

**DOL.10.36108/NJE/6791/20.0111**

*Nigerian J. Ent.* 2 (1&2) pp. 111 - 124, - 1976

**TEMPERATURE RELATIONS IN *BATHYCOELIA THALASSINA* H-S  
(ENTATOMIDAE) AND *SAHLBERGELLA SINGULARIS* HAGL. (MIRIDAE):  
ON HETEROPTERAN PESTS OF COCOA (*THEOBROMA CACAO* L.) IN  
NIGERIA**

IFEDIORAMMA E. NWANA AND ANTHONY YOUDEOWEI

*Department of Agricultural Biology,  
University of Ibadan, Ibadan, Nigeria.*

ABSTRACT

Development of *B. thalassina* and *S. singularis* was not accomplished at 15°C and 35°C. Development in both species was similarly affected by temperature in the range 20-30°C; an increase in ambient temperature within this range had a reduction in the developmental period. However, *B. thalassina* showed a wider range of temperature tolerance than *S. singularis*. The "preferred temperature" of 20.7°C to 34.9°C for *B. thalassina* was wider than 23° to 32°C for *S. singularis*.

INTRODUCTION

At the 4th conference of West African Cocoa Entomologists held in Accra, Ghana in December 1974, it was generally accepted that *B. thalassina* which was recently reported on Cocoa (Gerard, 1965) has now attained major pest status on this important crop. Several factors such as the insecticidal control of cocoa pests (Vernon, 1968) the introduction of new varieties of cocoa (Marchart and Lodos 1969) and probably climatic factors (Eguagie, 1974) have contributed to the success of *B. thalassina* on cocoa. In this paper, experiments made to investigate the relations between temperature (one of the most important components of climate) to the survival and development of *B. thalassina* are reported. For effective comparison, the effect of temperature on the survival and development of *S. singularis*, the most important pest of cocoa in Nigeria, was also investigated.

METHODS

*Sources of Insect Specimens*

A culture of *B. thalassina* was started in the Insectary of the Department on 4/73 with 7 males, 3 females and 16 nymphs of different instars collected from a Cocoa farm in Aba-Ijero, 3 miles west of Ondo. The culture was maintained on Cocoa cherelles; drinking water was supplied with a wet absorbent cotton wool in glass petri-dishes. *B. thalassina* laid eggs which hatched and the nymphs developed normally under insectary conditions reaching adult stage in 47-50 days. Eggs and nymphs used in all the experiments reported here were obtained from this culture.

Attempts to culture *S. singularis* in the laboratory were not successful because of high pre-reproductive adult mortality. Nymphs used for experiments were collected from the field. A large number of 1st instar nymphs were

collected and kept at the desired experimental conditions; as soon as 2nd instar nymphs were produced, they were picked with a soft camel-hair brush into the experimental cages for detailed observations.

#### *Effect of Temperature on Speed of Development*

Two Gallenkamp incubators, (IH-332 for temperatures up to 25°C and IH-150 for temperatures between 27°C and 35°C) were used for these experiments. The temperature settings were calibrated by using simple mercury-in-glass thermometers placed inside the incubators. Wet pads of absorbent cotton wool in two dissecting dishes (28.5cm x 21cm x 10cm) provided the desired humidity which ranged between 70% and 90% R.H. as determined with an Edney paper hygrometer.

Seven temperatures; 15°C, 20°C, 22°C, 25°C, 27°C, 30°C, and 35°C were set up. Each experiment was terminated when all the nymphs had moulted into adults or died.

Large numbers of 1st instar nymphs of *S. singularis* were collected from a field at the Cocoa Research Institute of Nigeria (C.R.I.N.) and kept at the desired temperatures. As soon as 2nd instar nymphs moulted, sets of 10 nymphs were placed in separate experimental cages with food and water. These cages were kept inside the incubators. Daily records of moults and deaths were taken.

Eggs of *B. thalassina* were collected in batches as they were laid, placed in separate experimental cages inside the incubators. The resulting nymphs were also allowed to develop within the incubators.

Five replicates of these cages were set up for each species at each temperature.

### RESULTS

Table I presents data on the incubation period of eggs of *B. thalassina* at various constant temperatures. Eggs did not hatch at 15°C or at 35°C; the signs of embryonic development, such as the appearance of the outlines of the embryo within the chorion, were rarely noticed. However, within the temperature range of 20-30°C increase in temperature caused a reduction in the incubation period from  $6.6 \pm 0.8$  days at 20°C to  $3.4 \pm 0.2$  days at 30°C. The relationship between temperature and incubation period was approximately curvilinear.

This shows that the effect of temperature on the length of the developmental period was not uniform within the temperature range suitable for embryonic development. The reduction in developmental period due to a unit increase in temperature was more at the lower temperature than at the higher temperature. Nymphal development in *B. thalassina* was not completed at 15°C and 35°C. Between 20°C and 30°C increase in temperature resulted in a reduction in the developmental period for all pre-imaginal instars (Table 2). Since eggs did not hatch at 35°C some eggs were incubated at room temperature and the resulting nymphs were reared at 35°C. Some developed up to the 4th nymphal stadium before death. The relationship between temperature and developmental period for each nymphal instar and for the total nymphal life of *B. thalassina* was approximately curvilinear (Fig.2).

