Agriculture, who kindly furnished initial mosquito identifications and checked mosquito determinations throughout the study.

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LARVAL DIFFERENCES BETWEEN *AEDES COMMUNIS* (DeG.) AND *A. IMPLICATUS* VOCK., (DIPTERA:CULICIDAE) [1] IN A COLORADO COMMUNITY

MARION E. SMITH
University of Massachusetts, Amherst

In the East River Valley area of the Gunnison National Forest of Colorado, in the vicinity of the Rocky Mountain Biological Laboratory at Gothic (alt. 9500 ft.), 9 miles north of Crested Butte, *Aedes implicatus* Vock. (the *impiger* of earlier authors, not of Walker-Vockeroth, 1954), occurs in numbers along with the more abundant and widely distributed *A. communis* (DeG.). Since larvae of the two species are very similar, a careful study was necessary to find characters helpful in distinguishing them in their various instars.

The larvae of *A. implicatus,* occurring in June through early July, according to the season, were almost invariably found in association with *A. pullatus* (Coq.), in small shallow pools left by receding stream waters and shaded by willow thickets, often with some running water feeding them. *A. communis,* although frequently associated with *implicatus* in these pools, was found in greatest abundance in almost pure cultures in rather deep semi-permanent pools in spruce forest, where *implicatus* was never collected. The emergence of *implicatus* adults paralleled that of *communis,* occurring after that of *A. cataphylla* and prior to the peak emergence of *A. pullatus.* Biting adults were captured through early August, and, like *communis,* were with only few exceptions taken in shaded areas adjacent to their breeding places.

FIELD CHARACTERS—SIZE, HEAD COLOR, GILL LENGTH. The *implicatus* larva could usually be distinguished from *communis* by the smaller size of the mature larva (not larger than the average third instar *communis*), by its uniformly dark head (lighter brown with dark sutures in *communis*), and by its generally shorter gills. In the *implicatus* larvae examined, the gills were frequently less than the saddle length, and usually less than twice as long, although a paratype series specimen from Norman Wells, N. W. T., loaned by Dr. J. R. Vockeroth, had gills more than three times the saddle length. In *communis,* the gills were usually at least twice the saddle length, and frequently three or more times as long. That the length of the gills of various species is influenced by the amount of dissolved salts in the water has been repeatedly demonstrated. (The author has collected larvae of *A. punctor* Kby. with gills more than twice the normal length, from a small rocky

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depression scoured clean of all detritus by raging stream waters.) Frohne (1953) reported that gills of Alaskan *implicatus* (as *impiger* [Wlk.]) from fresh-water bogs averaged 2.8 times the saddle length, from salt marsh, 0.6 (0.5–1.4), while those of fresh-water *communis* from the same pools averaged 2.5, from salt marsh 1.3 (0.3–1.5). Rempel (1953) has utilized the usually longer gill length of *communis* in his key.

SADDLE SPINES. In microscopic differences, the primary distinction between the two species made by Carpenter & LaCasse (1955) is in the structure of the saddle spines, so well discussed and illustrated by Frohne (1955). In *communis,* those toward the apex of the saddle are scarcely longer or stronger than those near the base, and rarely exceed the width of the setal ring of the saddle hair, whereas in *implicatus* the apical spines are larger and more thorn-like than the basal ones, and often longer than the width of the setal ring. This character proved to be consistent for all specimens examined, regardless of instar or geographic origin. Unfortunately, however, the spines of *implicatus* are much less obvious than those of *A. stimulans* (Wlk.), for instance, which can easily be seen with a dissecting microscope even on a living larva. In *implicatus,* the spines are shorter, and difficult to see except on slide-mounted specimens and with a compound microscope, but in case of doubt their structure will definitely differentiate the species.

COMB SCALE COUNTS. In *implicatus,* the scales of the comb are separate, distinct, and generally fewer in number than in *communis,* in which they often overlap like shingles. Barr (1958), Gjullin *et al.* (1961), and Nielsen & Rees (1961), among others, have utilized the comb scale count in separation of these species, with 35–40 or more cited for *communis,* fewer (about 25) for *implicatus.* In the Colorado material, a count of 30 or more for *communis,* less than 30 for *implicatus,* separated all but 3 of 92 individuals; in these, the counts varied on the two sides, bridging the dividing line. In *communis,* only 3 of 20 fourth instar larvae had fewer than 40 scales on each side; only 4 of 72 third and fourth instar *implicatus* possessed more than 25 on each side. Second and third instar *communis,* as shown in the following table, had lower comb scale

Species	Instar	Combs examined	Range	Average
communis	4	42	28–71	47
	3	7	29–56	39
	2	3	14–18	16
implicatus	4	36	15–31	22
	3	109	15–30	23

averages than the mature larva, although in *implicatus* ranges and averages were similar for the third and last instars. The two species, in the fourth instar, can be characterized, on the basis of available material, as follows: *communis* usually with 40 or more comb scales, rarely 30 or less; *implicatus* usually with 15–25 comb scales, rarely 30 or more.

