

ADULT EMERGENCE IN *BIOSTERES (OPIUS)*
*LONGICAUDATUS*¹ AND *ANASTREPHA SUSPENS*A²
IN RELATION TO THE TEMPERATURE AND MOISTURE
CONCENTRATION OF THE PUPATION MEDIUM³

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ABSTRACT

The effects of temperature and moisture concentration (MC) of the pupation medium were studied in relation to the developmental success of the parasitoid *Biosteres (Opus) longicaudatus* Ashmead and its host *Anastrepha suspensa* (Loew), the Caribbean fruit fly. Temperatures ranged from 22-32°C in 2°C increments; pupation media of 25, 50, and 75% MC (by weight) were tested. The developmental time for *B. longicaudatus* within the puparium of *A. suspensa* ranged from 10.6 to 24.4 days over the temperature range selected, but was not affected by MC.

Emergence periods for *B. longicaudatus* ranged from 5-7 days for temperatures from 26 to 28°C and lasted ca. 2 days for *A. suspensa* at temperatures above 22°C. Both parasitoids and flies had high rates of mortality at temperatures above 28°C. Total adult emergence was ca. 33% greater from *A. suspensa* larvae not exposed to parasitoids. Parasitoid emergence was significantly reduced at 22 and 24°C in the driest MC. The use of 25% MC significantly increased diapause among last-instar parasitoid larvae. Pupal diapause was not observed for *A. suspensa*.

Biosteres (Opus) longicaudatus Ashmead, a solitary larval-pupal endoparasitoid, has been established as a biological control agent against a number of species of tephritid fruit flies (Greany et al. 1976). This parasitoid was recently introduced into Florida by Dr. R. M. Baranowski, Agricultural Research and Education Center, Homestead, Fla., to help suppress populations of the Caribbean fruit fly, *Anastrepha suspensa* (Loew). In spite of its importance as a biological control agent (Greany et al. 1976), little knowledge is currently available regarding its developmental requirements.

This paper presents the results of research to determine the effects of temperature and moisture concentration of the pupation medium on the developmental success of *B. longicaudatus* and on the pupal survival of *A. suspensa*. These data will be of value in refining rearing conditions so as to maximize parasitoid production.

MATERIALS AND METHODS

B. longicaudatus was reared using *A. suspensa* (caribfly) larvae as hosts. Details of the techniques for rearing the host and parasitoid are presented by Burditt et al. (1975) and Greany et al. (1976), respectively.

¹Hymenoptera: Braconidae.

²Diptera: Tephritidae.

³Mention of a commercial or proprietary product in this paper does not constitute an endorsement of that product by the USDA. Received for publication 1 April 1976.

A. suspensa larvae developed in bagasse diet kept at 26-27°C, 60-70% ambient RH, and under a photoperiod of 13:11 LD. Five-day-old larvae (500/replicate) were exposed to 125 pairs (male and female) of parasitoids in string units consisting of larvae and diet secured between 2 pieces of paper toweling in an embroidery hoop. Host larvae were removed from the sting units after 24 hr and given sufficient diet to complete maturation. As the mature larvae left the diet, they were collected and placed in plastic cups 7.1 cm high and 9.5 cm diam that contained moistened plaster-grade vermiculite to a depth of 1.3 cm. Each cup had 2 side ventilation pores (3.6 × 1.2 cm) covered with 100-mesh screen. Fifty caribfly larvae were distributed uniformly over the surface, and then an additional 0.6 cm of vermiculite was placed over the larvae. The cups were kept at 60% RH with a photoperiod of 13:11 LD at 700 lux (Vitalite®). Larvae not exposed to parasitoids were reared and handled in the same manner other than being placed in sting units.

Treatments consisted of puparia held in vermiculite moistened to 25, 50, or 75% (by weight) and at temperatures from 22-32°C in increments of 2°C. Each treatment was replicated 4 times. The data were analyzed using analysis of variance and Duncan's new multiple range test. Text references to treatment differences in the figure are made only where significance at the 1% level occurred.

The percent water remaining in the pupation medium at the onset of emergence was determined from duplicate cups not containing *A. suspensa* puparia. This determination was made when emergence was noted in corresponding cups containing puparia. The water content dropped to ca. 21, 41, and 68% from the initial values of 25, 50, and 75%, respectively and was not significantly influenced by temperature.

