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THE LABORATORY BIOLOGY OF MEGATHYMUS STRECKERI AND MEGATHYMUS TEXANUS TEXANUS (MEGATHYMIDAE) WITH ASSOCIATED FIELD OBSERVATIONS

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INTRODUCTION

Since the descriptions of *Megathymus streckeri* (Skinner) and *Megathymus texanus texanus* Barnes & McDunnough 79 and 62 years ago, respectively, their life histories have remained virtually unknown. In the case of *streckeri,* Garth (1950) suspected one of three species of *Yucca* to be the foodplant; Stallings (1956) narrowed the *Yucca* species down to one; Remington (1959) cites *Yucca baileyi* Wooton & Standley and *Yucca glauca* Nuttall for *streckeri* and *texanus,* respectively, based on field and laboratory observations on first instar larvae of *streckeri.* Freeman (1963) speculated on *Yucca standleyi* McKelvey as the larval foodplant but, later on (1969), listed the life history as unknown. The literature is practically devoid of any references to the larval foodplant and life stages. As for *texanus,* hardly much more is known. Leussler's (1930) field observations in Nebraska on the larvae of a related subspecies had shown the utilization of *Yucca* (*glauca*) as the larval foodplant of the taxon now known as *Megathymus texanus leussleri* Holland. Stallings (*op. cit.*) stated that the egg of *texanus* is glued to a blade of *Yucca glauca* and Freeman (1969) remarked that the larval foodplant is indeed *glauca,* though offering no other information.

One of us (Stallings) has done considerable field work over the past 30 years in an attempt to solve the life history riddles of these two taxa. In that time, he has collected many ova of both taxa and has been able to rear *streckeri* larvae up to

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the fourth instar. He has not been successful in rearing either taxon through to adults and, in the past 30 years, has found only one *texanus* pupa and no *streckeri* pupae by searching in the field.

Wielgus became interested in working out the life histories of the two taxa around the early part of 1971, coincidental with his development of rearing techniques for other *Megathymus* larvae (Wielgus *et al.,* 1973). He was confident that these techniques, coupled with his strategic location for the procuring of yucca caudices, would lead to the solving of the life histories.

The two authors engaged in correspondence over the next two years in an exchange of information and ideas on the two taxa, and then decided on a joint effort toward solving the riddles. Stallings, by this time, had already acquired much field information regarding the two taxa. He had learned that *streckeri* and *texanus* females both select small plants on which to oviposit, with *texanus* favoring extremely small plants, and that the larva usually kills the plant or offshoot before working its way into the main part of the central rhizomatous system. In 1966, a number of plants with ova on them were marked and subsequently dug up the following spring, but only one parasitized larva was found. By 1973, Stallings had learned that *streckeri* larvae stuff their frass behind them as they burrow and that one *texanus* larva fed on the caudex on the outside without ever burrowing in. Both taxa were found to build their tents as spurs off the caudex in the manner of *Megathymus harrisi* Freeman (Stallings and Remington, unpublished observations), but this was not always the case since one *streckeri* larva constructed its tent in the center of the plant in the fashion of *Megathymus coloradensis coloradensis* Riley. This was the limited state of knowledge regarding the life stages of the two taxa up to the spring of 1973.

During the early part of June 1973, Don B. and Viola Stallings collected scores of ova of both *streckeri* and *texanus* from several localities in New Mexico, and Ronald S. and Joseph R. Wielgus found over 30 ova of *streckeri* on *Yucca baileyi* plants at an Arizona locality during the same month.

The collecting data are as follows:

1. *Texanus:* San Jon, New Mexico, 14 VI 1973, Don B. & Viola Stallings, Collectors (rearing prefix: SJ).
2. *Texanus:* 25 miles east of Santa Rosa, New Mexico, 14 VI 1973, Don B. & Viola Stallings, Collectors (rearing prefix: SR).
3. *Streckeri:* Sandia Mountains, New Mexico, 15 VI 1973, Don B. & Viola Stallings, Collectors (rearing prefix: SM).
4. *Streckeri:* East Sunset Mt., 15 miles southwest of Winslow, Coconino County, Arizona, 16 VI 1973, Ronald S. & Joseph R. Wielgus, Collectors (one adult male taken in flight, same locality and date; rearing prefix: ESM).