These Colorado *communis* specimens more nearly approached the comb scale average (40) given by Chapman & Barr (1964) for their recently described *communis* subsp. *nevadensis* than for the average they quote (62) for the typical western *communis.*

COMB SCALES—APICAL SPINULES. Carpenter & LaCasse (1955) state in their key that in *implicatus* the median spine of the comb scale is about one and one-half times the length of the subapical spinules, whereas in *communis* the spinules are subequal, although Gjullin *et al.* (1961) separate *implicatus* from *impiger* (Wlk.) by the subequal terminal spines of *implicatus.* Moreover, Chapman & Barr have recently (1964) described a western variety of *communis,* named by them *nevadensis,* which differs from typical *communis* primarily by the presence on the comb scale of a median spine more than twice as long as the lateral spinules. In all Colorado and eastern *communis* examined, the comb scales had nearly equal apical spinules, typically arranged terminally on the truncate apex of the scale, like the tines of a fork (see Fig. 1, F), as is shown by Carpenter & LaCasse (1955), or sometimes (see Fig. 1, G) with sub-

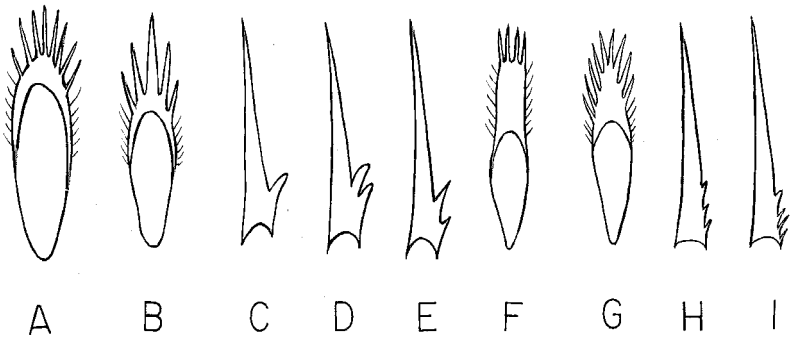

FIG. 1—Comb scales and pecten teeth of *Aedes implicatus* Vock. (A–E) and *A. communis* (DeG.) (F–I).

apical as well as apical spinules, all subequal (Chapman & Barr, 1964). In the Colorado *implicatus,* the rounded comb scales were typically fringed apically and subapically with a variable number of subequal spines, somewhat stronger than those of *communis* (see Fig. 1, A). Usually one or a few scales showed a median apical spine more strongly developed than the others (see Fig. 1, B), but always fewer than half the scales of a comb and often none at all. It is thus clearly evident that in view of the apparent variation in this character, in both species, the degree of development of the apical spines of the comb scales cannot be used for reliable differentiation of the species.

COMB SCALES—SHAPE. A comb scale character which evidently has not been utilized in taxonomic keys is perhaps of less variability and therefore of greater value than the comb scale counts and the structure of the spinules. In *implicatus* (both third and fourth instar larvae), the free toe-like apical portion of the slipper-shaped scale was usually rounded, very narrow, and much shorter than the apical spines (see Fig. 1, A & B); only a few larvae possessed scales in which the apical portion was as long as the spines, and such scales were always in a minority. In *communis* (both Colorado and Massachusetts specimens, and in second through fourth instar), the free toe-like apical portion was found to be at least as long as, and usually longer than the apical spines, and frequently narrowed before an apical expansion (see Fig. 1, F & G).

This structural difference is shown quite clearly for both species in the figures by Barr (1958), Carpenter & LaCasse (1955), and in Rempel's 1953 paper (in which *implicatus* is cited as *impiger*), and for typical *communis* by Chapman & Barr (1964) and Nielsen & Rees (1961), although the latter authors' figure for *implicatus* does not agree well for the scale structure of the Utah and Colorado materials on hand.

PECTEN TEETH. In the specimens of *implicatus* examined (including the Utah as well as the two later instars of the Colorado material), the pecten teeth, except for a few basal ones, possessed a basal spine (occasionally double or triple) so strongly developed and so widely divergent (45 to nearly 90 degrees) that the teeth appeared to be distinctly though unequally bifurcate (see Fig. 1, C-E). In *communis* the several widely separated basal denticles were weaker, usually less widely divergent, often less heavily pigmented than the tooth itself, and not at all suggestive of a basal bifurcation (see Fig. 1, H & I).