RESULTS

Duration of Parasitoid and Fly Development. Commencement of eclosion was influenced by temperature but not by moisture concentration (MC). *B. longicaudatus* females required an average of 23.7, 19.8, 15.2, 12.3, and 13.3 days to complete their development at 22, 24, 26, 28, and 30°C, respectively. Male and female caribflies (exposed and not exposed) required similar amounts of time; however, male parasitoids completed their development 2 days before the females at each temperature. For all insects concerned, developmental time was significantly (1% level) shortened with each 2°C rise in temperature from 22-28°C. Between 28 and 30°C, no significant changes in developmental time occurred. At 32°C, insufficient emergence prevented reliable values from being calculated.

Parasitoid and Fly Emergence Periods. *A. suspensa* males and females emerged within the cups over a period of ca. 2 days between 24 and 32°C. At 22°C, the period increased to 3-4 days. These emergence periods were not influenced by MC. *B. longicaudatus* adults, however, displayed longer emergence periods at most temperatures and MC (Table 1), although high morality abbreviated emergence at 32°C. Peak eclosion for both sexes of *B. longicaudatus* occurred 48 hr after the onset of emergence.

TABLE 1. MEAN (\pm SE) EMERGENCE PERIODS (DAYS)* FOR *B. longicaudatus*** IN RELATION TO AMBIENT TEMPERATURE AND MOISTURE†.

Temperature °C	% H ₂ O in pupation medium		
	25	50	75
22	3.6 \pm 1.2 ab	9.3 \pm 0.8 a	7.5 \pm 1.0 a
24	5.9 \pm 2.1 a	7.5 \pm 1.0 a	11.0 \pm 0.7 b
26	6.5 \pm 0.3 a	7.5 \pm 1.0 a	7.5 \pm 0.3 a
28	5.5 \pm 0.3 a	6.3 \pm 0.6 ab	5.0 \pm 1.0 ac
30	1.9 \pm 0.8 bc	3.4 \pm 1.0 bc	3.8 \pm 1.0 c
32	0.0 c	1.0 \pm 1.0 c	0.1 \pm 0.1 d

*Calculated from 4 replicates (cups)/treatment. Defined as the length of time between the emergence of the first and last adult insects within a cup.

**No significant differences were present for emergence periods between male and female parasitoids; therefore, the data were pooled.

†Means in the same column followed by the same letter or underscored means in the same row are not significantly different at the 1% level by Duncan's new multiple range test.

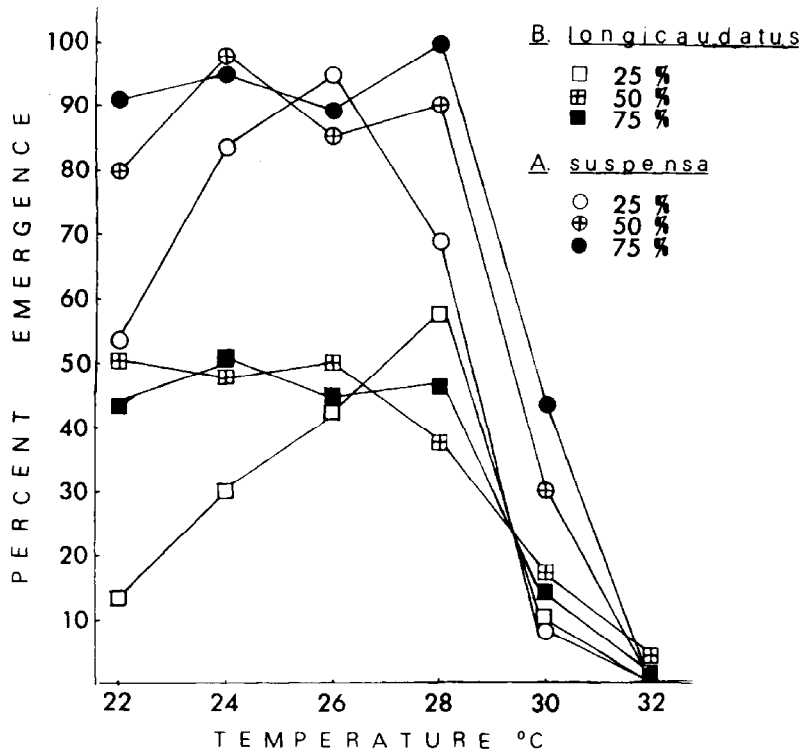


Fig. 1. Percent emergence of adult insects from *A. suspensa* larvae exposed to *B. longicaudatus* (parasitoids only) and not exposed (flies).

