

C. melanura also yielded two isolations of EE and one of WE.

The possible significance of these isolations is discussed briefly.

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A REVIEW OF THE MOSQUITO LARVAE OF FRANCE

I. GENERA *Culiseta*, *Mansonia*, *Orthopodomyia*, AND *Uranotaenia*

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INTRODUCTION. In recent years the study of the taxonomy and bionomics of the culicine mosquitoes of Western Europe has declined. In fact, no work which includes all of the species found in this region has been published since 1931, when Martini's "Culicidae" in Lindner's, "Die Fliegen der Palaearktischen Region," was published. Marshall's work on the species

occurring in Great Britain (1938), and Natvig's book on the species of the Scandinavian countries (1948) are excellent treatises, but they deal with relatively small geographical areas and, therefore, do not include all of the species found in the central and southern portions of the Continent. Séguy (1923) reviewed the species found within the geographical limits of France, and since that time only scattered papers which deal with the mosquitoes of certain specific areas of France have appeared in the literature.

When the writer was assigned to France in 1953, for duty with the U. S. Army

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Medical Service, he was confronted with the fact that there was no publication available which would serve as a guide to the identification of all the mosquitoes found in the country. The comprehensive works of Edwards (1921 and 1932) and Martini (1931) were found to be inadequate due to synonymy, descriptions of new species, new distribution records, and various other reasons. Séguy's work of 1923 was likewise found to be of limited value for the same reasons. As the determination of the species of mosquitoes present in the entire country was of vital importance to the preventive medicine program of the Army Medical Service, the writer undertook a study of the larvae of the mosquitoes of France in the fourth larval instar.

It was not deemed necessary to consider the larvae of the genus *Anopheles* in this project as the publication of Russell, Rozeboom, and Stone (1943) was found to be completely satisfactory. These writers present a section concerning the members of the genus *Anopheles* which occur throughout the continent of Europe. Recently *A. algeriensis* and *A. hyrcanus pseudopictus* have been reported for the first time from France (Hedeen, 1957; Rioux, 1954). However, these two species are included in the paper mentioned above, and their identification should present no difficulty if encountered in France by future workers.

In order to compile a complete list of the species of mosquitoes known to be present in France, it was necessary to consult many papers which had been published in a variety of journals and periodicals. These data were combined with the collection records of the Army Medical Service made throughout the country during the period of 1953 to 1956. In some instances it was necessary to contact French workers for the loan of specimens of certain species and various publications which were difficult to obtain. In this regard, the writer is especially indebted to the following individuals: Dr. E. Noeldner, Strasbourg; Dr. E. Roman, Lyon; Dr. Jean Rioux, Mont-

pellier. He is also grateful to Dr. E. Séguy of the French Museum of Natural History in Paris for making available the facilities of the entomology section of the Museum and for his helpful advice. Special thanks are given to Miss Thelma L. Ford of the Walter Reed Army Institute of Research, Washington, D. C., who prepared the illustrations.

THE PRESENT STUDY. The mosquitoes of France number approximately 53 species comprising 7 genera. The genus *Aedes*, with approximately 25 species has the largest number, followed by *Culex* with 9 species, *Anopheles* with 9, and *Culiseta* with 8. The genera *Mansonia*, *Orthopodomyia*, and *Uranotaenia* are represented in the French fauna by one species each.

The present paper is the first of a series of three dealing with the larvae of the mosquitoes of France. The genera *Aedes* and *Culex* will be considered in the second and third publications respectively.

Though this work is primarily concerned with the species of mosquitoes known to occur within the geographical boundaries of France, it is believed that the information given will be useful for the species occurring in other Western European countries such as Belgium, Luxembourg, Switzerland, Central and Southern Germany, and Northern Italy and Spain.

GENERIC KEY TO THE FOURTH INSTAR MOSQUITO LARVAE OF FRANCE

1. Siphon absent *Anopheles*
- Siphon present 2
2. Siphon modified to pierce plant tissues; being sharp at apex and toothed on one side *Mansonia*
- Apex of siphon not modified to pierce plant tissues; not sharp or toothed..... 3
3. Siphon without a pecten..... *Orthopodomyia*
- Siphon with a pecten..... 4
4. Eighth abdominal segment with a prominent sclerotized plate which bears the comb on its posterior border.... *Uranotaenia*
- Eighth abdominal segment without a prominent sclerotized plate..... 5
5. Siphon with several subventral or siphonal hair tufts..... *Culex*
- Siphon with only one pair of subventral hair tufts 6
6. Siphonal hair tufts inserted at base of siphon *Culiseta*
- Siphonal hair tufts not inserted at base of siphon *Aedes*

GENUS *CULISETA* FELT

Most European workers prefer to use the name *Theobaldia* Neveu-Lemaire, for this genus. This writer, however, prefers to subscribe to the view of Freeborn and Brookman (1943) which gives *Culiseta* priority over *Theobaldia*.