The effect of temperature on the development of nymphs of *S. singularis* was similar to that of *B. thalassina*, that is, increase in temperature within the

TABLE I. The incubation period of eggs of *B. thalassina* at different constant temperatures

| Temp.<br>(oC) | Mean Incubation Period (days)<br>Standard deviation | Variance<br>(S <sup>2</sup> ) |
|---------------|-----------------------------------------------------|-------------------------------|
| 15            | —                                                   | —                             |
| 20            | 6.6 ± 0.8                                           | .71                           |
| 22            | 5.2 ± 0.6                                           | 0.40                          |
| 25            | 4.4 ± 0.7                                           | 0.45                          |
| 27            | 3.9 ± 0.3                                           | 0.10                          |
| 30            | 3.4 ± 0.2                                           | 0.04                          |
| 35            | —                                                   | —                             |

TABLE II.

Effect of Temperature on the speed of development of the pre-imaginal stages *B. thalassina* (figures inside the table refer to means upper rows and standard deviations-lower row)

| Temp.<br>°C | Developmental Period ± Standard Deviation (Days) |              |              |               |              |               | Instar<br>I<br>to Adult | Egg to<br>Adult |
|-------------|--------------------------------------------------|--------------|--------------|---------------|--------------|---------------|-------------------------|-----------------|
|             | Egg<br>Stage                                     | Instar<br>I  | Instar<br>II | Instar<br>III | Instar<br>IV | Instar<br>V   |                         |                 |
| 15          | —                                                | —            | —            | —             | —            | —             | —                       | —               |
| 20          | 6.6<br>±0.9                                      | 8.1<br>±0.9  | 11.3<br>±0.8 | 13.2<br>±0.9  | 16.4<br>±1.7 | 19.2<br>±2.9  | 72.0<br>± 3.8           | 78.6<br>±.4     |
| 22          | 5.2<br>±1.0                                      | 7.3<br>±0.9  | 9.8<br>±0.8  | 11.8<br>±0.9  | 14.8<br>±1.6 | 17.3<br>± 3.7 | 59.7<br>± 3.2           | .64<br>±.1      |
| 25          | 4.4<br>±0.8                                      | 6.5<br>±0.5  | 7.9<br>±0.7  | 8.9<br>±0.8   | 11.4<br>±1.7 | 13.3<br>± 1.7 | 47.5<br>± 2.9           | .51<br>±.3      |
| 27          | 3.9<br>±0.3                                      | 5.2<br>±0.3  | 7.3<br>±0.7  | 8.3<br>±0.6   | 10.2<br>±1.6 | 11.9<br>± 2.0 | 43.4<br>± 2.6           | .47<br>±.2      |
| 30          | 3.4<br>±0.4                                      | 4.4<br>±0.4  | 6.2<br>±0.4  | 7.5<br>±0.4   | 9.4<br>±1.0  | 10.9<br>± 1.0 | 39.2<br>± 1.8           | 42.6<br>±.1     |
| 35          | —                                                | 4.1*<br>±0.3 | 6.6<br>±0.2  | 8.7<br>±0.5   | 12.2<br>±1.6 | —             | —                       | 0               |

TABLE III.

Effect of Temperature on Nymphal Mortality in *S. singularis*

| Temperature<br>°C | No. of<br>nymphs<br>reared | Number of nymphs dead within each nymphal stadium |          |          |          |          | Total dead<br>nymphs | Dead nymphs<br>as a percentage<br>of Total |
|-------------------|----------------------------|---------------------------------------------------|----------|----------|----------|----------|----------------------|--------------------------------------------|
|                   |                            | Instar 1                                          | Instar 2 | Instar 3 | Instar 4 | Instar 5 |                      |                                            |
| 15                | 30                         | 26                                                | 4        | -        | -        | 30       | 100                  |                                            |
| 20                | 50                         | 7                                                 | 3        | -        | 6        | 20       | 40                   |                                            |
| 22                | 50                         | 0                                                 | 5        | 4        | 4        | 11       | 22                   |                                            |
| 25                | 50                         | 0                                                 | 3        | 2        | 0        | 4        | 8                    |                                            |
| 27                | 50                         | 2                                                 | 4        | 0        | 1        | 7        | 14                   |                                            |
| 30                | 50                         | 0                                                 | 3        | 2        | 3        | 8        | 16                   |                                            |
| 35                | 20                         | 16                                                | 4        | -        | -        | 20       | 100                  |                                            |

20-30°C shortened the developmental period. At 20°C freshly moulted 2nd instar nymphs of *S. singularis* took  $27.3 \pm 0.7$  days to reach the adult stage whereas at 30°C the development from 2nd instar nymphs to the imago lasted  $15.4 \pm 2.1$  days. The average time spent in each nymphal stadium was shortened by increasing the ambient temperature (Fig.3.). At higher temperatures the spread in the time of moulting for any given stadium was reduced (Fig.4.); this observation was further confirmed by the reduction in the standard deviations for the mean duration of each nymphal stadium.