Parasitoid and Fly Emergence. A comparison was made of the production of adult parasitoids and flies from hosts either exposed or not exposed to parasitoids (Fig. 1). Production in both groups followed the same general pattern with respect to temperature and MC. Neither temperature nor MC had any significant effect on emergence for either group from 22-28°C with the exception of the 22°C-25% and 28°C-25% combinations for hosts not exposed to parasitoids, and the 22°C-25% and 24°C-25% combinations for hosts exposed to para-

sitoids. About 28°C significant reductions in emergence occurred in both groups. No significant differences in adult production occurred at any temperature between the 50 and 75% MC except for the 30°C-50% and 30°C-75% combinations for larvae not exposed to parasitoids. Exposing larvae to the parasitoids decreased total adult emergence (parasitoids plus flies) by ca. 33%. Caribflies accounted for ca. 10% of the adults emerging from exposed hosts with *B. longicaudatus* adults comprising the remainder.

Analysis of Puparial Contents. Puparia without emergence holes were dissected unless they had collapsed rendering the contents unidentifiable. Analysis of the puparial contents from larvae exposed to parasitoids was not conclusive because it was impossible to distinguish a dead unparasitized fly larva from a parasitized larva which died before the developing parasitoid reached sufficient size to be recognized. Nevertheless, certain general results can be reported. In exposed larvae, death usually occurred for the fly pupa and for the developing parasitoid prior to the formation of imaginal characteristics. At 28°C, 63 and 20% of the puparia without emergence holes had collapsed for the 75 and 50% MC, respectively. None of the puparia formed from unexposed larvae collapsed and ca. 83% of the flies which died during this stadium did so after forming the imaginal characteristics.

Some parasitized puparia were found to contain diapausing last instar *B. longicaudatus* larvae 2 months after the initial period of adult emergence. These larvae became motile upon removal from the puparium. Clausen et al. (1965) reports that the majority of diapaus-

TABLE 2. PERCENT (\pm SE) *B. longicaudatus* LARVAE IN DIAPAUSE IN RELATION TO AMBIENT TEMPERATURE AND MOISTURE.*

Temperature °C	% H ₂ O in pupation medium		
	25	50	75
22	7.0 \pm 1.3 ab	6.0 \pm 1.4 a	5.5 \pm 3.6 a
24	7.0 \pm 1.3 ab	4.5 \pm 0.5 ab	2.5 \pm 1.0 ab
26	10.0 \pm 1.4 ac	1.0 \pm 0.6 ab	1.0 \pm 0.6 ab
28	4.5 \pm 1.5 b	0.5 \pm 0.5 b	1.5 \pm 1.0 ab
30	14.0 \pm 2.2 c	2.5 \pm 1.0 ab	0.0 b
32	6.0 \pm 4.8 ab	0.5 \pm 0.5 b	0.0 b

*Percentages calculated from 4 replicates with 50 puparia/replicate. Percentages in the same column followed by the same letter or underscored percentages in the same row are not significantly different at the 5% level by an analysis of means using Duncan's new multiple range test.

ing *B. longicaudatus* larvae became adults in about 6 months. Incidence of diapause was consistently higher for the 25% MC and significantly increased for the cooler temperatures at 50 and 75% MC (Table 2).

DISCUSSION

Within the temperature and moisture ranges studied, *B. longicaudatus* appeared to have developmental optima similar to those of *A. suspensa*. This is not always the case, as Darby and Kapp (1934) found that *Doryctobracon (Opis) crawfordi* (Vier.) had more restrictive temperature requirements than its host *A. ludens* (Loew), the Mexican fruit fly. Studies by Prescott and Baranowski (1971) on

the effects of temperature on the survival of *A. suspensa* pupae indicated an optimum at ca. 25°C, and our investigations support their finding.

