The Ecology of the Mosquito Larvae of New Guinea

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INTRODUCTION

FROM SEPTEMBER 1943 to January 1945 I was in New Guinea as Officer in Charge, U. S. Navy Malaria Control Team 25, and was stationed at Milne Bay, Morobe, Finschhafen, and Saidor. The entire period was spent in almost daily field collecting of larval mosquitoes. During the same period Dr. George H. Penn was stationed at Milne Bay, Amsterdam Island, and Woendi Island as Officer in Charge, U. S. Navy Malaria Control Team 28. Before arriving in New Guinea we agreed to combine all collections and to record all habitat data on standard collection cards.

This study is based on an analysis of the habitats utilized by 47 species of mosquitoes present in a total of 1,508 collections. The habitat records presented here are not the results of opinions on habitat relationships; they are numerical analyses of all collection data.

Comprehensive studies of the ecology of the mosquito larvae of New Guinea are completely lacking. There are numerous scattered notes on habitat, especially for the more recently described species, and there are more detailed ecological studies of certain of the medically important species. But there is no broad ecological survey summarizing the habitat relationships of all common species of this area.

Some of the more important taxonomic works in which ecological notes may be found are those of Taylor (1914–1943), Hill (1925), Bonne-Wepster and Brug (1932, 1937, 1939), Lee (1944*a*, 1946), Lee and Woodhill (1944), King and Hoogstraal (1946–1947), and Marks (1947). Recently more detailed habitat studies of individual species of medical importance have been recorded by Horsfall and Porter (1947), Forbes and Horsfall (1947), and Penn (1947*a*).

Acknowledgments. Many persons have assisted in this study. I wish to thank Professor Robert Matheson, Cornell University, for his friendly encouragement and counsel. Dr. George H. Penn, Tulane University, assisted in developing the collecting technique, and made many of the collections. My appreciation is extended to the men of Malaria Control Teams 25 and 28 (W. W. Bonds, H. W. Dorman, A. S. Griswold, J. E. Surgenor, W. T. Whitfield, P. B. Tompkins, O. L. Andrews, A. C. Bodenman, W. L. Schmid, R. E. Geiger, J. P. Gallagher, and M. A. Greenblatt) by whose efforts many collections were made, often under trying field conditions. Professor F. A. Perkins, University of Queensland, extended every courtesy, including the full facilities of his Department, and Miss Elizabeth Marks of the same institution identified many specimens and supplied important literature aids. Dr. Alan Stone, U. S. National Museum, clarified many of the taxonomic problems. Dr. W. M. Rogoff and Dr. A. G. Humes supplied species lists to add to the distribution data.

LOCALITIES STUDIED

All collections were made within, or just adjacent to, military bases which in every case were situated along the North Coast. In general, these bases were built on strips of land lying between the ocean and the mountains, and varying in width from about a quarter of a mile to 5 miles. However, Woendi and Amsterdam were small coral islands.

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The most conspicuous feature of all areas was the ubiquitous coconut plantation. In most instances, puddles and artificial containers were common, whereas ponds, lakes, and marshes were nearly always absent. New habitats developed rapidly. The most outstanding of these were puddles and artificial containers. Moreover, each area was under intensive military control and, in several, thorough initial surveys were delayed because of enemy interference.

The above factors undoubtedly influenced the data. However, since each area was bordered by an accessible fringe roughly representative of natural conditions, and since collections were from both base periphery and from the more artificial base site, it is believed that significant data on the *habitat potentials* of the various species have been obtained.

The collecting areas and dates are:

Milne Bay, Papua (10° 20′ S/150° 30′ E).
- Gamadodo: September 1943 through March 1944; September through November 1944.
- Wagga Wagga: October through November 1944.
- Hilimoi: August through November 1944.
- Kana Kopa: October 1943 through January 1944; September through November 1944.

Morobe, Northeast New Guinea (7° 45′ S/147° 35′ E): November 1943.

Finschhafen, Northeast New Guinea (6° 35′ S/147° 50′ E): January through June 1944.

Saidor, Northeast New Guinea (5° 40′ S/146° 30′ E): February through June 1944.

Woendi, Padaido Islands, Dutch New Guinea (1° 15′ S/136° 20′ E): July through October 1944.

Amsterdam Island, Dutch New Guinea (0° 20′ S/132° 10′ E): August through October 1944.

METEOROLOGICAL DATA

The only data available were those of the temporary Navy Station at Milne Bay and the Australian Station at Samarai. Rainfall and temperature records for 1943 and 1944 were obtained from the Navy, and the long-time averages from Samarai. Since the majority of collections were from Milne Bay, data from these sources are indicative of conditions under which most of the collections were obtained.

Figure 1 compares the 29-year average monthly rainfall with that for the collecting period. It also compares the 9-year average monthly maximum, mean, and minimum temperatures with those for the collecting period.

The 29-year average rainfall shows no great monthly variation. Rainfall during the collecting period paralleled the long-time average, except during April and June 1944, when brief torrential rains increased the amount to far above the average. No collections were obtained from Milne Bay during these months. These data demonstrate an absence of definite wet and dry seasons. This is in marked contrast to the much-discussed wet and dry seasons which have played such an important role in mosquito bionomics in other tropical areas, notably the Solomon Islands and the New Hebrides. Similarly, temperature data show but slight seasonal variation.

No seasonal fluctuation in numbers of species or numbers of individuals of mosquito larvae was observed. It is concluded that neither rainfall nor temperature was a factor limiting the mosquito population during any season of the year.

METHODS

Distribution

Data were obtained from: (1) literature records; (2) collections from the detail-study areas; (3) unpublished records of A. H. Humes, W. M. Rogoff, and T. K. Ruebush, who were in New Guinea during periods corresponding to these collections.