The lethal effect of high and low temperatures on the pre imaginal stages of *S. singularis* is shown in Table 3. At 20°C, 40% of the 2nd instar nymphs died before adult emergence whereas 8% died before final moult at 25°C. Kumar (197) observed that nymphal mortality from laboratory reared nymphs of *S. singularis* was rarely below 20% and was higher with field-collected nymphs. The low percentage mortality recorded between 25°C and 30°C was associated with the favourable effect of temperature on nymphal survival and development.

The combined effects of long developmental periods and higher nymphal mortality at 20°C and 22°C clearly indicate that these temperatures are unfavourable for the increase in numbers of *S. singularis*. The mean screen temperature in the field during the period of build-up of mirid population on cocoa is usually 27.8°C (Wessel, 1964); this temperature falls within the range 25-30°C when minimum nymphal mortality and shorter developmental periods were recorded in the laboratory. Thus environmental temperature is likely to be one of the factors influencing survival and the seasonal fluctuations in the populations of *S. singularis* in the field.

The above results show that although *B. thalassina* and *S. singularis* developed under similar temperature condition *B. thalassina* showed a wider range of temperature tolerance than *S. singularis*. This partly explains the more persistent occurrence of *B. thalassina* on coeca throughout the year even during periods when ambient temperature is not favourable for survival of *S. singularis*

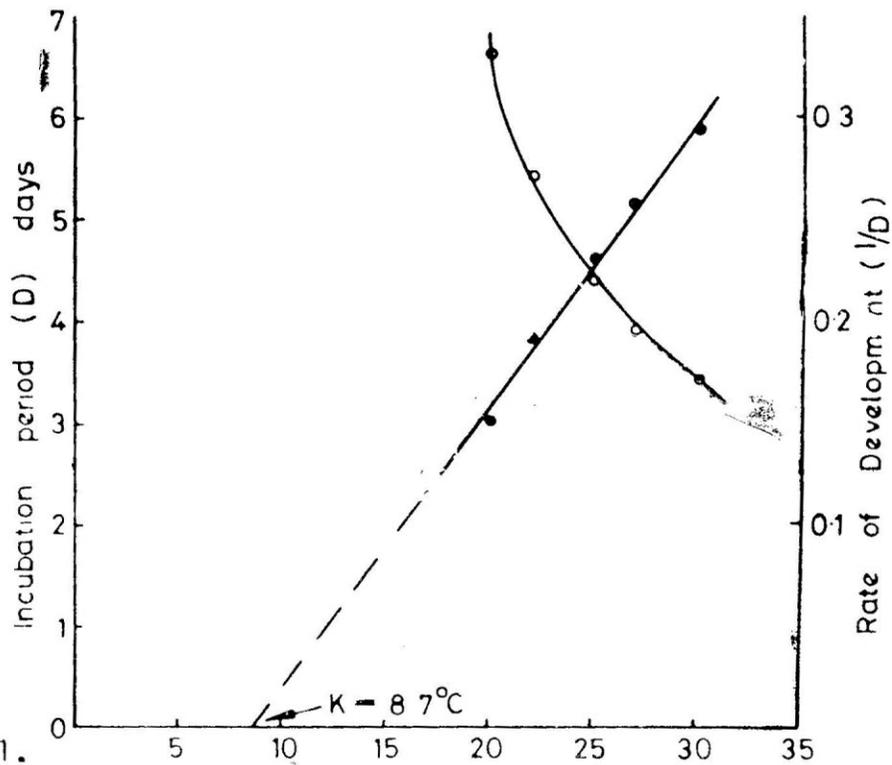


FIG. 1.

Fig. 1. Average incubation periods (curved lines) and the rate of development (straight line) of *B. thalassina* at different constant temperatures.

