FLIGHTLESS FEMALES OF *ACENTROPUS NIVEUS* REARED FROM MASSACHUSETTS PROGENITORS

by ASHER E. TREAT

The occurrence in 1953 of *Acentropus niveus* (Olivier) in Tyringham, Massachusetts, remote from its normally aquatic habitat, was related previously in this journal (Treat, 1954). The insects then captured included both males and fully winged females. The flightless form of the female, long studied in Europe, has not, to my knowledge, been found on this side of the Atlantic, nor has the rearing of these moths been reported in this country. The early stages have been described from European materials only. The present writing records the repeated occurrence of *Acentropus* in large numbers during 1954, and the rearing of flightless females from their eggs. Observations bearing upon the mode of respiration are also included. The extensive European literature is well summarized by Berg (1941).

From June 11 to 18, and from July 12 to September 4, 1954, a nightly watch for *Acentropus* was maintained at the lighted station in Tyringham where the moths had previously been captured. The records given in the Table indicate that in Massachusetts the winged females are by no means rare, as they are reported to be in Europe, and that in contrast to most European experience, they may be taken early as well as late in the summer. It is also evident from the Table that the occurrence of the winged females is not contingent upon dry weather, as had been suspected from their appearance during the previous summer toward the end of a prolonged drought.

The behavior of the insects at light was as previously described (1954), and was not appreciably different when a 15-watt "black light" fluorescent tube was substituted for a standard 150-watt incandescent bulb with photoflood reflector. The moths were found fluttering or resting at the ground surface, where they gathered in every depression and could be collected with fingers or forceps. Only twice was a moth seen in mid-air, even while hundreds were fluttering in the grass, and on these occasions the observed period of free flight was only momentary. Systematic search of the known ponds, streams, and bogs within a mile of the regular collecting station failed to reveal the breeding place of the insects. The problems of where they came from and how they reached the light remained unsolved.

Eggs were collected for rearing on July 20, and on August 24 and 25. Ovipositing females were placed in water containing some floating fragments of a moss which the larvæ later rejected as food. The moths remained at the water surface, depositing their eggs in mats upon the scales of the slightly submerged plants or in double rows along the stalks. Occasionally a female would creep below the surface by clinging to a partly submerged stem. It appeared impossible for them to submerge themselves by other means. While under water, such specimens were more or less ensheathed, with folded wings, in a

Appearances of *Acentropus niveus* at light in Tyringham, Massachusetts, between 1 June and 4 September, 1954.

Date	Time	♂ ♂ Taken	Winged ♀ ♀ Taken	Remarks
15 June	12:15 AM	21	1	Temp. 15° C. Dense fog. Many more seen than taken; many were carried off by ants.
20 July	10:15 PM	34	20	Temp. about 18° C., preceding thunder showers.
21 July	12:00 M	1		
22 July	11 PM	5		Temp. 14.5° C. Clear, after light rain.
23 July	9 PM	2		
	12 M	1		
24 July	9:45 PM	1		Other species abundant at "black" light.
28 July	10-12 PM	12	7	Two were seen in flight a foot or two above the ground. Weather cool and very damp.
18 Aug.		2		
19 Aug.	10:30 PM	1		After rain. Moth responded with leg movements to ultrasonic vibrations at 50 to 100 kcps.
23 Aug.	11 PM	7	3	Temp. 15° C. Clear. Southwesterly breeze.
24 Aug.	9 PM	69	8	Temp. 20° C. Light rain.
25 Aug.	9 PM	36	45	At Coleman lamp about 300 feet southwest of Four Brooks Pond, Tyringham, 1 mile north of regular collecting station. Temp. about 20° C.; calm. Two males seen at edge of pond; others at nearby lights.

silvery envelope of air which buoyed them quickly to the surface whenever their foothold on the plant was released. Eggs were also collected from females ovipositing in dry, open watch glasses; these were then transferred to water, where they developed normally. None of the moths survived for more then 18 hours after capture. Specimens of embryos and of subsequent stages were collected in alcohol at measured intervals.