All records available in the literature on New Guinea are listed for each of the 47

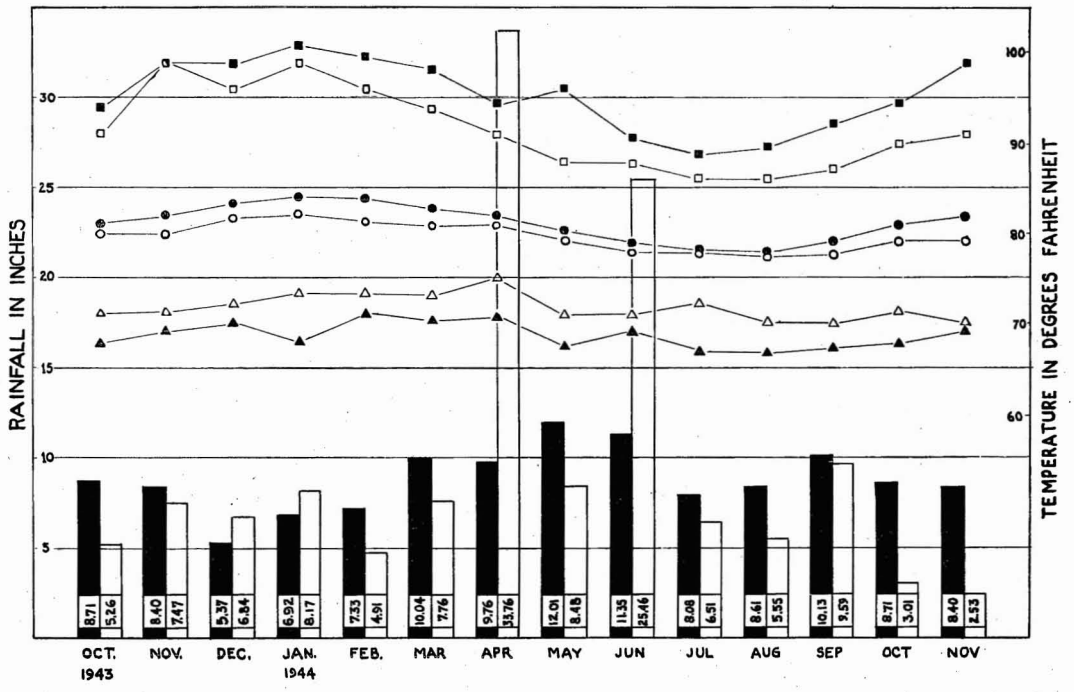

FIG. 1. Monthly temperature and rainfall during collecting period at Milne Bay (open symbols and blocks) compared with the long-time average for the Samarai weather station (solid symbols and blocks). Long-time average figures were obtained through courtesy of Directorate, Meteorological Services, RAAF, Melbourne.

species[2] collected in the areas of study. When the same locality is repeated by several authors, each reference is included. All type localities in New Guinea are given, but additional references to this locality are not repeated. Latitude and longitude for nearly every locality may be found in the U. S. Army Map Service *Gazetteer to Maps of New Guinea* (1943).

A great variety of spellings of the various place names was encountered. Moreover, many of the German names employed in Northeast New Guinea were changed after the area became an Australian mandate. To avoid confusion, all spellings used in this report are those given in the Army's *Gazetteer*.

Collecting Technique

Each collection was a sample from a particular microhabitat at a particular time. Each microhabitat usually presented at least one distinguishing characteristic, even when several of them were located in temporary water in close proximity. A single macrohabitat often included a large number of microhabitats in a very limited horizontal range. For example, in certain cases the superficial picture may have been of a definite marsh, yet separate collections could be made from puddles, artificial containers, coconut shells, etc., through a great range of microhabitats. As a result of sanitary control operations, repeat collections from the same microhabitat were seldom possible.

All ecological data were recorded in the field, using for each collection a 3×5 index card whereon space was provided in the center for recording the locality, date, time, and

[2] In the thesis on which this paper is based (deposited in the library of Cornell University) I have listed all distribution records of the 179 species ever recorded from New Guinea as well as my own distribution records for the 47 species discussed in this paper. In addition, all literature on the ecology of the larvae of each of the 179 species was summarized and compared with my own numerical data. However, for the sake of brevity, this paper deals primarily with distribution and ecological data for the 47 species I personally encountered.

collector's initials. Ecological terms were listed around the margins so the collector simply checked the appropriate blocks. This method reduced the possibility of omitting important data from field notes compiled at random. A similar card punch system is discussed by Boyd (1930).

Identifications

For most collections, a representative series of individuals was reared in isolation. Identifications in nearly every case were based on reared material. The majority of these reared adults were checked by Dr. Alan Stone of the U. S. National Museum, and others were checked by Miss Elizabeth Marks of the University of Queensland. Most of the specimens have been deposited in the U. S. National Museum, and representative series of associated larvae, pupae, and adults have been placed in the collections of Cornell University and the University of Queensland, Brisbane, Australia.

ANALYSIS OF DATA

Habitats

After all recorded data on the ecology of the larvae were assembled, it became obvious that the literature was markedly deficient in quantitative data. Scarcely a reference presents numerical data which show the actual degree of utilization of a habitat. Some authors use such terms as "sometimes," "rarely," "frequently," but most merely list all habitats without qualification, so that it is impossible to distinguish the usual from the unusual. Undoubtedly, many authors unduly stress rare habitats. It seems that single collections from such breeding places are so repeated in the literature that gradually the focus is concentrated on the rare to the point of neglecting the really important—the usual.

Therefore, I believe that only a numerical presentation of data can furnish both a brief and an accurate basis for determining habitat potentials, and only the use of numbers will permit a comparison of the results of different studies.

Larval habitats have been variously recorded by nearly every author who has attempted to summarize an extensive number of collections. The majority simply give the range of habitats applicable to the particular area, listing every specific habitat, such as "K ration box floating in a river." Such details are meaningless when data are compared. Moreover, even though some authors attempt to classify habitats, their descriptive terms are unique. Thus, comparison of data is almost impossible. Obviously there is need for a classification of habitats using very broad terms that are universally applicable.

Shannon (1931) proposed a very general classification dividing all habitats into two major categories: (1) depressions in the ground, and (2) water in containers above ground. He subdivided each of these into natural and artificial water. Bonne-Wepster and Brug (1932) found the following adequate for their investigation of *Stegomyia* in the Dutch East Indies: (1) earth-bound habitats, (2) vegetable breeding places, (3) man-made containers. Bates (1949) divided larval habitats into four major groups: (1) permanent or semipermanent standing water, (2) running water, (3) transient ground pools, (4) container habitats. Arnett (1950) summarized the habitats recognized in Panama as follows: (1) surface water, (2) aerial habitats, (3) artificial containers.

I believe that general use of such major categories by all workers, supported by numerical data, would quickly give an adequate picture of the habitat potentials of the various species. Such a picture could then be utilized as the basis of sound control procedures.

My organization of larval habitats corresponds to that of Bonne-Wepster and Brug and of Shannon. They were grouped into three major divisions: (1) fresh surface water, both natural and artificial, (2) fresh water in containers, both natural and artificial, (3) brackish or salt water. These were further divided into a rather large number of

more specific microhabitats, which are listed in Table 2.

The term "habitat index" is used as a convenient way of referring to the ratio between the number of collections of a species in a particular habitat and the total number of collections of that species.

