CONFLICT WITH CULEX

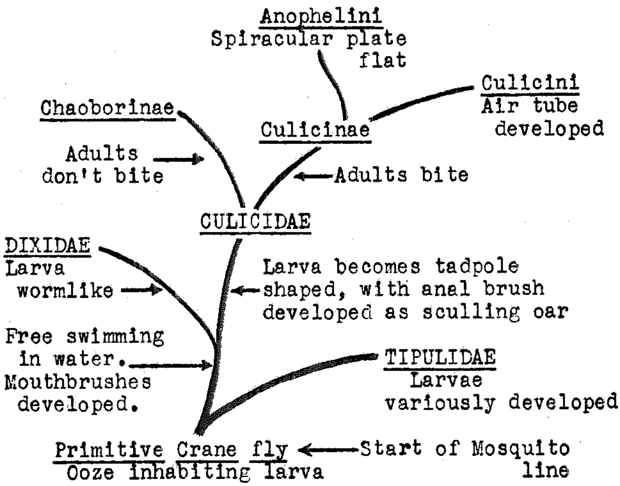
HERBERT H. ROSS
Illinois Natural History Survey, Urbana, Illinois

In the last 20,000 years man has changed from a primeval and possibly rare subtropical animal to his present condition as a widespread and a dominant species inhabiting the greater portion of the earth's surface, and having a complex and gregarious social structure. The increasing complexity of this social structure is a function of large and increasing population. This in turn has been achieved essentially by man's greater and greater ability to change various factors of his environment and make it better suited for his own survival and increase. Man ploughs natural prairie or cuts forests, and grows in their place plants such as corn or cotton which furnish greater quantities of food or material than the natural plants of the area. He makes clothes and builds heated houses, enabling him to live in colder areas than those to which he is naturally adapted. He collects water and redistributes it for irrigation or power. All this spells environmental control and it is a fair guess that he has so far only begun on a much longer path.

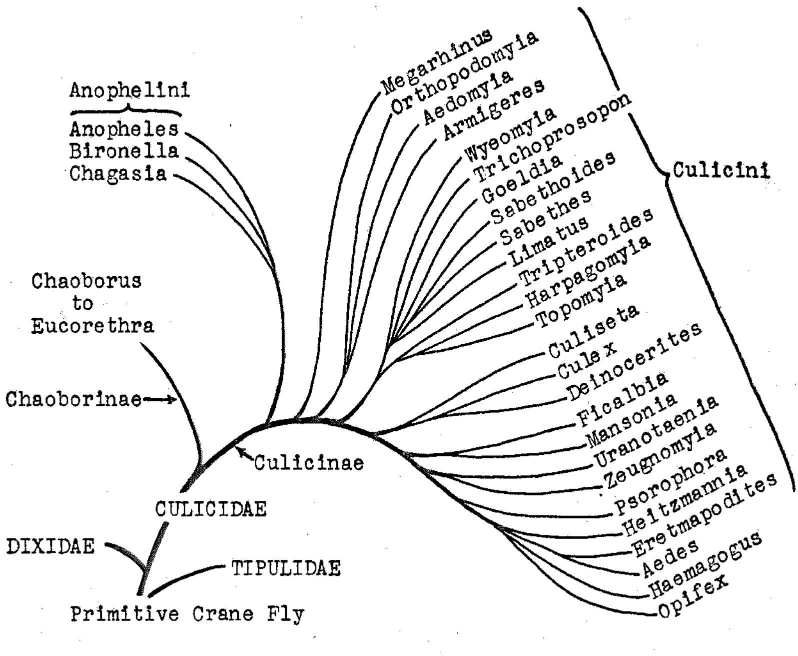
It is a paradoxical fact that every change that benefited man also benefited a host of insects. When succulent crops were planted together in fields, when grain was stored in quantity, when animals were brought together in flocks, some species of insects found these conditions irresistible and moved in for the feast. As a result man has been battling insects ever since he has consciously been bettering himself.