All of the ova were made available to Wielgus for an attempt at rearing and documenting larval morphology and behavior. Previous rearing work by Wielgus (unpublished observations) had shown that the rearing of *Megathymus* larvae under artificial laboratory conditions did not result in a marked change in larval morphology or adult phenotype and that, except for an accelerated larval growth rate, larval behavior remained, for the most part, relatively uninfluenced. It was decided, then, to rear all of the larvae on *baileyi* caudices under laboratory conditions.

METHODS OF REARING

At first, one ovum each was placed on individual potted plants and sections of caudices. The plants and caudices had been first placed in various containers (½-1 liter capacity) of damp sand and kept in a room maintained at 25.6 degrees C. Plants and caudices did not exceed 150 mm in caudex length initially. Previous experience with *baileyi* caudices had shown that preservation in a wholesome condition would be extremely difficult, since the caudices are prone to desiccation if exposed, or mold and rot if kept damp. It was felt that larval establishment was of paramount importance and that the risk of rotting caudices was the lesser of two evils. Later, as larval transfers became inevitable, other metholds of caudex preservation were tried. One of these involved coating the entire section of each caudex with melted paraffin in order to reduce loss of vital pulp moisture. This method was only partially successful and the caudices so treated deteriorated to the point where larval transfers were necessary after three to four weeks.

Another method involved wrapping each caudex with damp paper towelling and then bagging with polyethylene plastic, but this method was abandoned due to formation of mold and rot within a week after such treatment.

The most favorable caudex method involved bagging very large (40-70 mm in diameter, 30-40 cm in length) sections of *baileyi* caudices with tightly wrapped polyethylene plastic, leaving one end of each caudex exposed. The hard outer bark of each caudex acted to prevent loss of pulp moisture and, if left intact, reduced the likelihood of mold formation. The one exposed open end of each caudex, where the larva was introduced during transfer (Wielgus, *op. cit.*), desiccated slowly over the succeeding months.

Since *baileyi* caudices are not conducive to preservation over a prolonged period of time, an alternate rearing method was tried with several later-instar larvae of both taxa. This involved transfer to an artificial diet which could be more readily obtained and occupied less space (Petterson & Wielgus, 1974). The boring behavior and slow development of *streckeri* and *texanus* larvae point to the use of artificial diet exclusively in future rearings.

LARVAL BEHAVIOR

The incubation period of *streckeri* ova is relatively short and varies from 7 to 14 days at constant 25.6 degrees C; that of *texanus* ova at the same temperature varies from 10 to 16 days. Larval hatching behavior does not differ between the two taxa. The hatching larva cuts a circular hole approximately 1 mm in diameter in the micropylar area, a process that takes several hours. After attaining the requisite hole diameter, the larva exits within less than a minute. It then immediately proceeds down the leaf blade to the base of the leaf rosette. The larva then bores directly into the caudex, either at the side just at sand level, or at a point below the surface. No tent is constructed. Frass and particles of caudex are either placed around the burrow opening and attached thereto with silk or allowed to fall to the surface. If the burrow is made below the surface, these particles are incorporated with the sand. In almost all cases, the larvae entering the caudices above the surface level of the sand will exit several centimeters below, proceed to the bottoms of the caudices and attempt reentry. The damp sand appears to hinder this behavior and many larvae perish before they can reestablish themselves in the caudices. More than two-thirds of the larvae obtained suffered mortality in the first week of hatching.

As the larvae bore within the caudices, they plug the burrows behind them with tightly packed frass. The burrows do not follow any direct routes and are more often sinuous. A definite preference was noted for larval boring to occur at the interface of caudex pulp and outer bark covering. No tent is constructed and very little external evidence, aside from a minute entry hole, is present to show that a caudex is inhabited. This led to much grief in trying to locate the larvae during the first transfer process since several larvae were cut in two even during cautious sectioning of the caudices. After some trial and error, the interface burrow habit was noted which led to Wielgus' careful peeling off of the outer bark piece by piece in a girdling fashion. This method usually exposed the larval burrow and, in some cases, the larva itself. The disturbed larva usually retreats to the far end of the burrow and will turn around so as to face the intruder. Larvae display a defensive posture if prodded with a broomstraw and will bite at the foreign object savagely. If the mandibles take hold of the broomstraw they close tenaciously, but the larvae will not permit themselves to be pulled out of the burrows. Many times it is necessary to carefully expose the ends of the burrows and prod the larvae from behind. Even with this method, the larvae are reluctant to leave their burrows and will defecate heavily and expell a brownish fluid from their mouths.

