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Characterizing Distribution of the Head Width in a Holometabolous Insect Larvae[1)]

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完全변태류 幼虫의 頭幅分布 推定方法[1)]

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ABSTRACT

The d/w ratio, initially proposed for measuring resource utilization of an organism, was introduced for an objective description of the larval head width distribution in a holometabolous insect. The statistical method was successfully applicated in the case of *Sitophilus oryzae*, and, therefore, could be also used for characterizing the larval head width distribution of other insects.

INTRODUCTION

For studies on biolgy of insects in relation to ırious factors, informations on the characters of ch developmantal stage necessary. A prerequisite r such studies is, therefore, that each stage can : identified explicitely with some definite criteria. In the case of holometabolous insects which molt veral times during their larval stage, identification each instar from samples is the basic step to vestigate the biology of insect concerned.

As the size of each instar is so variable in relaon to nutrition or other factors, it is doubtful that ıe size could serve as a criterion.

Some authors have used the head width of larvae s a key for defining an instar stage under the round that its variation within an instar stage is ot so great as that of the size. By depending solely on the frequency curve or histogram, however, one can often distinguish no explicit point to separate two adjacent instar stages, especiallly when the number of the available larvae sampled is small. Thereby, the key must be rather subjective depending on the author.

In the present paper, a statistical method for an objective descriptiion of the head width distribution of an instar stage will be presented.

STATISTICAL CONSIDERATION

Assuming that the head width distribution of an insect larvae is a complex composed of some subpopulations which distribute normally, each subpoplation in the complex can be characterized statistically by two parameters; mean and variance.

Thereby, the two adjacent populations can be seaparated by the d/w ratio, initially proposed for

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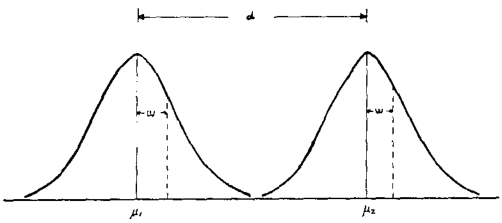

Fig. 1. A schematic diagram to illustrate the relationship between "d" and "w"

measuring the extent of the separation in the resource utilization between potentially competing species[3], where d is separation measure between the means and w is 1 standard deviation in the normal curve.

If the value of the ration is equal or greater than 4, the two distributions have negligible probability of overlapping in this theoretical situation[1].

Provided that a distribution is unbiased, then the mean, median and mode have the same value: the mode is an appropriate estimate of the mean.

The mode of each subpopulation is easily obtained from the histogram of the head width distribution and the standard deviation can be estimated with the d/w ratio in the case of the value 4. The 95% confidence interval of the head width of a subpoplu-ation (a larval instar) is, thus,

$$\bar{X}_i - 1.96w_i \leq X_{ij} \leq \bar{X}_i + 1.96w_i,$$

which is derived from the formula;

$$X = \mu + \sigma Z^{4)}.$$

In most sampling situations, however, the mean estimated from the mode could be more or less biased. In order to minimize the error due to this procedure, it is desirable to calculate the mean and the standard deviation from the subpopulationn grouped by the first estimation.

A CASE STUDY

Larval head width distribution of the rice weevil (*Sitophilus oryzae L.*) was studied. Rice in the storage infested with the rice weevil was sampled and stained with acid fuchsin[5]. The rice was then dissected under a stereo-microscope. The head width of each larva found was measured. The histogram obtained was shown in Fig. 2.

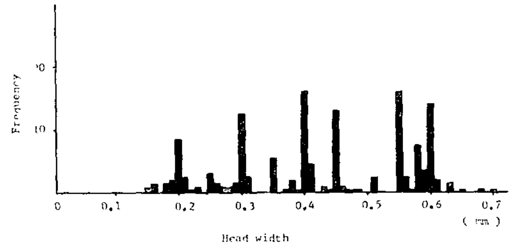

Fig. 2. The frequency distribution of head wid of the *Sitophilus oryzae* larvae sampl from the rice storage.