These pests we have mentioned classify as opportunists, who were of no direct hindrance to man before he started along the road to environmental control. There are pests belonging to another class, those such as beasts of prey, biting insects, and diseases, which were enemies of primeval as well as civilized man. The beasts of prey were originally the starkest enemy of man but are now under fairly good control. What of the insects? It seems certain that primeval man must have suffered just as much from biting insects as we do now. How he fared with insect borne diseases is a matter of conjecture. But it is certain that as human populations increased, they became more and more vulnerable to epidemics of insect-borne diseases, including the important ones carried by mosquitoes. This is a problem in areas which we have already cleared and subjugated. But there is another one. There are hundreds of thousands of square miles of country where the tremendous abundance of mosquitoes and other blood sucking flies has discouraged real development by civilized man, either for habitation or for the more efficient production of foodstuffs needed for expanding populations. There is a challenge here to control a facet of an environment before the environment as a whole can be controlled. So whether the battle is old or new, man finds himself engaged in a full-fledged conflict with Culex.

I have heard many people ask about this enemy "Where did it come from, how did it get started, why are there so many kinds of them?" and it started me to wondering also. People have studied the evolutionary history of elephants and extinct dinosaurs, but what about this much more important member of man's environmental resistance, the mosquito? How much do we know about the early history of this group and the evolutionary factors which led to their extremely abundant development? There is little about this in the literature and so a search was begun for information which would bear on this question. Fossil evidence gives few clues to the problem and it has been



A.



B.

FIG. 1. A. Phylogenetic tree illustrating the relationships of the Culicidae. B. Phylogenetic tree of the Culicidae, illustrating relationships of most of the genera.

necessary to piece together many bits of evidence from comparative bionomics and morphology. Gradually a picture has started to emerge and I would like to give you the highlights of a progress report.

The story of basic mosquito evolution is chiefly shown in the larvae. Adults and pupae have corroborative evidence, but the main line of adaptive developments has been for larval life. As we trace back down this line, Fig. 1(A), it is clear that the mosquito invented no really new structure but simply remodeled and improved parts that had already come into existence in previous groups. This is true not only of larval structures but also of the piercing-sucking mouthparts of the adult mosquito.

The base of the mosquito line, Fig. 2, starts with a primitive crane fly, in which the larva was wormlike and practically aquatic. Its mouthparts were generalized, and its spiracles had some sort of floats to keep them at the surface of the water for breathing. The next step upward was the adaptation of the mouthbrushes for feeding on surface organisms, as we see in the Dixidae, correlated with free aquatic existence. This was followed by a dual development which produced a swimming rather than a wriggling larvae: (1) the expansion of the thorax and slenderizing of the tail, and (2) the de-