This genus is represented in France by eight species, comprising three subgenera. The subgenera and the species included in each are as follows: subgenus *Culiseta*: *annulata* (Schrank, 1776), *subochrea* Edwards, 1921, *alaskaensis* Ludlow, 1906, *glaphyoptera* (Schiner, 1868); subgenus *Culisella*: *fumipennis* (Stephens, 1825), *morsitans* Theobald, 1901, *litorea* Shute, 1928; subgenus *Allotheobaldia*: *longiareolata* (Macquart, 1838).

terminated, however, the two records of Eckstein and Noeldner listed above are the only two published records in existence for this mosquito from France.

alaskaensis: Noeldner (1951) records this circumpolar mosquito from the vicinity of Strasbourg, and this appears to be the only location where *alaskaensis* has been collected.

annulata: Several European workers (Edwards, 1921; Marshall, 1938; Martini, 1931; Séguy, 1923; Natvig, 1948) record *annulata* from all regions of France. Collection records of the U. S. Army Medical Service (1953 to 1956, unpublished) indicate this species to be quite prevalent in the southwestern region (Departments of Charente-Maritime, Vendée, Charente,

KEY TO THE SPECIES OF FOURTH INSTAR LARVAE
GENUS *CULISETA*

(Morphological features are labelled in Fig. 1)

- | | |
|---|----------------------|
| 1. Distal pecten teeth long and hair-like..... | 2 |
| — Distal pecten teeth not long and hair-like..... | 5 |
| 2. Lower head hair (6) more than 4-branched, the branches being more or less equal in length (Fig. 2) | <i>glaphyoptera</i> |
| — Lower head hair (6) four or less branched, one or more of the branches being distinctly longer and stouter than the others..... | 3 |
| 3. Anal segment usually with four precratal tufts (rarely three or five) (Fig. 3)..... | <i>alaskaensis</i> |
| — Anal segment with two or three (rarely four) precratal tufts..... | 4 |
| 4. Distance between postclypeal hairs (4) equal to or greater than the distance between upper head hairs (5) (Fig. 1)..... | <i>annulata</i> |
| — Distance between postclypeal hairs (4) much less than distance between upper head hairs (5) | <i>subochrea</i> |
| 5. Siphon with six to twelve stout, widely-spaced spines; anal plate not completely surrounding the anal segment (Fig. 4)..... | <i>longiareolata</i> |
| — Siphon with a pecten not consisting entirely of stout, widely spaced spines; anal plate completely surrounding the anal segment..... | 6 |
| 6. Basal portion of pecten obliquely inserted, not more or less parallel to ventral and dorsal edges of siphon; pecten with two to four isolated, larger teeth distally (Fig. 5)..... | <i>fumipennis</i> |
| — Basal portion of pecten inserted more or less parallel to ventral and dorsal edges of siphon; pecten without two to four isolated, larger teeth distally..... | 7 |
| 7. Length of subventral tuft of siphon generally less than two-fifths ($\frac{2}{5}$) the length of the siphon (Fig. 6) | <i>morsitans</i> |
| — Length of subventral tuft of siphon generally more than two-fifths ($\frac{2}{5}$) the length of the siphon | <i>litorea</i> |

DISTRIBUTION IN FRANCE. *glaphyoptera*: This species has been reported from the vicinity of Strasbourg by Eckstein (1918) and by Noeldner (1951). Séguy (1923) comments that this is a species of "Southern Europe" and should be present in the south of France. As far as can be de-

termined, however, the two records of Eckstein and Noeldner listed above are the only two published records in existence for this mosquito from France.

subochrea: This species appears to be quite widespread throughout the country, but it was not collected during surveys of the Medical Service for the period of

1953 to 1956. Noeldner (1951) reports *subochrea* from Kolbsheim (Bas-Rhine) in Alsace, and Séguy (1923) records it from the following localities throughout the country: Troyes, Beyrouth, Perse, Ghilan, Calmors, Revigny, "Meuse." Roman (1940) has collected this species on one occasion from the vicinity of Lyon.

longiareolata: Séguy (1923) states that *longiareolata* has been recorded from the following localities: Paris, Rambouillet, Fontainebleau, Loire Inferieure, Hautes-Pyrenees, Vallee du Gave de Pau, Var, Alpes Françaises, Briançon, Menton. Calot (1944) lists it as occurring in the Department of Indre et Loire in central France, and Noeldner (1951) records it as having been found on one occasion in Alsace, near the city of Strasbourg. Roman (1940) records this mosquito from Lyon and states that it has also been reported from the Department of Calvados in the northwestern section though no specific reference to this latter record is included. Army collection records list *longiareolata* from the following localities, all of which are in the Department of Charente-Maritime on the western coast: Sablanceaux and Ars on the Ile de Re, Ile D'Oleron, Royan.

jumipennis: This widely distributed species is reported by most European workers to occur throughout Europe, except in the far north (Edwards, 1921; Marshall, 1938; Martini, 1931; Séguy, 1923). Army collection records confirm this widespread distribution, as they record the species as occurring from Cherbourg to Bayonne in the west, as well as from Pau in the south and Verdun in the northeast and Lille in the northwest.