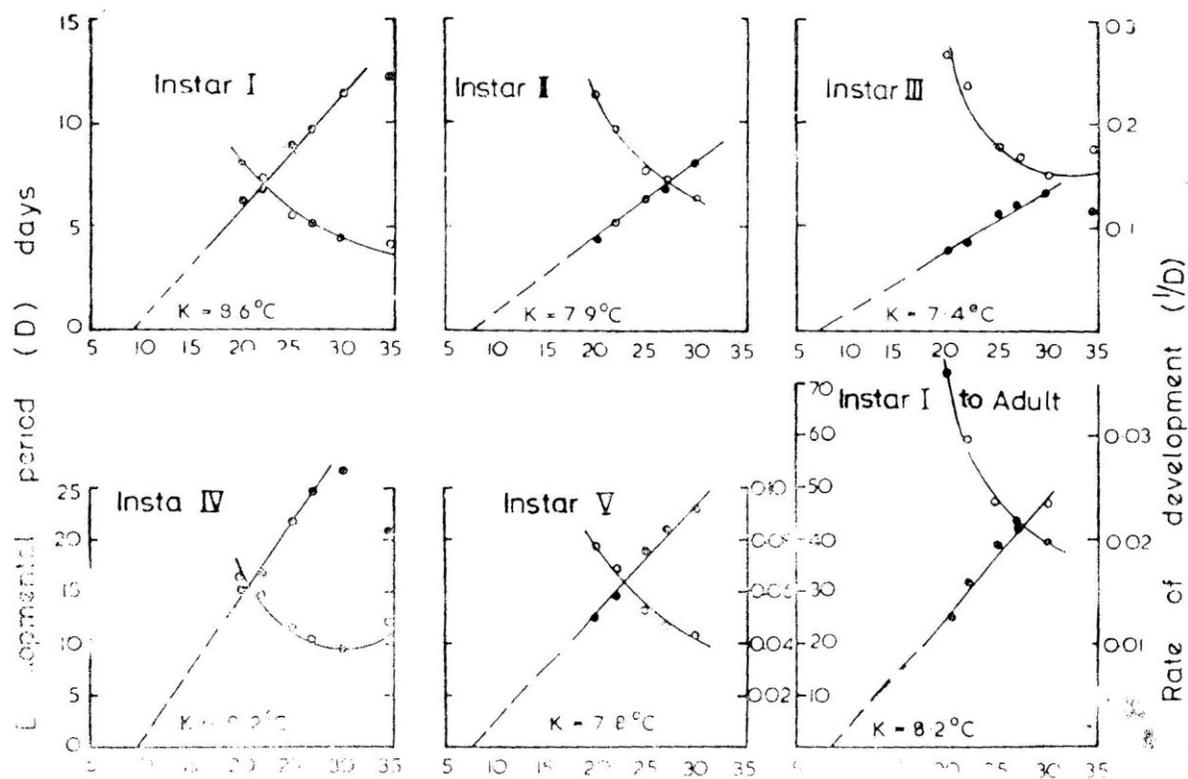


FIG. 2.

Fig 2 Average development periods (curved lines) and at rate of development (straight lines) foa various nymphal instars of *B. thalassae* the different temperature.

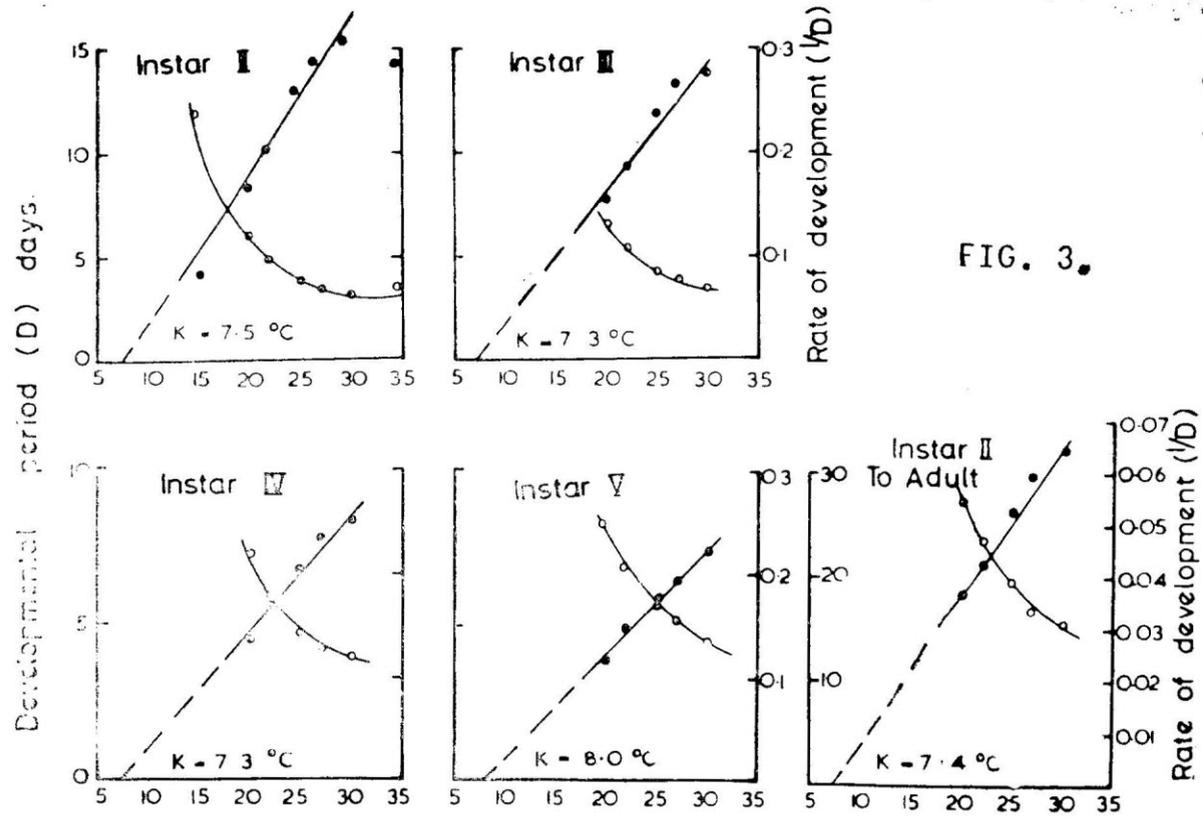


FIG. 3.

Average developmental periods (curved lines) and the rate of development (straight line) for the various nymphal instars of *B. thalassina* at different temperatures.