When transfers became inevitable, it was necessary to procure fresh *baileyi* caudices which were excavated in the field southwest of Winslow, Arizona. The excavation of these caudices led to some interesting discoveries regarding the field habits of *streckeri* larvae and which support the laboratory findings (Fig. 1). First, not all offshoots initially attacked by the larvae are killed and rarely, if ever, are older plants, inasmuch as both usually connect to an extensive rhizomatous root system. Second, caudices in the field may be heavily tunneled with old larval borings yet remain quite viable. Third, the central rhizomatous root system is usually quite massive and extends horizontally in all directions; some caudices approach 70-90 mm in diameter and virtually all larval borings are in these large caudices. Fourth, the larval borings in the field-collected caudices follow sinuous routes and old exit (?) holes are also in evidence. The nature of the soil (sandy) and the method of excavating the caudices precluded the finding of any remaining tents in 1973.

As the larvae passed through second and third instars, some losses occurred due to several larvae boring out through the caudices and wandering off. Only in late fourth instar did this habit truly cease. Instead, the larvae prepared holes in the sides or ends of the caudices through which they expelled frass and particles of pulp, all the while silking together the detritus which tended to form clumps or chains. At this point in time, several larvae were introduced to artificial diet and their feeding and burrowing habits did not differ appreciably from those larvae remaining in caudices.

As the larvae enter fifth instar, frass is no longer packed behind them as they burrow. Instead, it is passed out through one or more exit holes in the caudices (or slices of artificial diet) and a chamber is created at the burrow end. This chamber is kept free of frass and it is here that the larva spends most of its time. The burrows are usually widened in diameter as the larvae feed on the inner walls.

At larval maturity, one of the exit holes which has served for defecation will be kept only thinly capped. It is suspected that it is through this exit hole that the larva constructs its tent outward from the caudex. Evidence supporting this view was suggested by observing several *streckeri* larvae on yucca caudices and artificial diet. Those larvae on caudices invariably pushed out the frass plugs capping their burrows simultaneously with tent construction. Two larvae on artificial diet, though maintaining other exit holes in addition to the frass plugs capping the openings of the introductory rolled paper tubes, nevertheless, constructed their tents as extensions of the paper tubes (Figs. 27-29).

The larvae stopped regular feeding and entered diapause between the early parts of November and December 1973. Some irregular feeding was noted even during diapause as evidenced by an occasional frass pellet. The mature larvae remained unpowdered until termination of diapause. As noted earlier, two *streckeri* larvae on artificial diet constructed their tents as extensions of the rolled paper tubes. One of these larvae terminated diapause on 4 January 1974 and began to open up the silk and frass plug at the top of the tube on this date. Discrete powdering was noted on 12 January. As the tent grew in size, powdering became more pronounced. The tent was completed on 17 January and very heavy powdering up of the larva ensued. During the latter part of this time period, the larva remained at the top of the tent and the powder, which now coated the larva completely, filled the interstices of the tent. The larva dropped to the bottom of the burrow on the morning of the 24th of January and pupated later that same evening. This pupa was removed and placed in an artificial tent of rolled paper affixed to the inside bottom of a light-tight cardboard box approximately 100 mm on a side. Eclosion of a male took place on 18 February after a pupal duration of 26 days at constant 22.2 degrees C.

The other larvae did not construct similar tents. Instead, two merely pushed out the frass plugs while the others constructed only short, ringlike, open tents (Figs. 30 & 31). A silken closure was not present in these latter structures. Several times, prior to pupation, some of the larvae crawled out of the burrows and had to be returned. Pupation took place after a period of several days' quiescence, with the amount of powdering varying with each larva.