morsitans: *Culiseta morsitans* is recorded by the principal European workers as being cosmopolitan in its distribution throughout Europe. The collections of the Army Medical Service confirm this, as the mosquito has been taken from widely separated regions of the country at various times of the year.

litorea: Harant and Rioux (1954) were the first to report *litorea* from France;

their report was based on specimens collected from the region of the Camargue. So far as could be determined no other published records exist for the country. In June of 1955 the writer collected a large series of adult male and female specimens from beneath a bridge near Rochefort Sur-Mer (Charente-Maritime). This collection consisted of an approximately equal number of male and female specimens. Upon superficial examination, the females were tentatively identified as *morsitans*, but when males of this collection were studied in a more detailed manner, which included the examination of nine terminalia preparations, it was found that the species was *litorea*. *Culiseta morsitans*, *Culiseta jumipennis*, and *C. litorea* are so similar as adults that an error in identification, as indicated, can easily be made unless the male terminalia are studied. For this reason it appears possible that *C. litorea* may be more common in France than formerly believed.

Genus *Mansonia* Blanchard

Mansonia (*Coquilleltida*) *richiardii* (Ficalbi, 1890) is the only representative of this genus known from Western Europe. The name *Taeniorhynchus richiardii* is frequently seen in the literature for this species, but most workers agree that *Mansonia* is the correct generic name. This mosquito is widespread throughout continental Europe, and it has been reported by Séguy (1923) to occur throughout France. Most of the distribution records for *M. richiardii* which are available are based on adult collections. A collection of adults was made by the writer while bathing in the sea on the western tip of the Ile de Re (Charente-Maritime) in June of 1955. An intense search of the surrounding area was made in the hope of collecting the larvae. No larvae were located, although several bodies of water, which seemed to be ideal for the breeding of this species, were thoroughly searched.

The apex of the siphon of the larva of *M. richiardii* is sharply constricted and

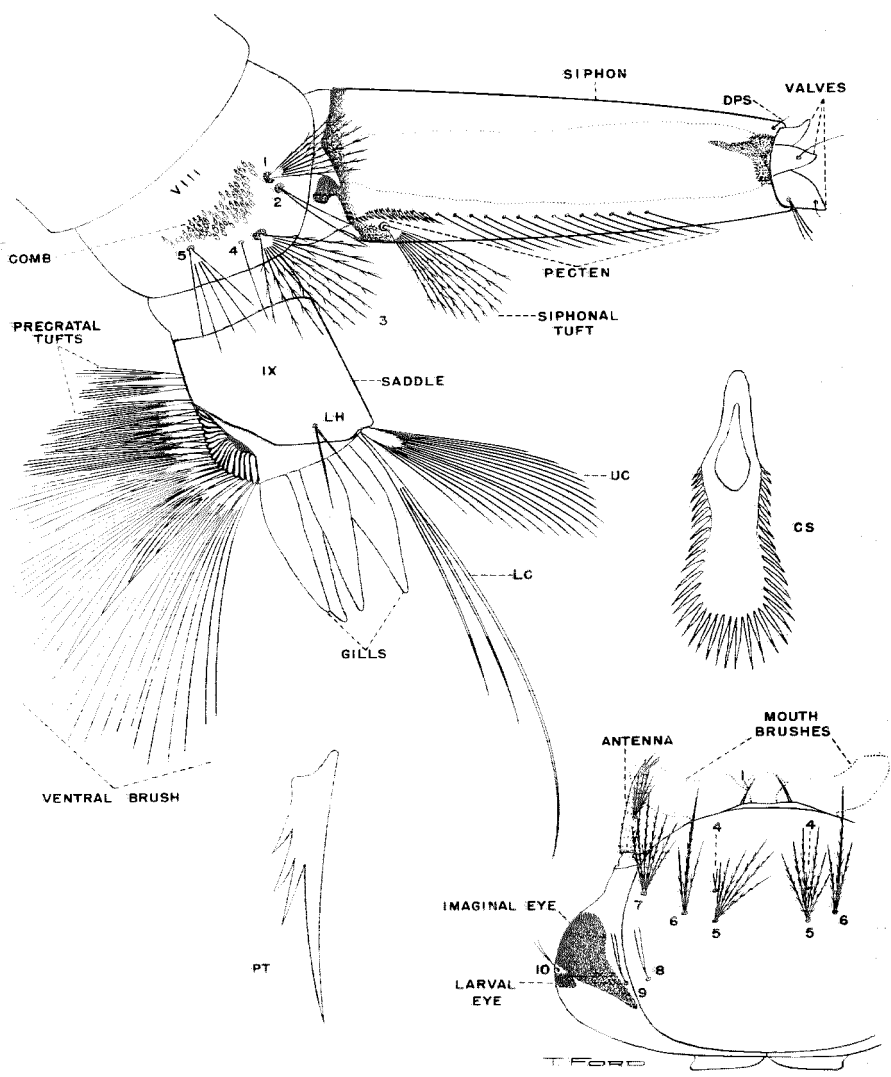


Figure 1.—Head and Terminal Segments of *Culiseta annulata* LH, lateral hair of anal segment; UC, upper caudal hair; LC, lower caudal hair; DPS, dorsal preapical spine; PT, pecten tooth; CS, comb scale.