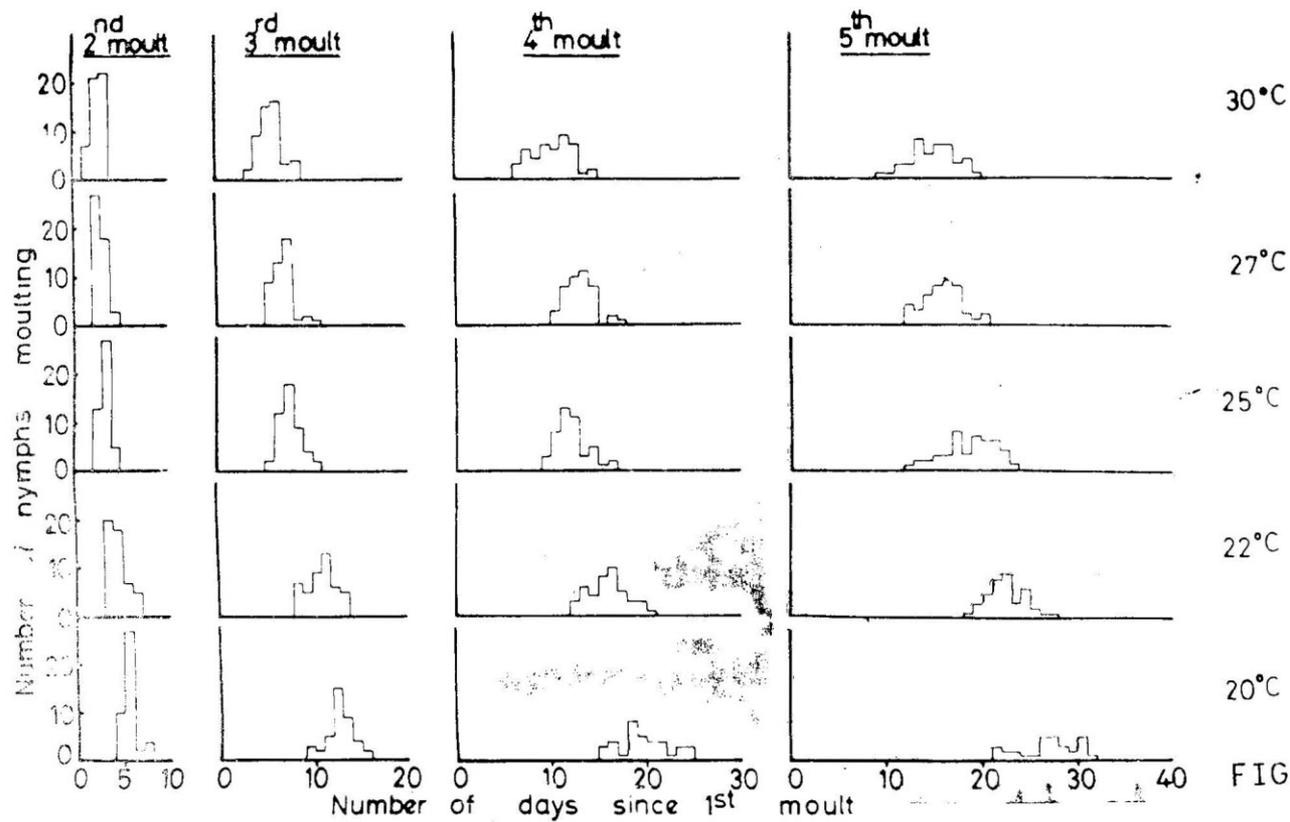


FIG. 4.