Habitat Factors

An extensive literature has accumulated in an attempt to determine the effect of chemical and physical factors on the breeding habits of various species. Many factors have been investigated, but specific conclusions concerning the role of any one factor as an absolute indicator of potential breeding are almost entirely wanting.

A comprehensive quantitative study of the physio-chemical factors such as light intensity, dissolved oxygen, etc., was impossible under our field conditions. Our aim was to describe the general character of the habitat by careful observations using quantitative determinations when possible. Therefore only major factors such as exposure, superficial character of the water, vegetation, *p*H, were considered. In this report the habitat factor is given as the percentage of our collections in which that factor was recorded.

It should be noted that stagnant water was always static, with varying amounts of organic debris in the early stages of decomposition. In polluted water, decomposition was always well advanced and produced a foul smell. *p*H was determined in the field for many but not for all collections, using Squibb's nitrazene paper (range 4.5–8.0). Salinity was measured with a hydrometer in all cases of suspected brackish water and was considered experimentally for *An. punctulatus* and for *An. farauti.*

Species Association

The most common method of presenting numerical data indicating the degree of association is in the form of a table showing the actual number of times any two species were found together in individual collections. However, Hacker (1921) proposed the "Association Unit" and Dice (1945) the "Association Index" as measures of the degree of association between species. A combination of the methods of Hacker and Dice was used in determining my association indices.

Collections of any one species were either pure or in various combinations with one or more additional species of mosquito larvae. The value (P) of pure collections for any one species (A) is the ratio between the number of times the species was collected alone and the total collections of species A. Then a measure of the value of mixed collections (M) can be taken as 100-P. Each cohabitant is assigned a relative portion of this total as follows: hM/t, where h equals the number of times species A was found with any other species and t equals the number of times species A was found with all cohabitants. In this paper, species having an association of less than 4 per cent have been grouped and given as "others."

Bironella

Because of the confusing status of various species in the genus *Bironella*, it was impossible accurately to determine species of this genus during the collecting period. Laboratory rearing was so difficult that only five adults were available for checking: two specimens from Milne Bay were identified by Dr. Stone as *B. travestitus* and three from the same locality as *B. soesiloi* sensu Swellengrebel and Rodenwaldt. Because of the rather limited literature on the biology of *Bironella* it is considered worth while to present these data even though more than one species is represented.

DISTRIBUTION: *Bironella* species were present in collections from Milne Bay, Morobe, Finschhafen, and Saidor. Collections were nowhere numerous and the number of individuals in each collection was always rather limited. It seems that *Bironella* species would have been represented more abundantly if extensive collecting had been possible from

the headwaters or at least from the higher reaches of the mountain streams.

HABITAT:

Total collections, 34

Habitat	*Number of collections*	*Habitat index*
Creeks: Pot holes	19	56
Creeks: Running	14	41
Rock holes	1	3

*p*H, 11 readings

Range	4.0–6.5
Mode	5.0
Average	5.1

Factor	*Percentage occurrence*
Shaded	76
Exposed	24
Temporary	3
Semi-permanent	56
Permanent	41
Clear	100
Vegetation	
Absent	56
Present	44
Sparse	30
Moderate	47
Abundant	23
Algae	17
Emergent	17
Overhanging	50
Submerged	11
Floating	5

The genus *Bironella* occurred mostly (68 per cent) in pure collections. Percentages of associates were: *U. argyrotarsis*, 11; *C. fraudatrix*, 9; *C. pullus*, 4; others, 8.

Bironella (Bironella) soesiloi sensu Swellengrebel and Rodenwaldt

"*B. papuae* No. 22147 (B. soesiloi Strickland)" Soesilo and van Slooten, 1931, Geneesk. Tijdschr. Nederland. Indië 71: 126.

Anopheles papuae soesiloi Strickland (Bei Soesilo and van Slooten, 1931) Swellengrebel and Rodenwaldt (1932: 62).

DISTRIBUTION: Dutch New Guinea: Boemi-Bezirk, Hollandia (Swellengrebel and Rodenwaldt, 1932). Lee and Woodhill record it as questionable from Boemi and Hollandia. Papua: Milne Bay (Lee and Woodhill, 1944; Author).

HABITAT: Lee and Woodhill (1944) record it from a swampy creek. Both of my collections were from pot holes in creeks, in fresh, temporary, clear, shaded water at a *p*H of 5. It was found once in a pure collection and once with *U. argyrotarsis*, *C. papuensis*, and *B. travestitus*.

Bironella (Brugella) travestitus (Brug)

Anopheles (*Bironella*) *travestitus* Brug, 1928, Geneesk. Tijdschr. Nederland. Indië 68: 921.

DISTRIBUTION: Dutch New Guinea: Tahahmerah (Swellengrebel and Rodenwaldt, 1932). Papua: Cape Endaiadere (Lee and Woodhill, 1944); Milne Bay (Lee and Woodhill, 1944; Author).

HABITAT: Lee and Woodhill record it in partially shaded swamps and in pools in a sago swamp. My single collection was from a temporary, shaded pot hole in a creek, with a sparse amount of debris, at a *p*H of 5, and in association with *U. argyrotarsis*, *C. fragilis*, and *B. soesiloi* sensu Swellengrebel and Rodenwaldt.

Anopheles (Anopheles) bancrofti pseudobarbirostris Ludlow

Anopheles pseudobarbirostris Ludlow, 1902, N. Y. Ent. Soc. Jour. 10: 129.

DISTRIBUTION: Northeast New Guinea: Sepik River, Madang (Lee and Woodhill, 1944); Saidor (Author). Papua: Cape Endaidere, Oro Bay, Terapo, Lalapipi, Dobodura (Lee and Woodhill, 1944); Milne Bay (Lee and Woodhill, 1944).

HABITAT: Lee and Woodhill state that it is found only in the jungle, usually in clear pools with abundant aquatic vegetation, in dense shade, or in places which receive direct sunlight only during the middle of the day.

In our survey, *pseudobarbirostris* was present in three collections from ponds with vegetation. Its scarcity may be due to the fact that its chief habitat seems to be rather large, permanent, well-vegetated bodies of clear, shaded water which were almost entirely ab-

sent in the study areas. It was collected with *An. punctulatus*, *An. farauti*, *U. argyrotarsis*, and *C. fraudatrix*.

Anopheles (Myzomyia) farauti Laveran

Anopheles farauti Laveran, 1902, Soc. de Biol. [Paris] Compt. Rend. 54: 908.
Anopheles punctulatus molluccensis Sw. and Sw. de Graaf. Lee and Woodhill (1944: 140).
Anopheles punctulatus farauti Laveran. Mackerras and Aberdeen (1946: 770); Mackerras (1947: 1–8).