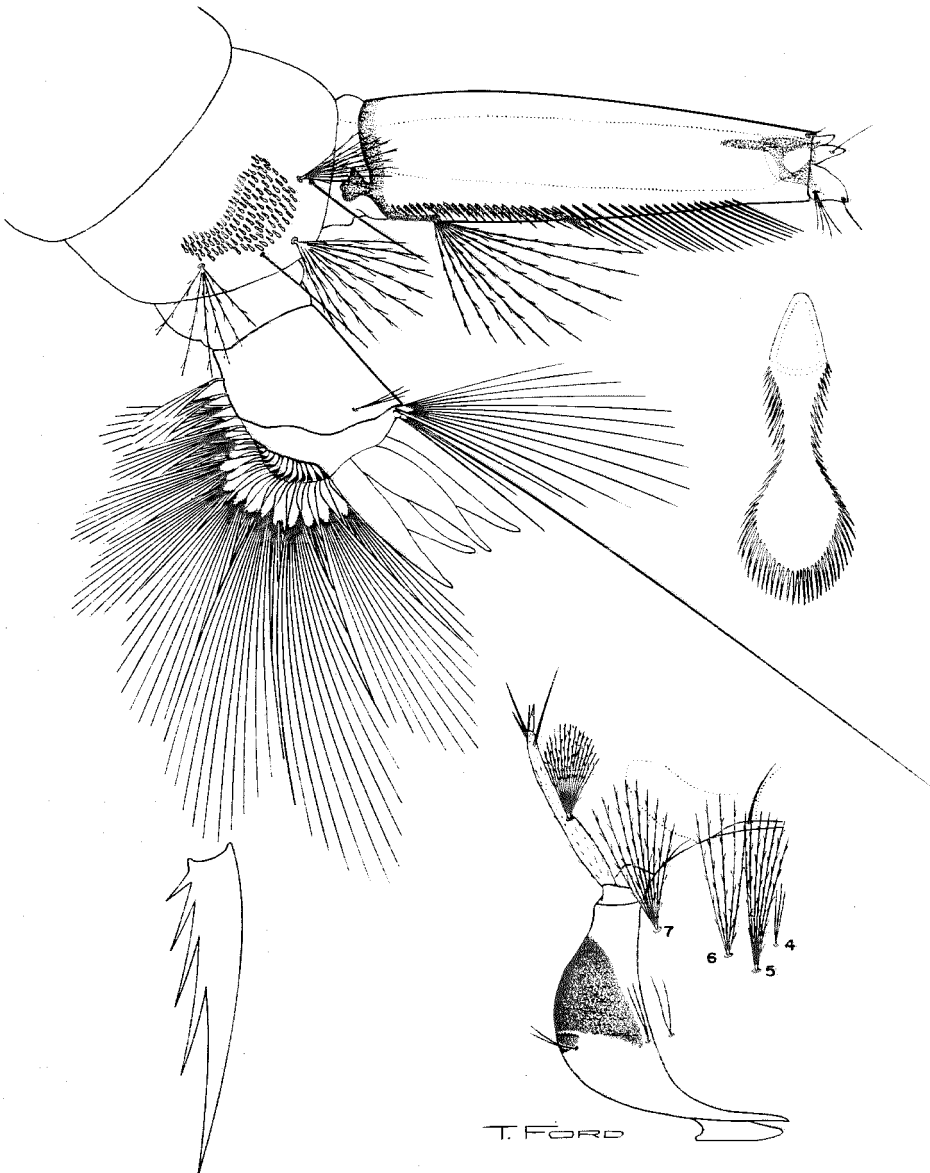


Figure 2.—Head and Terminal Segments of *Culiseta glaphyoptera*.