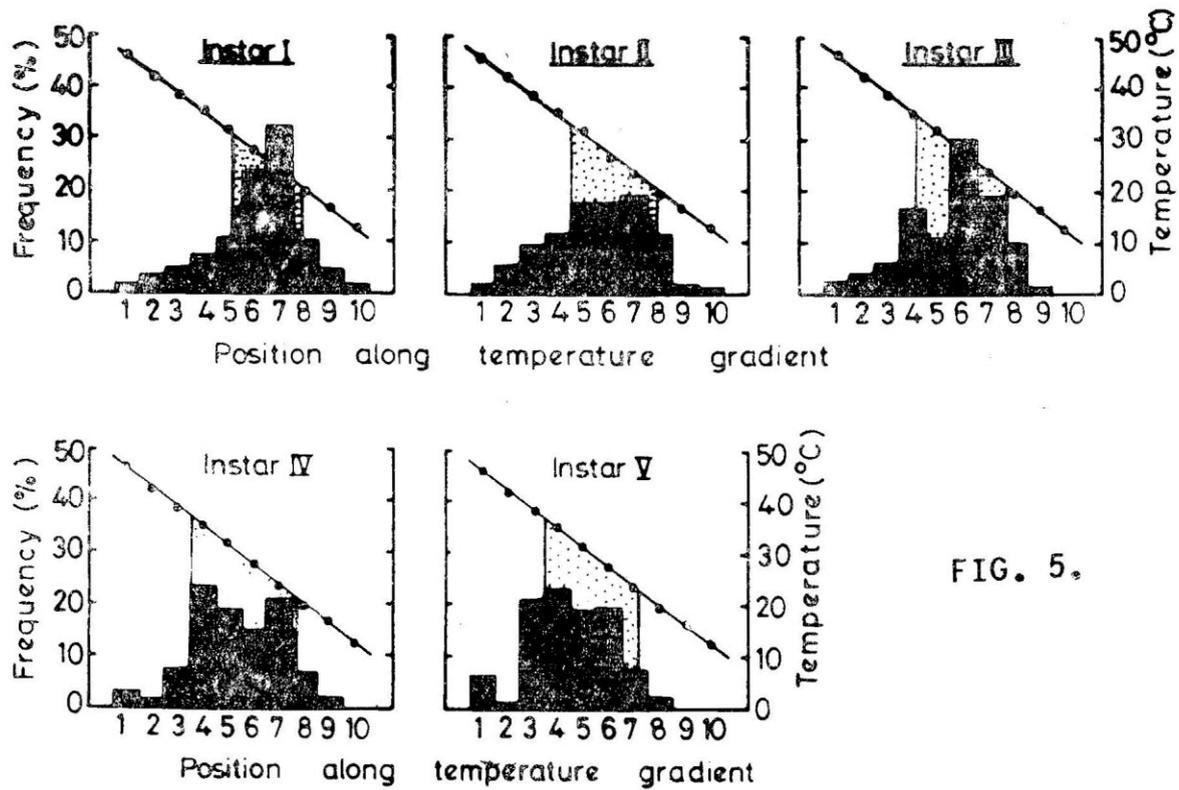


FIG. 5.

Fig5 The distribution of *B. thalassina* nymphs in a temperature gradient. Linear graph shows temperature gradient. Dotted area on each graph indicated "Preferred Temperature" range.

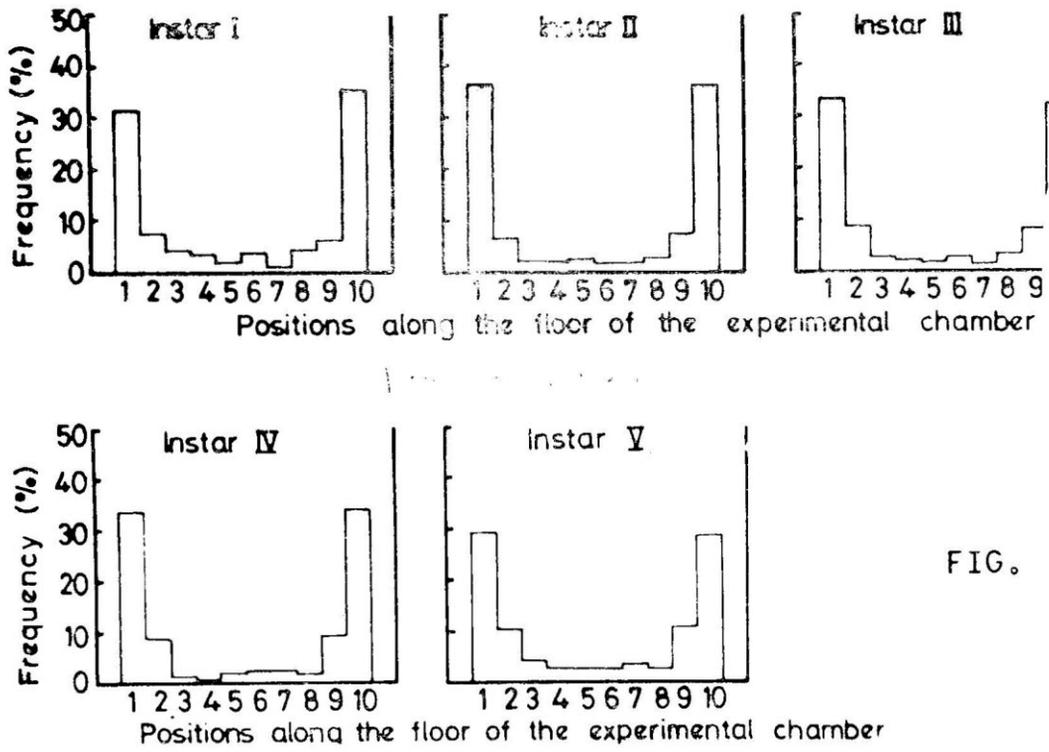


FIG.

The distribution of different nymphal instars of *B. thalassina* at uniform temperature.