In the attic laboratory the eggs hatched within 8 to 9 days. BERG and others have reported hatching periods varying from 12 to 31 days. At least 12 hours before the emergence of the larvæ, their silvery (and hence presumably gas-filled) tracheal trunks could be seen through the transparent egg cuticle. Since the plant genera described as the common food of *Acentropus* in Europe (*Elodea, Ceratophyllum,* and *Potamogeton*) were not found locally, the larvæ were offered such aquatic plants as could be collected. The only one accepted was *Elatine americana* (Pursh) Arn., the Waterwort or Mud Purslane. This minute, delicate, broad-leaved weed grew sparsely in Four Brooks Pond at depths varying from a few inches to about 4 feet, the uppermost leaves either floating or shallowly submerged. No evidence of attack by *Acentropus* was seen in any of the plants when collected. The later batches of larvæ were offered *Elodea* and *Ceratophyllum* obtained from a New York dealer, in addition to the locally collected aquatics. They showed a distinct preference for *Ceratophyllum,* readily leaving the other plants to tunnel in its tubular stems and leaves. Both *Elatine* and *Ceratophyllum* (but not *Elodea*) were used by the larvæ in building typical nests or "houses" such as those described by BERG.

Details of appearance, behavior, and development in all stages followed closely those described and illustrated by Berg (1941) and by Ritsema (1878). The larvæ showed a rather surprising tolerance of conditions unfavorable to many fresh water animals. Feeding was observed, at varying rates, in water ranging from 10° to 22° C. Prolonged exposure to temperatures between 24° and 26° C. appeared to be lethal. One month-old larva, isolated in its nest during late August, was still vigorously responsive to stimulation after more than four weeks at room temperature without food. During this time all other life in the small culture dish, with the possible exception of bacteria, had disappeared. Several other larvæ, after less prolonged starvation, recovered promptly when supplied with food.

On September 7 the cultures were transported from Massachusetts to Dumont, New Jersey, and from then on were kept in large glass jars, still at room temperature. The jars contained a deteriorating growth of *Ceratophyllum* in tap water turbid with microörganisms and populated also with snails, oligochætes, ostracods, and some surface-dwelling aphids of undertermined species. Larvæ were occasionally seen to creep out of the water and to wander briefly on the wet sides of the jars. In two instances they made cocoons under the lid of a jar, where they soon dried up and died. The survival rate in the culture started on August 25, though not measured with exactness, was reasonably high. Dead larvæ and pupæ were found rarely. As of January 18, 1955, this culture had produced 6 adults, and still contained 2 living pupæ and 11 larvæ in various stages. The other two cultures were not carried through, but were used to obtain preserved or experimental material.

The adults which have emerged thus far include 5 vestigially winged females and 1 normal male, all from eggs laid on August 25. The first adult, a female, was found dead at the surface of the water on December 22, 1954. Nearby was an empty cocoon containing pupal exuviæ with normal (*i. e.,* not

shrivelled) wing cases. The moth was fully developed except for the wings, which were short, flat, and truncated as though torn or broken. The abdomen was filled with eggs. The second adult, also from a pupa with normal wing cases, appeared on December 26 and lived for about 13 hours after it was discovered. It laid 6 eggs, which failed to develop. Its wings were somewhat longer than those of the first female; they were slightly curled or twisted, and were tapered at the tips. They extended to about the middle of the second abdominal segment when folded against the body. The fore wings were white beneath, and were marked above with longitudinal bands of sooty grey. The hind wings were white. Similar females appeared on the 1st and 3rd of January, 1955.