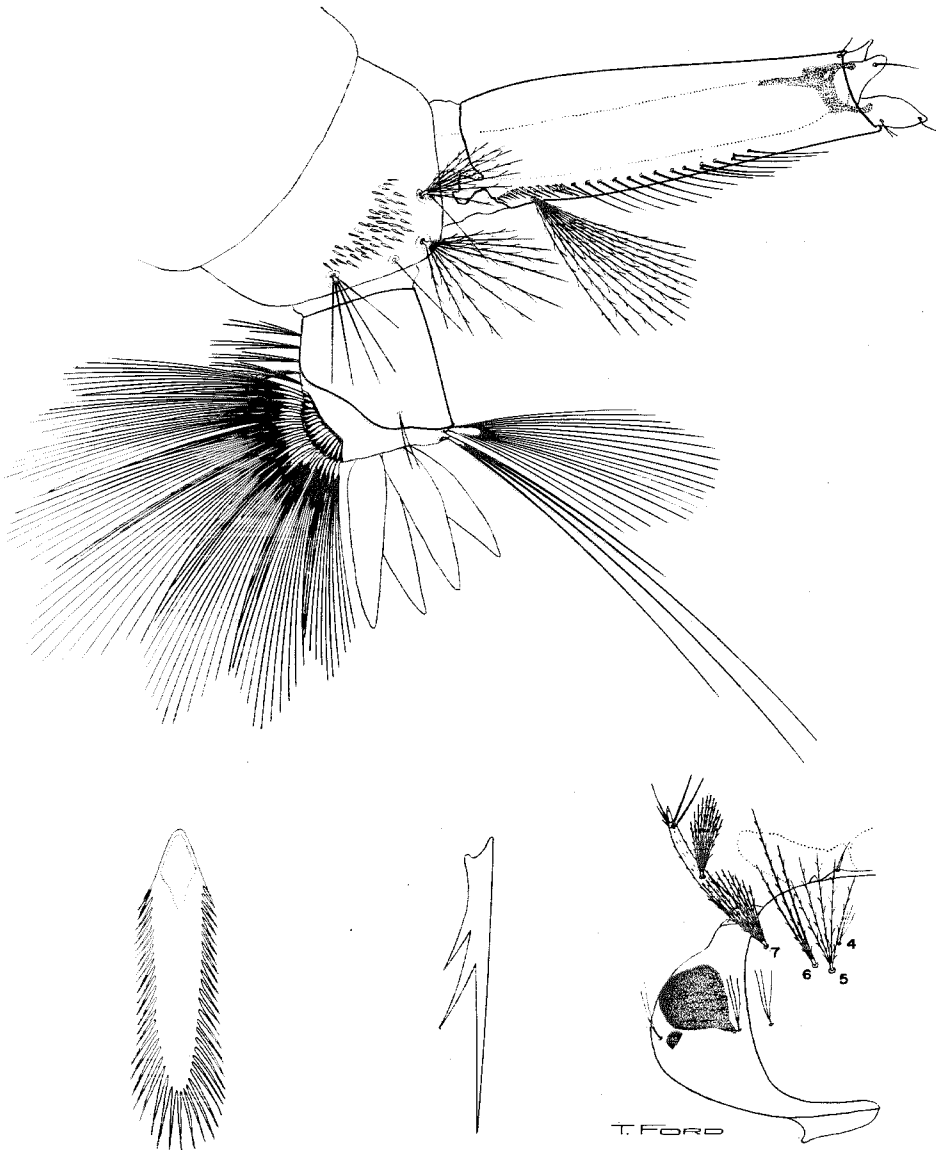


Figure 3.—Head and Terminal Segments of *Culiseta alaskaensis*.



Figure 4.—Head and Terminal Segments of *Culiseta longiarcolata*.