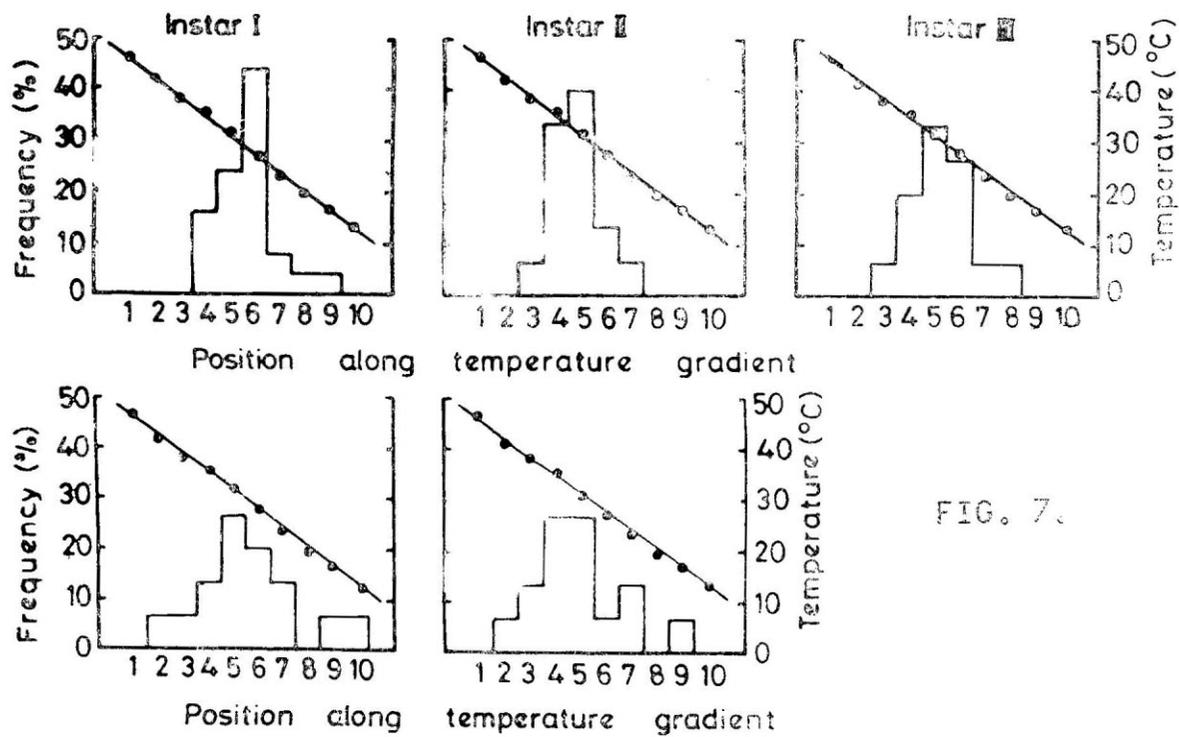


FIG. 7.

\*Fig 7 The distribution of single nymphs of *B. thalassina* along temperature gradient (12.5-46°C). Lower graph shows temperature gradient.

REACTIONS OF THE IMMATURE STAGES IN THE LINEAR  
TEMPERATURE GRADIENT

The linear temperature gradient apparatus was similar to that described by Youdeowei (1968). By putting cold water in the left copper box and hot water in the right one a gradient of temperature was established along the copper bar floor of the experimental chamber in about 25 minutes. The inside walls of the experimental chamber and the ends of the thermometers inside this chamber were painted with "Fluon" (polytetrafluoroethylene dispersion) in order to restrict the insects to the floor of the chamber. This treatment eliminated the errors which Chapman (1965) pointed out arose from differences between floor and air temperatures within the experimental chamber. The copper floor was also covered with moist absorbent paper in order to reduce the effects of gradient of saturation deficit and evaporation on the reactions of insects to the gradient of temperature (Madge 1965). The whole apparatus was illuminated by a 40-watt daylight fluorescent bulb 120cm long about 2 meters above it.

Pilot experiments were conducted using separate groups of ten 1st instar and 5th instar nymphs of *B. thalassina* in order to determine the limits of working temperature. The temperature range of 12.5°C to 46°C was found adequate. The temperature along the chamber were constantly recorded by the mercury-in-glass thermometer placed at regular intervals.

Ten *B. thalassina* nymphs of the required instar were put into the chamber through the central hole which was later sealed with a plastic cap. Their distribution on the floor was recorded after every 15 minutes for 2½ hours. The insects were redistributed with a fine camel-hair brush after each 15-minute record. Five replicates of the first and second instars and three replicates each of the 3rd, 4th and 5th instars were made. The experimental chamber was cleaned out and the absorbent paper was replaced after every experiment.

In another experiment, individual nymphs of *B. thalassina* were put into the temperature gradient chamber and their positions recorded after every 30 minutes for 2½ hours. Control experiments in which sets of ten nymphs were put into the gradient apparatus but with uniform temperature were also made. Tap water was put into the two end boxes of the gradient apparatus to give a uniform temperature of 27°C along the copper bar.

## RESULTS AND DISCUSSION

Once inside the chamber, *B. thalassina* nymphs moved up and down the temperature gradient for a while but eventually came to rest at various zones which indicated their "preferred temperatures". Fig.5 shows the distribution of the various nymphal instars of *B. thalassina* in the linear temperature gradient. Clearly, all the nymphal instars were unimodally distributed in the temperature gradient apparatus. The "peak preferred" temperatures, where most of the insects were found in the temperature gradient were determined by an inspection method following the suggestion of Chapman (1965). The "peak preferred" temperature varied between 26.0°C for 1st instar nymphs and 28.6°C for the 5th instar nymphs, with the later instar nymphs "preferring" slightly higher temperatures. The "preferred temperature range for the various instar nymphs lay between 20.7°C and 34.9°C.

When sets of ten nymphs of *B. thalassina* were put into the apparatus but at a uniform temperature, most of them aggregated at the end of the gradient chamber (Fig. 6) thus demonstrating the familiar end reaction which was probably due to low thigmokinesis.