The results of this rearing are given in Table 1. Each larva is identified by a rearing number which includes a letter suffix, the designation of which is as follows: AM = Artificial Medium; Y = Yucca. After further study, the adults and associated pupal cases, larval skins and head capsules will be distributed to the following institutions and individuals: Allyn Museum of Entomology; Los Angeles County Museum of Natural History; U.S.D.A. Vegetable Insects Laboratory, Mesa, Arizona; Don B. Stallings, and Ronald S. Wielgus.

OVUM

Streckeri, East Sunset Mt., Arizona (similar for *streckeri,* Sandia Mts., New Mexico, and *texanus,* San Jon and 25 miles east of Santa Rosa, New Mexico): Ovoid, 3.2 mm long, 2.6 mm wide, 2 mm high. Newly deposited ovum light olive-green or apple green, becoming pale green within 24 hours; chorion color changing during incubation from pale green, through pale pink, to light orange, becoming translucent greenish-buff with larval head visible through chorion as dark blackish spot in micropylar area just prior to hatching.

LARVAL DESCRIPTIONS

Streckeri:
First Instar (Sandia Mts., New Mexico & East Sunset Mt., Arizona populations): Head shiny blackish; trunk warm pinkish-orange; prothoracic shield blackish; suranal plate light orange.

Second Instar (Sandia Mts., New Mexico & East Sunset Mt., Arizona populations): Head reddish-orange; trunk warm pinkish-orange; prothoracic shield dark brown; suranal plate pinkish-orange. Several larvae (18 VII 1973): Head reddish-orange; trunk, first two thoracic segments creamy white, third thoracic and first to sixth abdominal segments gray, seventh to ninth abdominal segments creamy white; prothoracic shield very light tan; heart, a dark blackish dorsal line; suranal plate light tan. One larva, East Sunset Mt., Arizona population: Head light orange; trunk creamy white; prothoracic shield light orange; heart, a dark blackish dorsal line; suranal plate creamy white.

Third Instar (East Sunset Mt., Arizona population), immediately after moulting, 2200 hours, 22 VII 1973: Head, trunk, prothoracic shield and suranal plate pale creamy white. At 2200 hours, 23 VII 1973: Head reddish; trunk creamy white; prothoracic shield barely marked with reddish-brown; heart, a dark grayish dorsal line; suranal plate creamy white with light brownish mark caudad.

Fourth Instar (East Sunset Mt., Arizona population): Head reddish; trunk creamy-white with grayish intersegmental areas; prothoracic shield barely marked with shiny brown; suranal plate very light brown.

Fifth Instar (East Sunset Mt., Arizona population): Head reddish; trunk creamy-white with grayish intersegmental areas; prothoracic shield barely marked with shiny light brown; suranal plate very light brown.

Sixth Instar (East Sunset Mt., Arizona population), 24 hours after moulting, 20 X 1973: Head reddish, with midcranial inflection and laterofacial sutures creamy-white; clypeus and labrum whitish; trunk creamy yellowish-white and covered with short, light brownish hairs; prothoracic shield shiny, same color as trunk; suranal plate shiny, same color as trunk, with short light brownish hairs. Measurements: 8 mm wide at third thoracic segment and 60 mm in length.

Texanus:

First Instar (San Jon and East Santa Rosa, New Mexico populations): Head shiny blackish; trunk warm pinkish-orange; prothoracic shield blackish; suranal plate light orange.

Second Instar (San Jon and East Santa Rosa, New Mexico populations): Head reddish-orange; trunk pinkish-orange; prothoracic shield reddish-brown; suranal plate reddish-brown. Several larvae (18 VII 1973): head light orange to reddish-orange; trunk grayish cephalad becoming creamy white caudad; prothoracic shield unmarked to lightly marked with reddish-brown (blackish in East Santa Rosa population); heart, a dark blackish dorsal line; suranal plate transluscent to light reddish-brown (light orange in East Santa Rosa population).

Third and Fourth Instars (San Jon and East Santa Rosa, New Mexico populations): Head reddish; trunk creamy white; prothoracic shield shiny, same color as trunk or lightly marked with brown; suranal plate very lightly marked with brown caudad.