In 1945 Owen described *An. koliensis* from the Solomons. This form is intermediate between *An. punctulatus* and *farauti*. Certain earlier workers have long recognized "intermediates" which are clearly *koliensis;* others make no distinction. Obviously, in the latter cases the material cannot be safely referred to any of the three species (or subspecies) of the complex. I have limited the literature in the following discussions to those who, apparently, were clearly aware of *koliensis* or at least of intermediate forms. I believe that most of my material is *farauti* but, since all of the collections were made without knowledge of *koliensis* and since only a relatively few individuals were available for subsequent careful checking, certainty is impossible.

DISTRIBUTION: Dutch New Guinea: Batavia-bivak, Motorbivak, Kokas, Kaimana, Fakfak, Prauwenbivak, Tanahmerah, Sorong, Meervlakte, Salawati, Biak Island, Japen Island, Aru Island (Lee and Woodhill, 1944); Hollandia (Lee and Woodhill, 1944; Rozeboom and Knight, 1946); Merauke (Lee and Woodhill, 1944; Mackerras, 1947); Padaido Islands, Amsterdam Island (Author). Northeast New Guinea: Lae, Salamaua (Lee and Woodhill, 1944); Ramu Valley (Mackerras, 1947); Wewak (Mackerras and Aberdeen, 1946; Mackerras, 1947); Finschhafen, Saidor (Author). Papua: Samarai, Port Moresby, Koitaki, Oro Bay, Dobodura (Lee and Woodhill, 1944); Lalapipi (Lee and Woodhill, 1944; Mackerras, 1947); Bulldog, and near mouth of Lakekamu River (Horsfall and Porter, 1947); Milne Bay (Lee and Woodhill, 1944; Mackerras, 1947; Author).

HABITAT:

Total collections, 170

Habitat	*Number of collections*	*Habitat index*
Puddles	89	52
Creeks: Running	26	15
Creeks: Pot holes	23	14
Swamps	9	5
Borrow pits	8	5
Ditches	5	3
Ponds	3	2
Marshes	2	1
Coral pools	2	1
Artificial containers	2	1
Rock holes	1	0

*p*H, 67 readings

Range	4.0–8.0
Mode	5.0
Average	5.7

Factor	*Percentage occurrence*
Shaded	25
Exposed	75
Temporary	55
Semi-permanent	21
Permanent	24
Clear	66
Muddy	17
Stagnant	15
Polluted	2
Vegetation	
Absent	39
Present	61
Sparse	30
Moderate	43
Abundant	27
Algae	42
Emergent	25
Overhanging	16
Submerged	10
Floating	7

In the New Hebrides and Solomon Islands, Belkin *et al.* (1945), Perry (1946), and Daggy (1945) found that the breeding places consisted primarily of relatively large collections of surface water, but that after heavy rains a great variety of small temporary water collections was used. In New Guinea, Lee and Woodhill (1944) considered sago swamps, backwaters of creeks, and grassy pools and puddles as common habitats. Horsfall and Porter (1947) also give natural pools and

grassy margins of streams as most frequently used sites. Nearly all of these recorded habitats are represented in my collections. However, *farauti* was collected almost entirely (99 per cent) in surface water; the only other habitat represented was artificial containers. The range of surface habitats was rather wide but these data clearly show the great relative importance of puddles.

All workers in the New Hebrides-Solomons area have emphasized the contrast in utilization of wet- and dry-season breeding sites. No such contrast was apparent from my observations nor has such been reported by other workers in New Guinea.

Seventy-five per cent of my collections were made in exposed situations. All authors state that *farauti* occurs both in sun and shade; however, Belkin *et al.* (1945), Daggy (1945), Perry (1946), and Horsfall and Porter (1947) give a preference for sunlight, whereas Lee and Woodhill (1944) give a preference for semi-shade.

Vegetation was present in 61 per cent of my collections. Lee and Woodhill (1944), Belkin *et al.* (1945), Perry (1946), and Horsfall and Porter (1947) consider the presence of vegetation or floatage of prime importance in the ecology of *farauti*.

Only 17 per cent of my *farauti* collections were taken from muddy water, whereas 32 per cent of the *punctulatus* collections were from muddy water. This difference was emphasized by Lee and Woodhill (1944), who stated that *farauti* is rarely recorded in man-made pools with a heavy suspension of clay but that such pools serve as the typical breeding place of *punctulatus*. Horsfall and Porter (1947), on the basis of quantitative data, concluded that *farauti* is dominant in sandy or mucky soil whereas *punctulatus* is dominant in heavy clay.

Nothing on *p*H relationships has been reported. My 67 readings from nearly all habitats show a very wide range (4.0 to 8.0). However, both the mode and the average were approximately 5.5.

Lee and Woodhill (1944) record *farauti* at a salinity of 1.4 per cent at Goodenough Island. Perry (1946), in the New Hebrides-Solomons area, found it common in water containing less than 70 per cent sea water, and stated that its upper maximum level was 75 per cent sea water. From a total of 170 collections in strictly coastal localities, only four were taken in brackish water on Amsterdam Island. Two were from puddles at salinities of 10 per cent sea water, one was from a coral pool at a salinity of 20 per cent, and one from a similar pool at 70 per cent sea water.

Daggy (1945) reared *farauti* from egg to adult at a maximum of 65 per cent sea water and found that "late larval development" was possible in salinities greater than that of sea water. My laboratory investigations showed that fourth instar larvae withstood all concentrations up to 100 per cent sea water for 24 hours, but that the survival was greatly reduced at salinities greater than 30 per cent.

SALINITY

Percentage sea water	*Number of larvae used (4th instar)*	*Percentage alive after 24 hours*
0	21	100
10	7	100
20	11	60
30	21	76
40	22	23
50	23	9
60	15	7
70	20	5
80	18	5
90	15	0
100	36	3

Larval associates have been recorded by Buxton and Hopkins (1927), Belkin *et al.* (1945), and Perry (1946), but no one has recorded the degree of association. *Farauti* occurred mostly (77 per cent) in mixed collections. Percentages of associates were: *C. pullus*, 21; *An. punctulatus*, 16; *C. halifaxi*, 11; *C. squamosus*, 8; *C. annulirostris*, 6; *C. fraudatrix*, 5; *U. argyrotarsis*, 4; others, 6.

Anopheles (Myzomyia) longirostris Brug

Anopheles (Neomyzomyia) longirostris Brug, 1928, Geneesk. Tijdschr. Nederland. Indië 68: 278. Type locality: Near Upper Digoel River, Dutch New Guinea.