In experiments carried out with single nymphs on gradients of temperature in the range 12.5–46.0°C, their successive positions at 30 minute intervals in the gradient chamber gave cumulative frequency distributions largely corresponding to the distributions of groups of ten nymphs on the gradient of temperature (Fig. 7). Thus when either individual nymphs or sets of ten nymphs were placed on the temperature gradient, the hot and cold ends of the apparatus were consistently avoided. It is therefore suggested that klinokinesis was at least part of the mechanism which led the nymphs to accumulate in the preferred temperature zone (Fraenkel and Gunn, 1961).

Youdeowei (1968) suggested that orthokinesis, involving a slowing down of locomotion was part of the mechanism leading to grouping in insects. Furthermore, he pointed out that in *Dysdercus intermedius* Dist., the individuals ended to join a group already formed and so increased the aggregation once started. This would lead to faulty deductions if such groups were formed outside the species' real "preferred temperature zone". In order to avoid any unreliable conclusions arising from such errors both individuals and groups of insects were tested. The similarity in the "preferred temperature" range for groups of ten nymphs and those for individual nymphs confirmed that the actual "preferred temperature" range for *B. thalassina* was between 20.7°C and 34.9°C in a temperature gradient offering choices in the range 12.5°C to 46.0°C. In the same chamber maintained a uniform temperature, groups of ten nymphs of *B. thalassina* accumulated at the ends of the apparatus. This provided further confirmation that the aggregation in the middle portion of the gradient apparatus in the presence of a gradient of temperature was a case of true temperature preference.

Madge (1968) and Youdeowei (1970) carrying out similar experiments obtained different "preferred temperatures" for *S. singularis*; Madge (1968) recorded 17°–24°C whereas Youdeowei (1970) recorded 23°–32°C. It is noteworthy that several workers have observed that the "preferred temperature zone" for an insect species usually corresponds to the temperature of its normal habitat (Fraenkel and Gunn 1961; Wigglesworth, 1967; Youdeowei 1968). Madge's (1968) results is therefore quite remarkable because 17°C is hardly recorded in cocoa farms and 24°C is far below the normal temperature of 27°–35°C recorded during the day in cocoa farms in many parts of Southern Nigeria (Nwana, 1975). The range of 23°–32°C from Youdeowei (1970) thus appears to indicate the true "preferred temperature range" for *S. singularis*. This range corresponds to the normal temperatures recorded in cocoa farms, but is, however, more limited than the "preferred temperature" obtained for *B. thalassina* during the present study. The wider range of "preferred temperature" for *B. thalassina* indicates that this insect can tolerate a wider range of temperature than *S. singularis* in the field.

The above results, at least partly explain the occurrence of *B. thalassina* in cocoa farms at periods when adverse weather effects seem to limit the population of *S. singularis*.

## REFERENCES

- CHAPMAN, R. F. (1965). The behaviour of nymphs of *Schistocerca greggii* (Forsk.) Orthoptera, Acrididae) in a temperature gradient, with special reference to temperature preference. *Behaviour*, **24**:283-317
- EGUAGIL, W. E. (1974). Observations on the Ecology of the cacao shield bug *Bathycoelia thalassina* H - S (Heteroptera) in Nigeria. *Conf. W. Afri. Sci. Abidjan*, **1974**. (Abstract)
- FRAENKEL, G. S. and Gunn, D. L. (1961). The Orientation of animals: Kinesis, and Compass Reaction. *Dove Publications, Inc. New York*. 376 pp.
- GERARD, B. M. (1965). *Bathycoelia thalassina* H - S (Hemiptera: Pentatomidae) a pest of *Theobroma cacao* L. *Nature, Lond.* **207** (4999), 881.
- KUMAR, R. (1971). The natural history of cocoa-capsids. *C. M. Newsletter*, **147**: 2-23
- MADGE, D.S. (1965). The responses of cotton stainers (*Dysdercus fasciatus*) to relative humidity and temperature and the location of their hygrosensors. *Entomologia exp. & appl.* **8**: 135-152.
- (1968). The behaviour of the cacao mirid (*Sahlberagella singularis* Hag) some environmental factors, *Bull. ent. Soc. Nigeria* **1**: 63 - 70
- MARCHART, H. and Ledos, N. (1969). The biology and insecticidal control of the cocoa pod pentatomid *Bathycoelia thalassina* (Herrich-Schaeffer) Hemiptera Pentatomidae). *Ghana J. Agric. Sci.*, **2**: 31 - 37
- NWANA, I.E. (1975). Studies on the Hemiptera-Heteroptera Associated with farms in Nigeria. *Ph.D. Thesis. University of Ibadan, Ibadan Nigeria*.
- VERNON, A. J. (1964). Cocoa yield increase by control of Capsids (Miridae). *Chem. Ind.*, 320-321
- WESSEL, M. (1964). A brief outline of the climate of the main cocoa growing of Western Nigeria. *Pro. Conf. Mirids & other pests of Cacao, Ibadan* 90 - 97
- WIGGLESWORTH, V. B. (1967). The Principles of Insect Physiology. *Lond. M* (6th edition) 741 pp.
- YOUDEOWEI, A. (1968). The behaviour of a cotton stainer, *Dysdercus intermedius* (Heteroptera: Pyrrhocoridae) in a temperature gradient and the effect of temperature on aggregation. *Entomologia exp. & appl.* **11**: 68-80