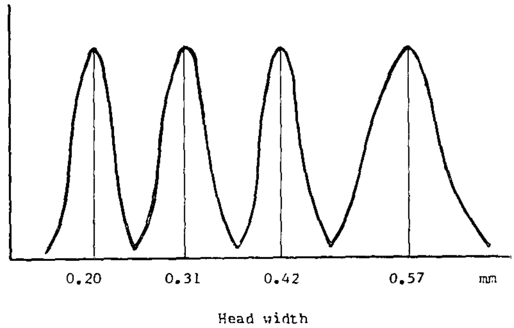

Fig. 3. The frequency distributiou of head widt of the *Sitophilus oryzae* larvae estimate based on assumption of normality withi an instar stage.

The larval head width distribution was compose of four distinct groups, which indicates that the insect has four larval stages in its life cycle. How (1962) identified four larval instars of the ric weevil reared on wheat, although he did not presen any criteria. Wilbur (1978) also showed four larva instars in the rice weevil.

Values of the modes for the first-, second-, third- and fourth group were 0.20mm, 0.30mm, 0.40mm and 0.55mm, respectively. Based on the assumption of normality, the standard deviations were estimateu as 0.025mm, 0.025 mm, 0.025mm and 0.038mm for the first-, second-, third- and fourth group, respectively.

The 95% confidence intervals of the head width in each instar were then calculated and shown in Table 1. Since the characterizations were based on the sample data, the parameters could be biased: the modes and the means could have different values in the data. In order to correct the possible bias,

ble 1. The head width distribution characteristics of the four larval stages of *Sitophilus oryzae* estimated by the use of the formula, d/w=4

Instar	First Estimation[a]			Second Estimation[b]		
	Mean (mm)	S.D.	C.I. 95[c]	Mean (mm)	S.D.	C.I.95
I	0.20	0.025	0.15~0.25	0.20	0.026	0.15~0.25
II	0.30	0.025	0.25~0.35	0.31	0.026	0.26~0.36
III	0.40	0.025	0.35~0.45	0.42	0.025	0.37~0.47
IV	0.55	0.038	0.48~0.62	0.57	0.039	0.49~0.65

[a] The means are assumed to be the same as the modes.
[b] The estimates are calculated from the sample set grouped by the first procedure.
[c] 95% confidence interval of the head width

e parameters were calculated from the data gro- ›ed in accordance with the first estimates. The sults were illnstrated in Table 1 and Fig.3. As .ow in Table 1, the 95% confidence intervals of e head width for the first-, second-, third- and urth instar were 0.15-0.25mm, 0.26-0.36mm, 37-0.47mm, and0.48-0.65mm, respectively.

DISCUSSION

The head width of larval stages, which has :en used as a key for identiying each instar stage, often so variable that it is difficult to distinguish ıe stage from the others by depending solely on the ·equancy curve of the head width. Nevertheless ɔ relevant method has been so far presented to ›ercome the difficulties.

The statistical consideration based on the d/w ıtio could be applicable to characterize the head ·idth distribution of a stage and thus to identify it. The ambiguity of the conventional method be, ıus, minimized and one could define the range of ıe head width of each stage with a definite error, % for example. Instead of the mode, the median, ·hich is often desirable as a measure of central ≥ndency, could be used if the mode is not distingu- ;hable from the frequency curve or histogram. In he case of the rice weevil, the method was succes- fully applicated in identifying each instar reasona- ly as shown above.

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摘 要

完全 변태류 昆虫에 있어서 各幼虫期의 구분은 頭幅에 의하는 것이 常例이다. 그러나 分布의 特性이 정의되지 않는 在來的 方法으로는 客觀性이 보장되지 못하며 때로 令期의 判定조차 어려울 경우가 있다. 이러한 短點을 보완, 各令期의 頭幅分布의 特性을 통계적으로 기술하기 위해서 "d/w"比의 개념을 도입하는 것을 검토하였다. 쌀바구미 幼虫의 頭幅分布를 이 比를 이용하여 정의하였으며 이러한 例는 다른 昆虫의 경우에 있어서도 合理的으로 적용될 수 있음을 보여주는 것이라 思料된다.