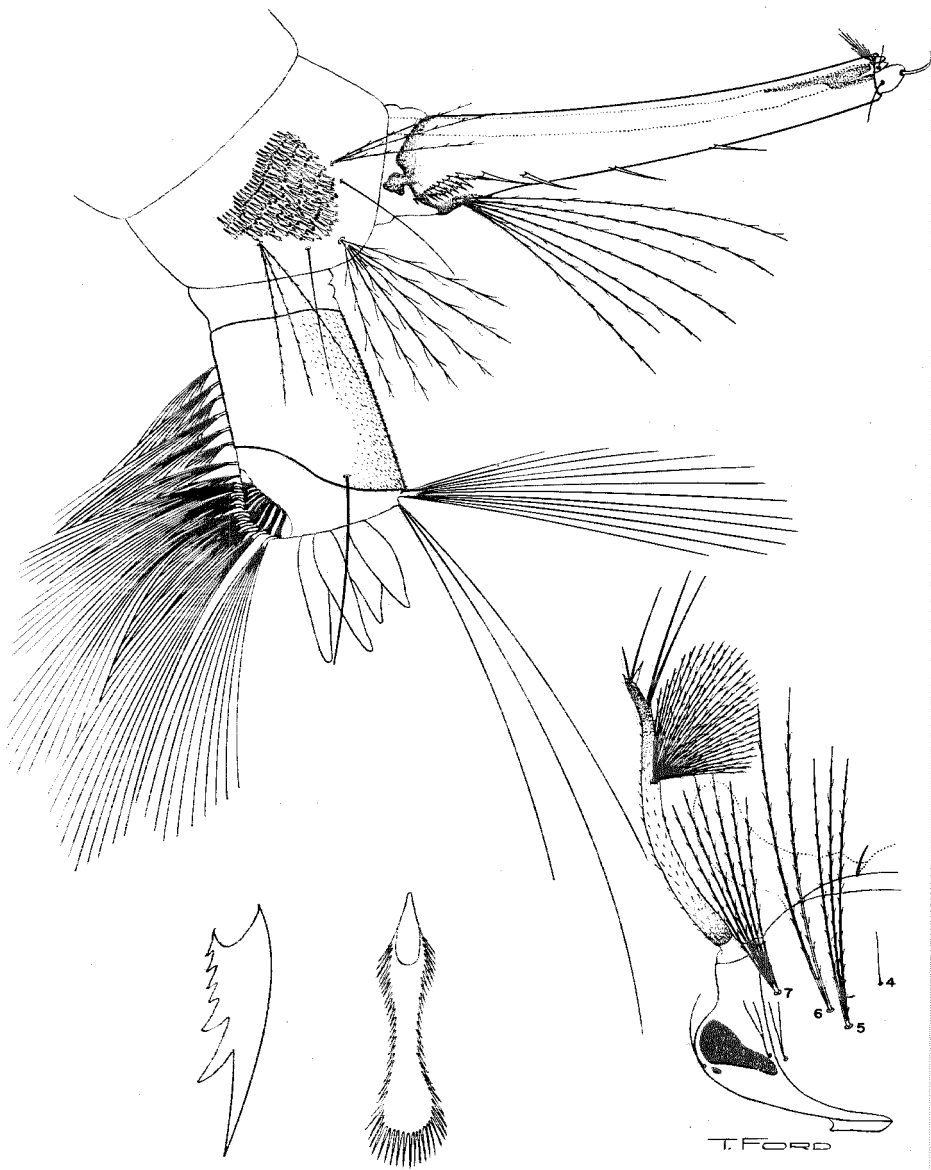


Figure 5.—Head and Terminal Segments of *Culiseta fumipennis*.

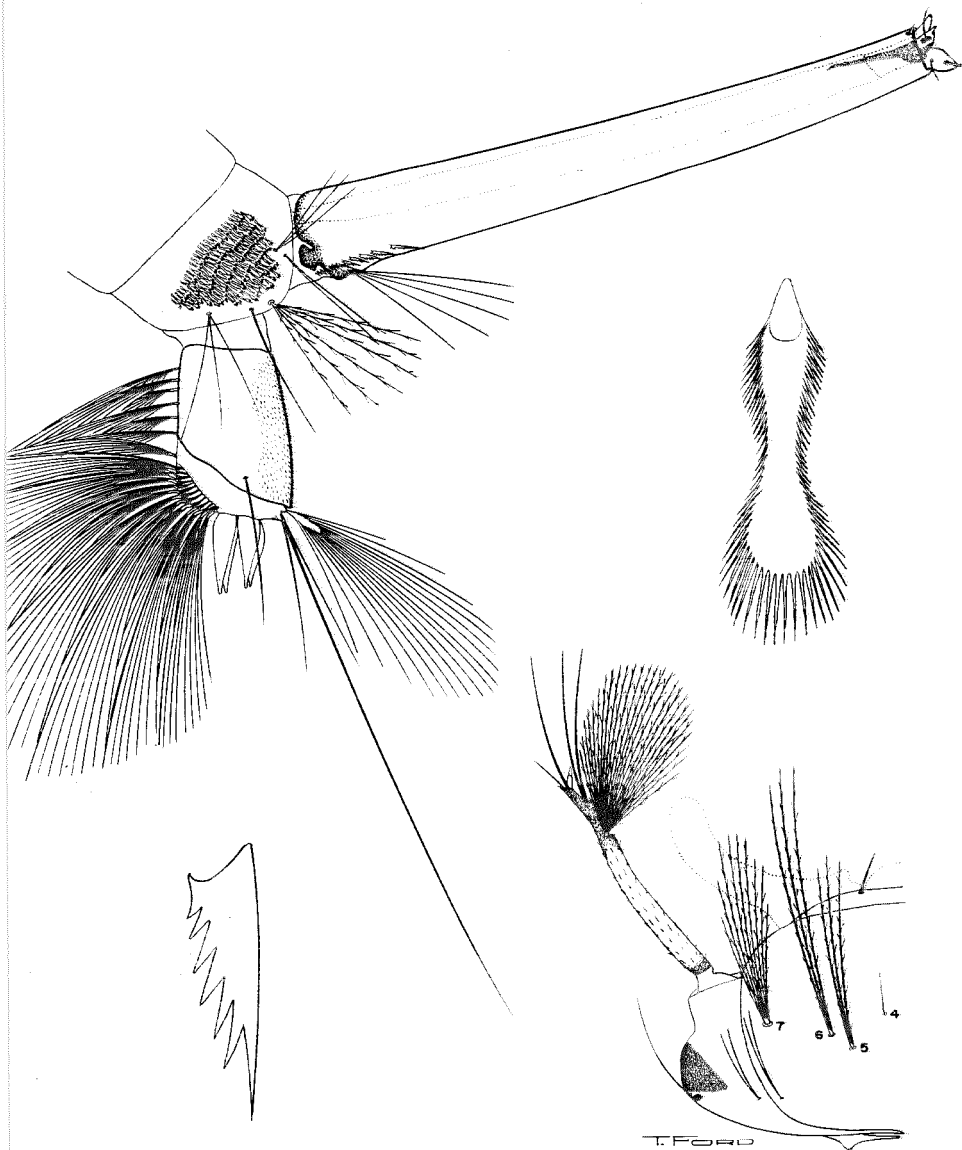


Figure 6.—Head and Terminal Segments of *Culiseta morsitans*.