DISTRIBUTION: Dutch New Guinea: Pionierbivak (Lee and Woodhill, 1944); Fakfak, Tanahmerah, hinterland of Geelvink Bay (Swellengrebel and Rodenwaldt, 1932). Northeast New Guinea: Lae (Lee and Woodhill, 1944). Papua: Sinemi, Port Moresby (Lee and Woodhill, 1944); Bulldog (Lee and Woodhill, 1944; Mackerras, 1947); Milne Bay (Lee and Woodhill, 1944; Mackerras, 1947; Author).

HABITAT: Swellengrebel and Rodenwaldt (1932) and Lee and Woodhill (1944) recorded *longirostris* most often from shaded swamps and pools in the jungle or near its fringes. My single collection was taken from a temporary, exposed puddle, in fresh clear water having a sparse amount of algae, in association with *An. farauti*, *An. punctulatus*, and *C. pullus*.

Anopheles (Myzomyia) punctulatus Dönitz

Anopheles punctulatus Dönitz, 1901, Insekten Börse 18: 36. Type locality: Bogadjim, Northeast New Guinea.

Anopheles punctulatus punctulatus Dönitz. Lee and Woodhill (1944: 134); King and Hoogstraal (1946*b*: 153–156); Mackerras (1947: 1–8); Mackerras and Aberdeen (1946: 770).

DISTRIBUTION: Dutch New Guinea: Pionierbivak, Tanahmerah (Lee and Woodhill, 1944; Mackerras, 1947); Aru Islands, Meervlakte, Bataviabivak, Motorbivak, Fakfak, Japen Island, Idore (Lee and Woodhill, 1944); Biak (Lee and Woodhill, 1944; Horsfall and Porter, 1947); Hollandia (Lee and Woodhill, 1944; Rozeboom and Knight, 1946; King and Hoogstraal, 1946*b*); Wamal (Mackerras, 1947); Padaido Islands (Author). Northeast New Guinea: Bogadjim (Dönitz, 1901); Sepik River, Lae, Salamaua, Bulolo, Upper Watut (Lee and Woodhill, 1944); Wau (Lee and Woodhill, 1944; Horsfall and Porter, 1947); Ramu Valley, Maprik (Mackerras, 1947); Wewak (Mackerras and Aberdeen, 1946; Mackerras, 1947); Alexishafen (T. K. Ruebush); Finschhafen, Saidor (Author). Papua: Cape Endaiadere, Koitaki, Dobodura (Lee and Woodhill, 1944); Port Moresby (Lee and Woodhill, 1944; Horsfall and Porter, 1947); Bulldog (Lee and Woodhill, 1944; Mackerras, 1947; Horsfall and Porter, 1947); near mouth of Lakekamu River (Horsfall and Porter, 1947); Milne Bay (Lee and Woodhill, 1944; Mackerras, 1947; Author).

HABITAT:

Total Collections, 151

Habitat	*Number of collections*	*Habitat index*
Puddles	125	83
Ditches	8	5
Swamps	6	4
Creeks: Pot holes	5	3
Creeks: Running	3	2
Ponds	2	1
Borrow pits	1	1
Artificial containers	1	1

*p*H, 27 readings

Range	5.0–7.0
Mode	7.0
Average	6.0

Factor	*Percentage occurrence*
Shaded	16
Exposed	84
Temporary	83
Semi-permanent	10
Permanent	7
Clear	56
Muddy	32
Stagnant	11
Polluted	1
Vegetation	
Absent	55
Present	45
Sparse	37
Moderate	44
Abundant	19
Algae	49
Emergent	11
Overhanging	10
Submerged	22
Floating	8

Punctulatus is widespread throughout New Guinea but collections from the interior are still too meager to prove the interesting hypothesis of Taylor (1934) that *punctulatus* supplants *farauti* in inland localities. This hypothesis is discussed by Lee and Woodhill (1944) and Horsfall and Porter (1947).

Punctulatus was recorded almost entirely (99 per cent) from surface water; the only other habitat utilized was artificial containers. It was collected from a variety of surface habitats but my evidence is overwhelming that only puddles are important. Puddles were the important habitat of both *farauti* and *punctulatus*, but *punctulatus* showed a considerably greater affinity for this habitat (*punctulatus* in puddles, 83 per cent; *farauti* in puddles, 52 per cent). Furthermore, 32 per cent of the *punctulatus* collections were taken from muddy water, in contrast to 17 per cent for *farauti*. Lee and Woodhill (1944), Belkin *et al.* (1945), and Horsfall and Porter (1947) have all emphasized small, temporary surface-water collections as the principal habitat.

In the Solomons, Belkin *et al.* (1945) recorded a contrast in wet- and dry-season habitats. They state that, during the dry season, *punctulatus* almost disappears and is found mainly in streams, whereas, during the wet season, it is found in an endless variety of surface waters. No such contrast was apparent from my observations, nor has such been recorded by others for New Guinea.

Swellengrebel and Rodenwaldt (1932), by listing a great variety of artificial containers, have given undue stress to the utilization of this habitat. Neither Lee and Woodhill (1944) nor Belkin *et al.* (1945) recorded *punctulatus* from artificial containers, and Horsfall and Porter (1947) reported that tin cans were rare habitats.

Lee and Woodhill (1944) and Belkin *et al.* (1945) emphasized that *punctulatus* is found primarily in sunlight. My figure, 84 per cent for exposed situations, is in striking agreement.

Punctulatus was recorded approximately to the same degree both with and without vegetation, and this is in general agreement with Lee and Woodhill (1944) and Belkin *et al.* (1945). However, Horsfall and Porter (1947) state that *punctulatus* habitats are essentially those free of floatage.

Nothing relative to *p*H has been recorded. My data, from 27 readings, give a range of 5 to 7 and a mode of 7, which is significantly higher than the mode of 5 recorded for *farauti*.

Lee and Woodhill (1944) state that *punctulatus* has not been found in brackish water, and none of my 151 collections was from such habitats. However, Horsfall and Porter (1947) did record it rarely from brackish water.

The salt tolerance of *punctulatus* under laboratory conditions apparently has not been reported. My laboratory studies showed that the percentage of fourth instar larvae surviving for 24 hours was greatly reduced only at salinities greater than 50 per cent sea water. Percentage emergence of fourth instar larvae in 10 per cent sea water was identical with that in distilled water, but was significantly reduced at all higher salinities. However, fourth instar larvae emerged to a limited degree at all salinities including 100 per cent sea water. This is particularly interesting because of the absence of brackish water collections.