Fifth Instar (San Jon, New Mexico population): Head dark reddish; trunk creamy yellowish-white, covered with short black hairs; prothoracic shield shiny, very light brown, virtually same color as trunk; suranal plate shiny, very light brown, virtually same color as trunk. Measurements (8 IX 1973): 8 mm wide at third thoracic segment and 60 mm in length.

Sixth Instar (San Jon, New Mexico population): Head reddish; trunk creamy white with yellowish overtones, covered with short blackish hairs; prothoracic shield shiny, same color as trunk; suranal plate same color as trunk. Measurements (26 IX 1973): 8.5 mm at third thoracic segment and 70 mm in length.

Seventh Instar (San Jon, New Mexico population): Head reddish, becoming dark reddish-brown in fully mature larva, with midcranial inflection and laterofacial sutures creamy white; clypeus and labrum whitish; trunk creamy yellow, covered with short light brownish hairs; prothoracic shield shiny, same color as trunk, spiracula light reddish-brown; suranal plate not shiny, same color as trunk, with longer light brownish hairs. Measurements (1 XII 1973): 10 mm at third thoracic segment and approximately 75 mm in length.

PUPAL DESCRIPTION

Streckeri, East Sunset Mt., Arizona (similar for *streckeri,* Sandia Mts., New Mexico, and *texanus,* San Jon, New Mexico): Width at widest part: 8.3 mm - 11 mm; length: 40 mm - 51 mm; head gray, shading to pinkish-brown on wing covers; vertex and collar dark brown; abdominal segments light pinkish-buff; cremaster short (1 mm or less), with bristles, not spatulate.

ADDENDUM

On 18 May 1974, in the field at East Sunset Mt., Wielgus discovered two *streckeri* tents containing empty pupal cases, and the final piece in the *streckeri* life history puzzle was put into place. It was interesting to note that Wielgus also collected 22 ova, two second instar larvae, and two adult males in flight, concurrently.

The tents were, indeed, constructed as spurs off the caudices but were extended outward from the caudices at a point only a short distance (*ca.* 20 mm) *below* the surface of the soil. The tents followed closely the adjacent caudices and penetrated the soil surface either under the dead and dry yucca rosettes, or at a point a short distance away (Figs. 32 & 33). In the examples shown, one tent did not extend above the flattened rosette; the other tent, incorporating native soil and rock particles which rendered it extremely inconspicuous, extended above the soil surface a mere 35 mm. Both tents were virtually indistinguishable from the surrounding soil and plant litter and it is little wonder that this feature of the *streckeri* life history had remained undetected for so many years. It is presumed that *texanus* larvae construct similarly *hidden* and *cryptic* tents, as suggested by their virtually identical laboratory behavior.

CONCLUSION

The successful rearing of *streckeri* and *texanus* from ova to adults has raised several questions in the minds of the authors, foremost of which is, "Why do the larve behave as they do?" We can only speculate on evolutionary adaptation to a competitive situation involving other *Megathymus* species utilizing the same foodplants. For example, by the time that females of *streckeri* and *texanus* come upon the scene in May, June and July to oviposit, the earlier emergences of the *coloradensis* complex will already have had a first crack at the choicest plants. The larvae of the *coloradensis* complex are tent-builders and usually feed in the upper caudices of small to medium-sized plants, leaving virtually untouched the main rhizomatous systems. The larvae of *streckeri* and *texanus,* under eons of competitive stress, have apparently adapted to utilizing these systems and thereby avoided direct competition with other megathymids. Still unanswered is why tents are not constructed until just prior to pupation.

