda for assisting arrangement of the manuscript.

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摘　要

柄杓のシナハマダラカ幼虫採集能率

水田のシナハマダラカ幼虫の絶対密度を推定するために，柄杓（直径 15 cm，深さ 3 cm）の採集能率を調べた．また採集能率に対し，稲の発育段階の違いが与える影響を検討した．

水田に 1 m 四方のプラスチック枠を設置し，その中にシナハマダラカ幼虫を各齢 25, 50, 100, 200, 400, 800 匹/m^2 の密度段階で放し，各段階で 50 杓すくい，1 杓当りの平均幼虫数を求めた．1 杓当りの平均幼虫数は幼虫の絶対密度と高い相関関係を示した．この結果より，柄杓で得られた幼虫の相対密度は絶対密度に転換できると結論し，それぞれの齢について回帰式を求めた．

田植えの後（7 月），穂の出る前（9 月）とその中間（8 月）に同様の枠を 6 個設置し，各齢幼虫密度 100 匹/m^2 で，各枠内から10杓とり，稲の発育段階の違いが採集能率に与える影響を調べた．その結果各発育段階で採集された幼虫数には有意の差はなかった．このことから，稲のある発育段階で得られた柄杓の採集能率はそのまま他の発育段階にある水田にも適用できると結論した．