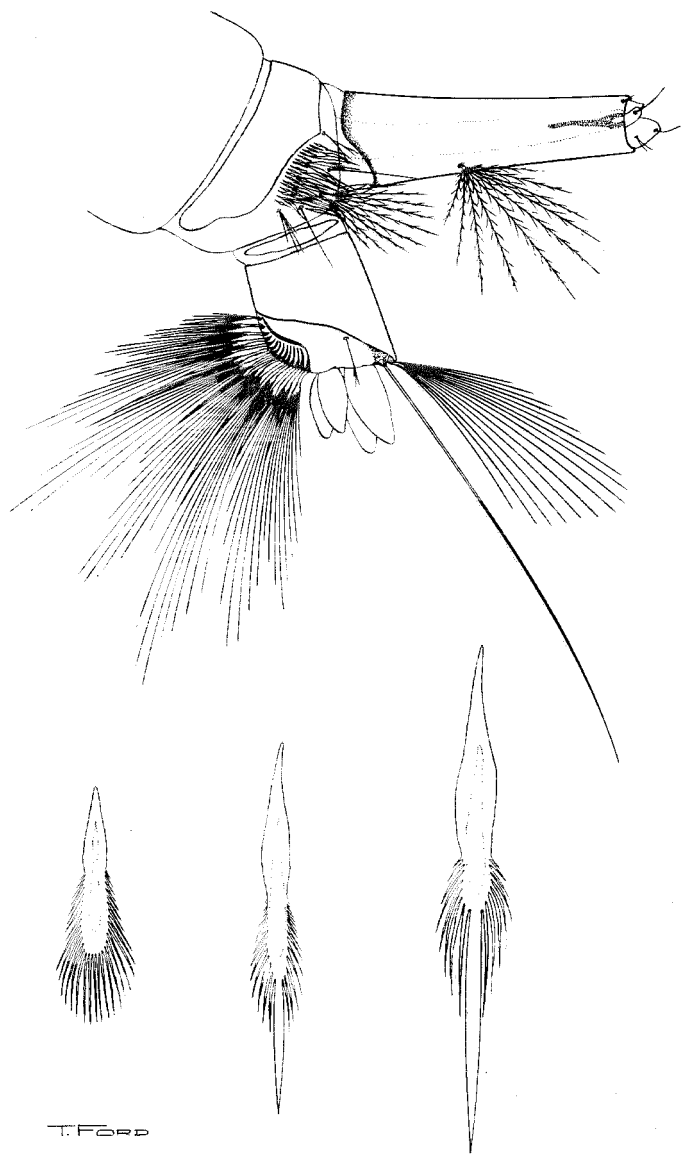


Figure 7.—Terminal Segments of *Orthopodomyia pulchripalpis*.