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Table 1. Results of Rearing

Taxon	Sex	Rearing Number	Pupal Measurements		Wing Measurements				Remarks
					Forewing			Hindwing	
			Width	Length	Apex to Base	Apex to Outer Angle	Outer Angle to Base	Base to End Vein CU1	
Streckeri	M.	ESM 1-73 AM	10 mm	45 mm	35 mm	23.5mm	23.5 mm	26 mm	Pup. 24 I 74 Em. 18 II 74
Streckeri	M.	ESM 2-73 AM	8.3 mm	40 mm	29 mm	20 mm	20 mm	20 mm	Pup. 14 III 74 Em. 4 IV 74
Streckeri	F.	ESM 3-73 AM	10 mm	46 mm	33 mm	20.5mm	23.5 mm	23 mm	Pup. 16 III 74 Em. 7 IV 74
Streckeri	M.	SM 1-73 AM	6.6 mm	33 mm	25 mm	15 mm	16 mm	17 mm	Pup. 22 III 74 Em. 10 IV 74
Streckeri	F.	ESM 4-73 Y	9.5 mm	50 mm	34 mm	23 mm	23 mm	23 mm	Pup. 28 III 74 Em. 19 IV 74
Streckeri	M.	ESM 5-73 Y	9 mm	44 mm	33 mm	21 mm	23 mm	22 mm	Pup. 31 III 74 Em. 21 IV 74
Streckeri	M.	ESM 6-73 Y	9 mm	44 mm	33 mm	21 mm	23 mm	21 mm	Pup. 9 IV 74 Em. 30 IV 74
Streckeri	F.	ESM 7-73 Y	9 mm	43 mm	32 mm	21 mm	22 mm	22 mm	Pup. 9 IV 74 Em. 30 IV 74
Streckeri	F.	ESM 8-73 Y	11 mm	51 mm	38 mm	24 mm	27.5 mm	27 mm	Pup. 18 IV 74 Em. 9 V 74
Streckeri	F.	ESM 9-73 AM	9 mm	43 mm	Failed to Expand		-	-	Pup. 19 IV 74 Em. 11 V 74
Texanus	F.	SJ 1-73 Y	9 mm	48 mm	30 mm	20 mm	20 mm	23 mm	Pup. 29 IV 74 Em. 17 V 74
Texanus	-	SR 1-73 Y	-	-	-	-	-	-	In diapause 21 V 74

Field observations of 15 July 1973 on Megathymus streckeri (Skinner) larval habits.

Locality: East Sunset Mountain, 15 miles southwest of Winslow, Coconino County, Arizona.

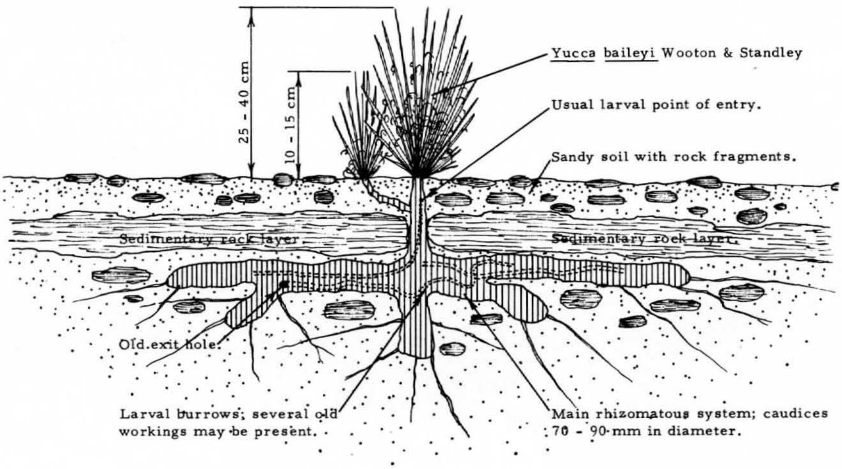

Fig: 1: Field obsevations on *M. streckeri* larval habits.

Fig. 2-5: *Megathymus*. 2, Habitat, *M. streckeri*, desert southwest of Winslow, Coconino Co. Arizona; *Yucca baileyi* in foreground, East Sunset Mountain in distance. 3, Juvenile plant of *Y. baileyi* with ova; foodplant of *M. streckeri;* from locality in Fig. 2; scale in inches. 4, Larva of *M. streckeri in situ* in *Y. baileyi* caudex, same locality, 19.VII.1973. 5, Larva of *M. texanus* in situ in cutaway *Y. baileyi* caudex, fourth instar, *ex ovum*, 26.VIII.1973..