SALINITY

Percentage sea water	*Number of larvae used (4th instar)*	*Percentage alive after 24 hours*	*Percentage emerging*
0.....	108	97	33
10.....	60	83	33
20.....	58	60	2
30.....	82	74	8
40.....	97	57	6
50.....	87	44	4
60.....	52	19	11
70.....	65	5	2
80.....	64	11	10
90.....	67	4	2
100.....	121	4	3

Nothing has been recorded relative to larval associates. *Punctulatus* was found mostly

(65 per cent) in mixed collections. Percentages of associates were: *C. pullus*, 18; *An. farauti*, 15; *C. halifaxi*, 12; *C. annulirostris*, 6; *C. squamosus*, 5; others, 9.

Toxorhynchites spp.

In our series of reared individuals, only adult females are represented, so that accurate specific determinations are impossible. However, because many collections of larvae were obtained, it is considered worth while to give my distribution and habitat data for the genus even though possibly more than one species is represented.

DISTRIBUTION: The genus is represented in my records from Padaido Islands, Saidor, Finschhafen, and Milne Bay.

HABITAT:

Total collections, 59

Habitat	*Number of collections*	*Habitat index*
Artificial containers	40	68
Tree holes	9	15
Coconut shells	9	15
Rock holes	1	2

*p*H, 22 readings

Range	4.0–8.0
Mode	5.0–5.5
Average	5.6

Factor	*Percentage occurrence*
Shaded	73
Exposed	27
Temporary	84
Permanent	16
Clear	43
Muddy	10
Stagnant	39
Polluted	8
Vegetation Absent	100

Newkirk (1947) found *Toxorhynchites splendens* commonly in rain barrels and once in a latrine pit at Milne Bay. My specimens were found most abundantly in artificial containers. They occurred to an approximately equal extent in pure (52 per cent) and in mixed collections. Percentages of associates were: *A. scutellaris*, 6; *T. bimaculipes*, 5; *A. albolineatus*, 5; *Arm. breinli*, 5; *C. fragilis*, 5; others, 22.

Tripteroides (Rachisoura) confusa Lee

Tripteroides (Rachisoura) confusa Lee, 1946, Linn. Soc. N. S. Wales, Proc. 70: 251. Type locality: Milne Bay, Papua.

"Known with certainty only from the type locality but probably quite widely distributed. This is very likely the species which has usually been called *T. atra*, owing to the paratype of that name seen by Edwards not being conspecific with the type." (Lee, 1946.)

Lee (1946) recorded *T. confusa* from tins and coconut shells, in association with *T. bimaculipes*. My single pure collection from Milne Bay was from a taro leaf axil in clear, temporary, shaded water.

Tripteroides (Mimeteomyia) argenteiventris (Theobald)

Polylepidomyia argenteiventris Theobald, 1905, Mus. Nat. Hungarici Ann. 3: 118. Type locality: Paimumu River, Papua.

DISTRIBUTION: Dutch New Guinea: Assike, Merauke, Tanahmerah (Bonne-Wepster, 1938); Hollandia (Lee, 1946). Northeast New Guinea: Tsili Tsili, Nadzab (Lee, 1946); Lae (Lee, 1946; Mackerras, 1946); Finschhafen (Author). Papua: Paimumu River (Theobald, 1905); Dobodura (Lee, 1946); Milne Bay (Lee, 1946; Author).

HABITAT:

Total collections, 7

Habitat	*Number of collections*	*Habitat index*
Coconut shells	4	57
Artificial containers	3	43

*p*H, one reading 4.0

Factor	*Percentage occurrence*
Shaded	100
Temporary	100
Clear	33
Stagnant	56
Polluted	11
Vegetation Absent	100

Brug (1934) reported *argenteiventris* from leaf axils of *Curcuma* plants, and Lee (1946)

stated that it has been found in relatively fresh water in tins, in old coconuts, and in tree holes. I did not collect it from tree holes or from leaf axils. *Argenteiventris* occurred to an approximately equal degree in pure (43 per cent) and in mixed collections. Associates were: *A. scutellaris* (19 per cent), others (38 per cent).

Tripteroides (Tripteroides) bimaculipes (Theobald)

Phoniomyia bimaculipes Theobald, 1905, Mus. Nat. Hungarici Ann. 3: 114. Type locality: Moroka, Papua, and Madang, Northeast New Guinea.

Stegomyia ornata Taylor. Taylor (1914*a*: 189); Breinl (1915: 317); Edwards (1924: 361). Synonymy in Lee (1946: 231).

DISTRIBUTION: Dutch New Guinea: Hollandia (Lee, 1946; King and Hoogstraal, 1946*c*, *f*); Nakasawa, Sapari, Mt. Dafonsero, Doromena (Lee, 1946); Assike, Merauke, Tanahmerah, Explorateurbivak (Bonne-Wepster, 1938); Amsterdam Island (Author). Northeast New Guinea: Madang (Theobald, 1905); Lakekamu Gold Field (Breinl, 1915); Lae (Lee, 1946; Mackerras, 1946); Tsili Tsili (Lee, 1946). Papua: Moroka (Theobald, 1905); Milne Bay (Taylor, 1914*a*; Edwards, 1924; Lee, 1946; Author); Lalapipi, Bulldog, Dobodura, Buna, Cape Endaiadere (Lee, 1946).

HABITAT:

Total collections, 37

Habitat	*Number of collections*	*Habitat index*
Artificial containers	25	68
Coconut shells	5	13
Tree holes	5	13
Leaf axils	2	5

*p*H, 18 readings

Range	4.0–6.5
Mode	5.0
Average	5.4

Factor	*Percentage occurrence*
Shaded	76
Exposed	24
Temporary	100
Clear	51
Stagnant	42
Polluted	7
Vegetation Absent	100

Taylor (1934) found *bimaculipes* in cut ends of bamboo, and Lee (1946) found it in hollow logs, tree holes, artificial containers, and coconut shells. In our surveys it occurred frequently (84 per cent) in mixed collections. Percentages of associated species were: *A. albolineatus*, 19; *A. scutellaris*, 14; *U. nigerrima*, 11; *Toxorhynchites* spp., 7; *A. notoscriptus*, 7; *Arm. milnensis*, 5; *U. argyrotarsis*, 5; others, 16.

Tripteroides (Tripteroides) brevipalpis? Brug

Tripteroides (*Tripteroides*) *brevipalpis* Brug, 1934, Bul. Ent. Res. 25: 508.

Lee (1946) stated that two specimens from Oro Bay and several from Biak (in the University of Queensland collection) differ from *T. brevipalpis* in a few details. He believes that it would be wise to wait for more adequate material before describing this "probably new form." Miss Elizabeth Marks, University of Queensland, in a personal communication to me, states: "The specimens of *T. brevipalpis?* from Biak mentioned by Lee are your series."