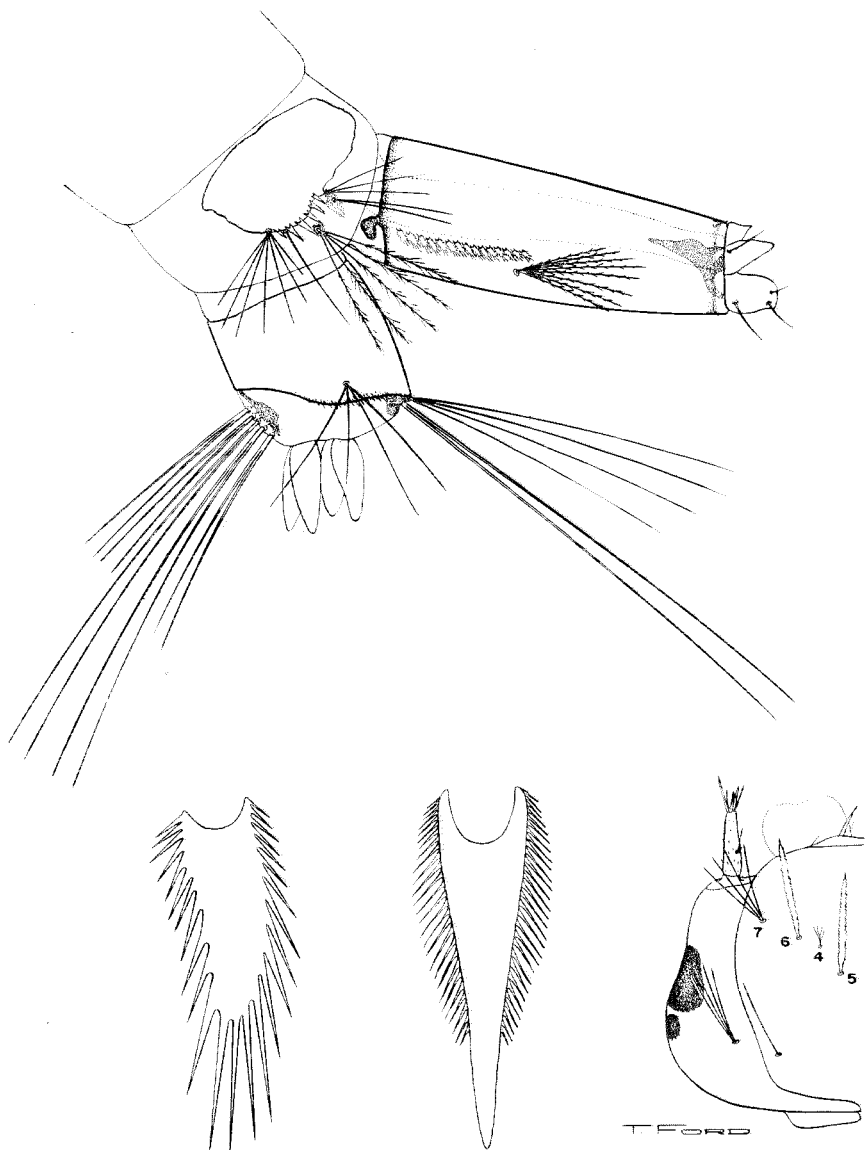


Figure 8.—Head and Terminal Segments of *Uranotaenia unguiculata*.

armed with an elaborate arrangement of hooks and spines which enable the larva to remain attached to the submerged portion of aquatic plants during the entire course of development of the immature stages. Because of this peculiar modification of the siphon it is the belief of the writer that it is impossible to confuse this mosquito with any other species occurring in Western Europe.

Genus *Orthopodomyia* Theobald

Orthopodomyia pulchripalpis Rondani, 1872, (Fig. 7) is the only species of this genus reported from Western Europe. Prior to this paper, only two records of *O. pulchripalpis* apparently existed from France. Séguy (1923) reports it from Marly in the vicinity of Paris, and Callot and Van Ty (1944-45) record it from the Department of Indre et Loire in the central portion of the country. In March of 1955 the writer made a routine collection of tree-hole breeding mosquitoes from a cavity in a large sycamore tree, (*Platanus acerifolia*) in the vicinity of the city of La Rochelle. Upon examination of the collection in the laboratory six specimens of this species were recovered. The collection also included numerous larvae of *Aedes geniculatus* and one specimen of *Anopheles plumbeus*.

The identification of this mosquito in the larval stage should present little or no difficulty when it is encountered in the region of Western Europe. It may be quickly distinguished from other mosquito larvae by its pinkish color and the absence of a pecten.

Genus *Uranotaenia* Lynch—Arribalzaga

Like the two preceding genera, this genus is represented in the French fauna by a single species, *Uranotaenia unguiculata* Edwards, 1913 (Fig. 8). This mosquito was previously regarded as an Eastern Mediterranean species. It has been recorded as far east as Iraq (Khattat, 1955). Its presence in France was first reported by Rioux (1954) from the Bas Langue in

the southern region of the country. Doby (1955) has confirmed its presence in this region by making a subsequent collection. This mosquito was not collected in any of the surveys conducted by the Army Medical Service during the period of 1953 to 1956.

The larva of *U. unguiculata* is not readily distinguished from the larvae of several species of the genus *Aedes* except in the fourth instar. In the fourth instar the characteristic chitinized plate appears on the eighth abdominal segment, and this plate bears the comb on its posterior border.

SUMMARY. A review of the larvae of the culicine mosquitoes of France which belong to the genera *Culiseta*, *Mansonia*, *Orthopodomyia*, and *Uranotaenia* is presented. A key for distinguishing all the genera reported from the country is included as well as a key to the species of the genus *Culiseta*. Distinguishing characteristics of the species of the other genera included in this paper are emphasized, and a brief consideration of the genus *Anopheles* is included.

Distribution records reported by previous writers are compiled, and collection records of the Army Medical Service during the period of 1953 to 1956 are presented.

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PARTICLE SIZE STUDIES USING A NON-THERMAL AEROSOL FOG GENERATOR DESIGNED FOR CONTROL OF ADULT INSECTS

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INTRODUCTION. Insecticidal aerosols are widely used by the Military Forces in outdoor applications for the destruction of adult populations of mosquitoes and other flying insects. From extensive use of available commercial devices it was concluded that the needs of the Military Forces could be met best by the development of a non-thermal aerosol generator providing for ready selection of the particle size making up the aerosol. When large quantities of insecticide are dispersed annually, as in the military operation, it is important that the correct particle size for maximum kill be achieved. For adult mosquitoes this is believed to be in the range of 20-30 microns mmd. This paper describes one in a continuing series of

studies of equipment and methods of producing controlled sized particles in an insecticidal aerosol.

DESCRIPTION OF EQUIPMENT. The equipment used for these studies was a non-thermal aerosol generator designed and developed by Messrs. Robert G. Hahl and Harry N. Lowe, Jr., of the U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia. The unit consists of a gasoline engine, a blower, an insecticide reservoir and pump, a unique but simple flow control system assuring positive control of the liquid flow rate and a nozzle and discharge assembly that can be adjusted to any desired position (Fig. 1).

The nozzles permit the use of a low