The first of the two pecten teeth figured by Gjullin *et al.* (1961) for *implicatus* is the typical form of tooth found in the Colorado specimens. Although Dodge (1963) uses as a key character for *implicatus* the presence of about 5 denticles on the pecten tooth, as in some of the

Colorado *communis* specimens, and as shown by the figure in Carpenter & LaCasse (1955) and in the second figure given by Gjullen *et al.*, such a tooth was not found in the Colorado material. However, until further careful examination is made of material from other areas, the degree of variability of this character within the species as a whole cannot be stated; for the Colorado population studied, it was a dependable differentiating character.

BODY HAIRS. The branching of prothoracic hairs #1 and #5, utilized by Nielsen and Rees (1961), is a helpful supplementary character, but shows considerable variation within the species. The figures for the Colorado material were similar to those given by the preceding authors, but differed slightly from those in the Carpenter & LaCasse descriptions (1955). Although much overlap occurred, the following summary was usually helpful, in combination with other characters, for early as well as fourth instars:

communis—#1 usually double (sometimes single) in the fourth instar; #5 usually double or triple in the fourth instar (sometimes 4- or 5-branched), usually double in the third, and often so in the second.

implicatus—#1 usually single in all instars, very rarely double in the fourth; #5 usually double in the fourth (often single, rarely triple), usually single (rarely double) in earlier instars.

The dorsal and ventral abdominal hairs (#1 and #13) are stated by Nielsen and Rees in their 1961 key to be usually all single in *implicatus*, single or double in *communis*. In the Colorado *implicatus*, these hairs were so frequently double, although less often than in *communis*, that this character could not be used in differentiating the species.

Rempel (1953) used as a key character the number of tufts of the ventral brush that precede the barred area (1 in *communis*, 3–4 in *implicatus*). Other authors cite different counts. In the Colorado, Utah, and Massachusetts material examined, no consistent difference between the species could be detected; in both species, two tufts were usual, one rare, and three common.

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SUMMARY. In a search for differentiating larval characters between Colorado *A. communis* (DeG.) and *A. implicatus* Vock., the only constant difference found for all specimens examined was in the structure of the saddle spines. Almost equally reliable for the specimens on hand were the shape of the comb scales and of the pecten spines, although references to these structures in the literature suggest that some variation may occur in other populations. Supplementary characters of value, despite overlap between the species, lie in the gill-saddle ratio, the comb scale counts, and the branching of the prothoracic hairs. Of little or no value for the material at hand were several characters used in published keys: the relative lengths of the apical spinules of the comb scales, the branching of abdominal hairs #1 and #13, and the number of tufts of the ventral brush that precede the barred area.

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CONTROL OF *CULICOIDES MELLEUS* (COQ.) (DIPTERA: HELEIDAE) WITH GRANULAR INSECTICIDES AND THE EFFECT ON OTHER FAUNA

WILLIAM J. WALL, JR.[1] AND OSCAR W. DOANE, JR.
Cape Cod Mosquito Control Project

During the years 1958 and 1959 we conducted a series of studies aimed at establishing an economically feasible method of controlling *Culicoides melleus* (Coq.), one of the most common blood sucking gnats found on Cape Cod. These studies resulted in recognition of the principal breeding areas in intertidal sand (Wall and Doane, 1960), effective control in small plots with a variety of chemicals (Wall, 1960), and general information on its life span and habits.

The early work also indicated that chlorinated hydrocarbons might kill or injure shellfish located in or adjacent to *C. melleus* breeding areas, and that considerable chemical residue might be left on or in the shellfish following insecticide application. Consideration was also given to the possibility that this residue would render these organisms objectionable for human consumption.

The tests described in the present paper were planned to determine: (1) the effect of granular chlorinated hydrocarbons on *C. melleus* in clam breeding areas; (2) the quantity of insecticidal residue on and in the clams; and (3) the effect of a large scale helicopter application of granular material on *C. melleus* and other fauna.

[1] Permanent address: State College, Bridgewater, Massachusetts.

EXPERIMENT I

METHOD AND MATERIALS. In the summer of 1960, upon approval of the local shellfish warden, a site bordering on a commercial clam bed in the Town of Chatham was selected for treatment. This site was in a protected bay having a high and relatively uniform *C. melleus* larval population. Six plots, each 25 yards in length and 8 yards in width were laid out in the test area. BHC, DDT, and dieldrin, formulated on 30/40 mesh attaclay at a concentration of 1.0 percent with urea were distributed by hand on the test plots at about low tide. Each plot received a single dosage of one insecticide. Sampling procedure was the same as that employed by Jamnback and Wall (1958). The check area was adjacent to the treated areas. Larval samples were taken immediately before treatment, and 3, 7, and 14 days after treatment. The results of these tests are summarized in Table 1.

Table 1 shows that DDT at a dosage of 0.5 pound per acre, and dieldrin at dosages of 0.4 and 0.2 pound per acre reduced *C. melleus* larval populations more than 95 percent three days after application, and 100 percent 14 days after application. DDT at a dosage of 1.0 pound per acre also gave 100 percent