DISTRIBUTION: Dutch New Guinea: Padaido Islands, called Biak by Lee in the above discussion (Author). Northeast New Guinea: Finschhafen (W. M. Rogoff). Papua: Oro Bay (Lee, 1946).

HABITAT:

Total collections, 8

Habitat	*Number of collections*	*Habitat index*
Tree holes	4	50
Artificial containers	3	37
Coconut shells	1	12

*p*H, 8 readings

Range	5.0–7.0
Mode	6.0
Average	6.0

Factor	Percentage occurrence
Shaded	87
Exposed	13
Temporary	100
Clear	50
Stagnant	44
Polluted	6
Vegetation	
Absent	100

In common with all species of *Tripteroides* in our collections, *T. brevipalpis?* was limited entirely to small collections of water in containers. It was found primarily (88 per cent) in mixed collections. Percentages of associates were: *A. scutellaris*, 27; *A. albolineatus*, 27; *C. ?uniformis*, 20; *U. papua*, 14.

Harpagomyia genurostris (Leicester)

Malaya genurostris Leicester, 1908, Cul. Malaya: 258.

DISTRIBUTION: Northeast New Guinea: Saidor (Author); Alexishafen (T. K. Ruebush). Papua: Dobodura, Cape Sudest (King, 1944). Aside from the mimeographed records of King (1944), these are the first New Guinea records of this Oriental species.

HABITAT: Brug (1932) recorded larvae from the leaf axils of *Colocasia* spp., *Crinum* sp., *Susum malayanum aquatica*, and from the inflorescence of *Cyrtandra glabra*. King (1944) reported it from the leaf axil of taro (*Colocasia* sp.).

All of my eight collections were taken from leaf axils (taro, 63 per cent; banana, 37 per cent), in clear, shaded water. This species and *Aedes kochi* were the only larvae with an absolute affinity for any one habitat. *Harpagomyia genurostris* was found associated with *A. kochi* once; otherwise it occurred in pure collections.

Uranotaenia (Uranotaenia) albescens Taylor

Uranotaenia albescens Taylor, 1914, Ent. Soc. London, Trans. 1913 (Part IV): 705.

DISTRIBUTION: Papua: Milne Bay (Lee, 1944*a*; Author).

HABITAT: All New Guinea records are from surface water. Taylor (1914*c*) recorded it from clear, shallow, grassy pools, and Lee (1944*a*) added wheel ruts. My single collection was taken from a clear, sluggish, exposed running creek with abundant emergent vegetation, at a *p*H of 5, and associated with *Anopheles farauti*.

Uranotaenia (Uranotaenia) argyrotarsis Leicester

Uranotaenia argyrotarsis Leicester, 1908, Cul. Malaya: 214.

Uranotaenia argyrotarsis var. King and Hoogstraal (1946*f*: 148).

DISTRIBUTION: Dutch New Guinea: Hollandia (King and Hoogstraal, 1946*f*). Northeast New Guinea: Finschhafen, Saidor (Author). Papua: Milne Bay (Author).

HABITAT:

Total collections, 58

Habitat	Number of collections	Habitat index
Creeks: Pot holes	24	41
Swamps	9	15
Puddles	9	15
Artificial containers	6	10
Creeks: Running	5	9
Borrow pits	4	7
Ditches	1	2

*p*H, 27 readings

Range	4.0–8.0
Mode	5.0
Average	5.5

Factor	Percentage occurrence
Shaded	63
Exposed	37
Temporary	26
Semi-permanent	50
Permanent	24
Clear	65
Muddy	7
Stagnant	26
Polluted	2
Vegetation	
Absent	51
Present	49
Sparse	27
Moderate	46
Abundant	27

Algae	28
Emergent	36
Overhanging	33
Floating	3

Argyrotarsis was quite common in my collections but apparently it has not previously been reported from either Papua or Northeast New Guinea.

It has been recorded by Taylor (1934) and by King and Hoogstraal (1946*f*) from ground pools. Ninety per cent of my collections were from surface water, but 10 per cent were from artificial containers. *Argyrotarsis* occurred mostly (71 per cent) in mixed collections. Percentages of associates were: *C. pullus*, 20; *C. halifaxi*, 13; *An. farauti*, 10; *C. fraudatrix*, 7; *Bironella* spp., 5; others, 16.

Uranotaenia (Pseudoficalbia) nigerrima Taylor

Uranotaenia nigerrima Taylor, 1914, Ent. Soc. London, Trans. 1914 (Part I): 203. Type locality: Milne Bay, Papua; Lakekamu Gold Field, Northeast New Guinea.

DISTRIBUTION: Dutch New Guinea: Pionierbivak (Bonne-Wepster, 1938), Hollandia (King and Hoogstraal, 1946*c*); Padaido Islands (A. G. Humes). Northeast New Guinea: Lakekamu Gold Field (Taylor, 1914*a*); Finschhafen, Saidor (Author). Papua: Milne Bay (Taylor, 1914*a*; Author); Mekeo District (Hill, 1925).

HABITAT:

Total collections, 56

Habitat	*Number of collections*	*Habitat index*
Artificial containers	30	54
Coconut shells	16	28
Spathes and leaves	8	14
Puddles	1	2
Ditch	1	2

*p*H, 9 readings

Range	4.0–6.5
Mode	5.5
Average	5.3

Factor	*Percentage occurrence*
Shaded	65
Exposed	35
Temporary	98
Semi-permanent	2
Clear	47
Muddy	10
Stagnant	33
Polluted	10
Vegetation Absent	100

Nigerrima has been recorded from fallen leaves, fallen coconut bracts, coconut shells, and tree holes (Taylor, 1934; Lee, 1944*a*; King and Hoogstraal, 1946*c*). However, my indices show that spathes and leaves were seldom utilized and that tree holes were never used. Artificial containers and coconut shells were the more important habitats. This species occurred to an approximately equal degree in pure (52 per cent) and mixed collections. Percentages of associates were: *Arm. breinli*, 9; *T. bimaculipes*, 9; *A. albolineatus*, 7; *A. scutellaris*, 6; *Toxorhynchites* spp., 6; *C. fragilis*, 6; others, 5.

Uranotaenia (Pseudoficalbia) papua Brug

Uranotaenia papua Brug, 1924, Bul. Ent. Res. 14: 441. Type locality: Pionierbivak, Dutch New Guinea.