Survival of nonexposed hosts was quite high under most experimental conditions, while under the same conditions hosts that had been exposed to parasitoids produced ca. 33% fewer adults (parasitoids plus flies). It is likely that most of the exposed hosts that died were parasitized as Greany et al. (in press) found that opportunistic bacterial pathogens were better able to attack parasitized *A. suspensa* puparia, especially at elevated temperatures. It is also possible that some hosts were superparasitized, and thereby stressed even further.

Diapause in fruit fly parasitoids was recorded for *B. (Opius) tryoni* (Cameron) and *B. (Opius) fulliway* (Silv.) by Pemberton and Willard (1918). Clausen et al. (1965) notes larval diapause among *B. longicaudatus* collected from areas having cool winters. The results of our study add quantitative support to Clausen's observations because an increase in diapause was noted when temperatures were reduced to 24 and 22°C. Darby and Kapp (1934) recorded a higher incidence of diapause in *D. crawfordi* where the conditions under which the host pupae were held had become dryer than normal. Our data agree with their findings since the use of 25% MC significantly increased the incidence of diapause. From the standpoint of mass rearing *B. longicaudatus*, it would seem advisable to have at least a 50% MC in the host's pupation medium because this moisture level reduces diapause, thereby permitting a higher proportion of adult parasitoids to emerge and lessens the potential effect of the rearing program in selecting against diapause.

In summary, the optimum temperature range for development of *B. longicaudatus* and for the pupal stage of *A. suspensa* appears to be between 24 and 28°C, with moisture concentrations in the pupation medium of 50 and 75%.

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SELECTIVE FEEDING ON SWEETPOTATO VARIETIES BY SOUTHERN ARMYWORM¹—(Note). Although considerable damage often is inflicted on sweetpotatoes by Lepidoptera, no information was found on resistance of sweetpotatoes to leaf-feeding Lepidoptera in the field. An experimental planting of 8 sweetpotato varieties heavily infested with southern armyworm, *Spodoptera eridania* (Cramer) afforded an opportunity to evaluate feeding differences.

Eight sweetpotato varieties were planted in single row randomized plots 30 ft long with 5 replicates. The caterpillar population was dispersed fairly evenly over the plots and the vines of the different sweetpotato varieties often extended across 2 and sometimes 3 rows; as a result larvae had access to as many as 4 varieties within a small area. Twenty leaves randomly selected from plants originating in each plot were evaluated as to percent injury, and rated on a scale of 1-8, for increasing levels of damage. Results were analyzed by Friedman's test (Langley, R. 1960. *Practical Statistics*. Dover, New York. 399 p.).

NC Porto Rico 198 was significantly ($p=0.05$) less damaged than were either NC 212 or Gold Rush (Table 1). Although other varieties suffered intermediate levels of damage, these data were not significantly different from varieties most or least damaged. These results clearly indicate that southern armyworm exhibits a preference for some varieties of sweetpotato. The assistance of Dr. L. E. MacCarter in analyzing the data is gratefully acknowledged. Dale H. Habeck, Department of Entomology and Nematology, University of Florida, Gainesville, Florida 32611.

TABLE 1. INDEX OF MEAN DAMAGE TO LEAVES OF 8 SWEETPOTATO VARIETIES BY SOUTHERN ARMYWORM, *Spodoptera eridania*.

Variety	Feeding Index*					Mean
	Replicate					
	1	2	3	4	5	
NC Porto Rico 198	2.6	4.5	4.3	3.4	4.1	3.8a†
Centennial	4.5	6.0	5.6	4.8	4.7	5.1ab
Gem	3.7	6.0	4.6	4.8	7.2	5.2ab
Rose Centennial	3.3	5.5	6.4	6.4	5.3	5.3ab
Georgia Red	3.4	5.5	6.0	6.3	5.8	5.4ab
Porto Rico Unit #1	5.4	5.7	5.3	6.4	4.9	5.5ab
NC 212	5.3	6.6	6.4	6.6	5.2	6.0 b
Gold Rush	5.9	6.0	6.7	7.2	5.6	6.3 b

*Data are the mean damage on 20 leaves examined in each replicate where 1=0-12.5% leaf consumed, 2=12.5-25.0%, etc. to 8=87.5-100%.

†Means followed by the same letter are not significantly different from each other at $p=0.05$.

¹Florida Agricultural Experiment Station Journal Series No. 184.