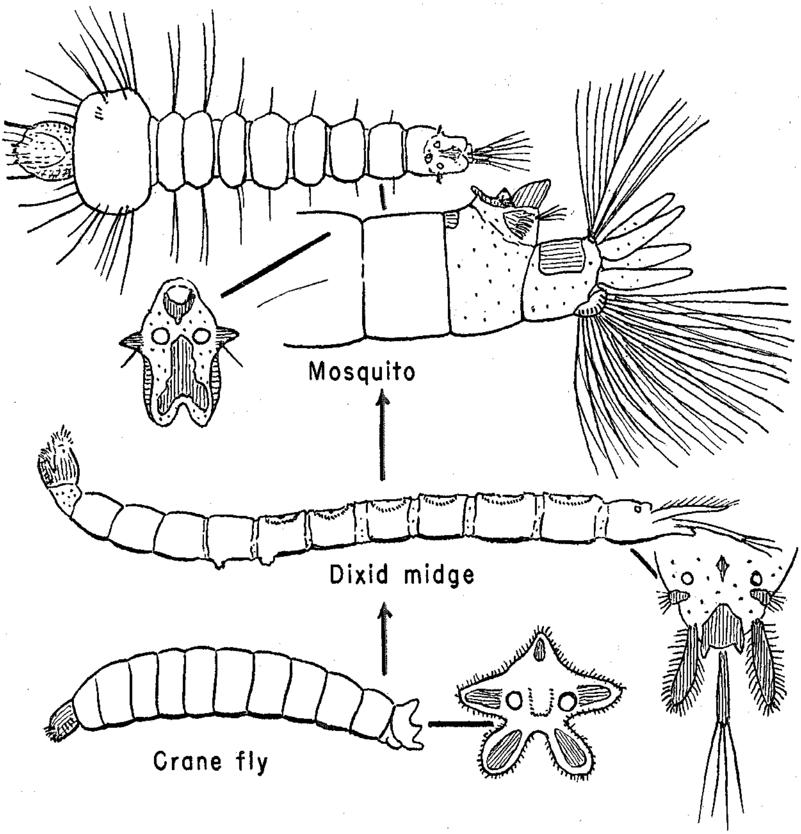


FIG. 2. Larvae and spiracular apparatus of a crane fly (Tipulidae), dixid (Dixidae), and mosquito (Culicidae), illustrating steps in the evolution leading to the mosquito.

velopment of the anal brush of hairs which acted as rudder and sculling oar. This stage is shown perfectly in *Eucorethra,* of the Chaoborinae. Thus at this point we have a full fledged mosquito larva, but the adult does not bite.

This introduces the next stage. The adult developed piercing-sucking mouth-parts, simply by an elongation and slenderizing of parts already present in the more primitive forms. Thus the first true mosquito came into being, still retaining the surface feeding larva. The

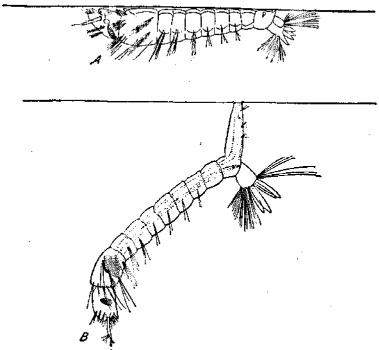


FIG. 3. The two principal types of mosquito larvae. *A,* Anophelini (without spiracular tube); *B,* Culicini (with spiracular tube). (After King, Bradley, & McNeel.)

genus *Anopheles* is very little changed from what this original ancestor must have been, so little that the genus is in reality a living fossil, at least 70 million years old, but certainly a highly successful fossil.

The next step was the development of a tube for the spiracular openings, Fig. 3. This enabled the larva to hang suspended from the surface membrane and feed below the surface more easily and presumably more efficiently than the anophelines. Mechanically, however, these tube-bearing larvae can do nothing that the anopheline larvae can't do. Both swim and dive well, each can feed both at the surface or below. Are there other differences, perhaps physiological, perhaps related to stratification of food organisms, linked or correlated with the tube that have led to the development of this group? Regarding these points, there is a little evidence that culicine larvae can live in water with a lower oxygen tension than can those of anophelines. On the question of food stratification, limnological studies have shown that microorganisms occur at definite different depths during various parts of the diurnal cycle. The tube of the culicines and perhaps also their feeding times, may be correlated with the changing levels of microorganisms. One thing seems certain, that a structure of this sort would not have evolved unless it endowed its possessor with definite advantages in the struggle for existence.

A family tree of the group, Fig. 1(B), emphasizes some interesting points—(1) the antiquity of the anophelines, (2) the persistence of some early lines of the culicines, especially *Orthopodomyia,* and (3) the tremendous burst of development of diverse culicine lines at the apex of the tree. There is a very peculiar circumstance about this burst. It coincides with the development in the larva of a comb and some sort of pecten, many of them becoming highly developed in various species (Fig. 4). This poses a real question: What is the function of these structures? I have found no answer yet, but the evolutionary evidence is such that there seems no doubt but that the comb and pecten are highly advantageous to the larva.

One part of this burst of genera illustrates some of the restrictive limitations of specialization. The group of sabethine genera, represented in Fig. 1(B) by the series from *Wyeomyia* to *Topomyia,* lost the anal brush early in its history, probably as an extreme adaptation to living in container-type habitats. The group has evolved into a large fauna of genera and species, but has remained restricted to container habitats and has never re-invaded the open water habitats from which its earliest ancestor came.

We find some real paradoxes with regard to certain genera. Here are two instances. Both *Culiseta* and *Culex* ap-

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