At 9:15 A. M. on January 10, a normal male and a vestigially winged female were found, a few inches apart, at the water surface, where they remained for several hours. Copulation was not observed, but may have occurred before the moths were discovered. When first seen, and for more than 10 hours thereafter, this female was engaged in behavior exactly conforming to BERG'S description of oviposition in his flightless females. With the middle legs extended and beating rhythmically, the body was curved ventrally around a stem of the floating food plant against which the genitalia, just beneath the water surface, were continually rubbed. No eggs were laid, however, and upon dissection the ovaries were found to be rudimentary and devoid of recognizable eggs. The abdomen, though distended in appearance, was occupied chiefly by a large air space. No other abnormalities were noted. The "Tympanalkessel" showed the expected reduction in size as compared with that of the winged female (Treat, 1954), measuring 369 microns in its greatest dimension. The other females possessed mature eggs, and in some instances dropped a few of these, singly, in the water. At no time, however, did they exhibit the characteristic ovipositing attitude or behavior, but rather remained at the water surface with their abdomens elevated as though awaiting the male. These observations are of interest as indicating that the ovipositing reaction is not necessarily contingent upon the presence of mature eggs in the reproductive tract. They also show that the reduction in size of the wings and tympanic organs is not a direct consequence of the growth of the ovaries. Heitmann (1934) has reached a similar conclusion with reference to other Lepidoptera in which wings and tympanic organs show a parallel reduction in the females.

Because of the suggestion of Thorpe (1950) that the flightless females of *Acentropus niveus* employ "plastron respiration" while under water, special attention was given to the wettability of the body surfaces. Only the legs appeared to be consistently hydrophilic. For the first few hours after emergence, the upper parts of the body floated high and dry, as though coated with wax. This water repellancy seemed somewhat diminished with the passage of time. During most of the adult life — never more than 36 hours — the 3 pairs of large, round spiracles on the 2nd to 4th abdominal segments were above the water surface and were evidently open to the atmosphere. The anterior part of the abdomen was somewhat inflated ventrolaterally, and there were irregular compressional movements as of breathing. While in

air, the spiracles were surrounded by rings of erect scales. Under water, these scales were depressed as though by the external fluid pressure, in such a way as to cover the spiracular openings. Upon re-emergence into air, the scales could be seen to spring into the erect position, leaving the spiracular orifice free. The moths seemed unable to submerge themselves or to remain under water when forcibly submerged, except when in contact with submerged vegetation, or when, during the last few hours of life, the water repellancy had been partially lost. When the moths were held under the surface by a soft brush, irregular air masses could be seen clinging to the body, chiefly at the abdominal intersegments and about the region where the wings adhered to the body. These air masses did not appear to be held in place by special scales or setæ, nor did they bear any consistent positional relation to the spiracles. Although these observations do not appear to favor the suggestion of plastron respiration in the flightless females, they do not exclude the possibility that the insects may employ this process under more natural conditions than those of the laboratory.

BERG has demonstrated that the larval spiracles of *Acentropus* are covered by a thin cuticular film. The pupal spiracles of at least the 2nd to 4th abdominal segments are open, however, and the cocoons normally contain gas bubbles believed to be derived from the plants to which they are attached. BERG states that if this gas is released, and the cocoons are allowed to fill with water, the pupæ soon die. In conformity with this experience, it was found that gas-free cocoons usually contained dead pupæ. On January 18, however, 2 male pupæ were removed from damaged and gas-free cocoons too far deteriorated to have supplied significant quantities of exygen for several days previously. At least one of these pupæ was alive and capable of movement. The abdominal tracheal trunks were visible as silvery tubes beneath the cuticula in both specimens. When transferred to a covered watch glass, in air, the living pupa died within a few hours, and both became deeply shrunken as though by desiccation. It may thus be questioned whether some cuticular respiration is not possible in the pupal as well as in the larval stage.

References

Berg, K., 1941. Contributions to the biology of the aquatic moth *Acentropus niveus (Oliv.) Vidensk. Medd. naturh. Foren. Kbh.* 105: 59-139.

Heitmann, H., 1934. Die Tympanalorgane flugunfähiger Lepidopteren und die Korrelation in der Ausbildung der Flügel und der Tympanalorgane. *Zool. Jahrb. Anat.* 59: 135-200.

Ritsema, C., 1878. *Acentropus niveus* Oliv. in zijne levenswijze en verschillende toestanden. *Tijdschr. Entomol.* 21: 81-114.

Thorpe, W. H., 1950. Plastron respiration in aquatic insects. *Biol. Revs.* 25: 344-390.

Treat, A. E., 1954. *Acentropus niveus* in Massachusetts, remote from water. *Lepid. News* 8: 23-25.

Dept. of Biology, The City College of New York, New York 31, N.Y., U.S.A.