DISTRIBUTION: Dutch New Guinea: Pionierbivak (Brug, 1924); Assike, Merauke, Tanahmerah (Bonne-Wepster, 1938); Padaido Islands (Author). Northeast New Guinea: Finschhafen, Saidor (Author). Papua: Milne Bay (Lee, 1944*a*; Author); Dobodura (King and Hoogstraal, 1946*c*).

HABITAT:

Total collections, 24

Habitat	*Number of collections*	*Habitat index*
Artificial containers	9	38
Spathes and leaves	8	33
Coconut shells	3	13
Rock holes	2	8
Tree holes	1	4
Puddles	1	4

*p*H, 5 readings

Range	4.0–5.5
Mode	5.5
Average	5.1

Factor	Percentage occurrence
Shaded	68
Exposed	32
Temporary	100
Clear	73
Stagnant	27
Vegetation Absent	100

U. papua has been reported breeding in rusty tins (Lee, 1944*a*) and in a cup fungus (King and Hoogstraal, 1946*c*). My data show that the only important habitats were artificial containers and spathes and leaves. It occurred chiefly (71 per cent) in pure collections. Percentages of associates were: *A. scutellaris*, 5; *A. albolineatus*, 4; *C. ?uniformis*, 4; *T. brevipalpis?*, 4; others, 12.

Aedes (Mucidus) aurantius chrysogaster (Taylor)

Mucidus chrysogaster Taylor, 1927, Bul. Ent. Res. 18: 67.

DISTRIBUTION: Dutch New Guinea: Padaido Islands (A. G. Humes). Northeast New Guinea: Morobe (Author). Papua: Milne Bay (Author). These are the first records of *chrysogaster* from New Guinea.

HABITAT: *Chrysogaster* was present in five collections from temporary surface water. It occurred twice in puddles, once in a creek pot hole, once in a coral depression, and once in a small artificial hole in active use as a urinal in which the degree of pollution was obviously very high. Taylor (1927) recorded it in a shallow, semi-shaded rock pool containing a large quantity of decaying vegetable matter with *C. halifaxi*. It occurred solely in mixed collections. Associates were: *C. pullus*, *An. punctulatus*, *U. argyrotarsis*, and *C. halifaxi*.

Aedes (Finlaya) candidoscutellum Marks

Aedes (*Finlaya*) *candidoscutellum* Marks, 1947, Queensland Univ., Dept. Biol. Papers 2:1.

DISTRIBUTION: Dutch New Guinea: Hollandia (Marks, 1947*b*). Papua: Milne Bay (Marks, 1947*b*; Author).

HABITAT: Marks (1947*b*) reported this species from tree cavities, and stated that it appeared to show a preference for clear water. My two collections were both from tree holes, in clear, shaded water, associated with *A. keefei*.

Aedes (Finlaya) hollandius King and Hoogstraal

Aedes (*Finlaya*) *hollandius* King and Hoogstraal, 1946, Wash. Ent. Soc. Proc. 48: 38. Type locality: Mount Dafonsero, near Hollandia, Dutch New Guinea.

DISTRIBUTION: Dutch New Guinea: Mount Dafonsero (King and Hoogstraal, 1946*d*); Hollandia (King and Hoogstraal, 1946*c*, *d*). Northeast New Guinea: Finschhafen (King and Hoogstraal, 1946*d*). Papua: Dobodura (King and Hoogstraal, 1946*c*, *d*); Milne Bay (Author).

HABITAT: King and Hoogstraal (1946*c*) record *hollandius* from fallen palm leaves (25 collections), tree holes (2 collections), tin cans (2 collections), and a rock pool (1 collection). I did not find *hollandius* in fallen palm leaves. In four collections it occurred twice in rock holes, once in a tree hole, and once in an artificial container. All of my collections were from temporary, clear, shaded water without vegetation. It occurred mostly (75 per cent) in mixed collections. Associates were: *A. papuensis*, *A. albolineatus*, *A. novalbitarsis*, *C. halifaxi*, and *C. fraudatrix*.

Aedes (Finlaya) keefei King and Hoogstraal

Aedes (*Finlaya*) *keefei* King and Hoogstraal, 1946, Wash. Acad. Sci. Jour. 36: 311. Type locality: K. B. Mission, Milne Bay, Papua.

DISTRIBUTION: Papua: K. B. Mission, Sariba Island (King and Hoogstraal, 1946*a*); Milne Bay (King and Hoogstraal, 1946*a*; Author).

HABITAT:

Total collections, 11

Habitat	*Number of collections*	*Habitat index*
Tree holes	10	91
Coconut shells	1	9
*p*H, 2 readings	4.5,5.0	

Factor	*Percentage occurrence*
Shaded	90
Exposed	10
Temporary	100
Clear	100
Vegetation Absent	100

This uncommon species has been reported only from the Milne Bay area. King and Hoogstraal (1946*a*) recorded it from a stump hole, and in my collections it occurred almost entirely in tree holes. It was found mostly (64 per cent) in mixed collections. Percentages of associates were: *Toxorhynchites* spp., 14; *A. scutellaris*, 14; *A. albolineatus*, 14; *A. candidoscutellum*, 14; *T. bimaculipes*, 8.

Aedes (Finlaya) kochi (Dönitz)

Culex kochi Dönitz, 1901, Insekten Börse 5: 38. Type locality: "Neu-Guinea." Allotype male, Milne Bay, Papua (Marks, 1947*a*).

Aedes poicilia (Theobald) has been recorded from New Guinea by the following: Theobald (1905); Taylor (1914*a*, *b*); Breinl (1915); Bonne-Wepster (1938). However, recent revisions by Knight and Laffoon (1946) and Marks (1947*a*) state that all Australasian records of *poicilia* undoubtedly refer to *kochi*.

DISTRIBUTION: Dutch New Guinea: Fakfak (Bonne-Wepster, 1938); Merauke (Marks, 1947*a*); Amsterdam Island (Author). Northeast New Guinea: Madang, Seleo, Berlinhafen, Mount Hanseman, Astrolabe Bay (Theobald, 1905); Lakekamu Gold Field (Taylor, 1914*a*; Breinl, 1915); Draeger Harbor, Cape Cretin (Edwards, 1926); Bulwa (Taylor, 1934); Finschhafen (Mackerras, 1946); Lae (Mackerras, 1946; Marks, 1947*a*); Saidor (Author). Papua: Samarai Island, Mekeo District (Taylor, 1914*a*); Karema (Taylor, 1914*b*); Wasima Island, Yule Island (Hill, 1925); Milne Bay (Marks, 1947*a*; Author).

HABITAT:

Total collections, 45

Habitat	*Number of collections*	*Habitat index*
Leaf axils	45	100
Banana (37 per cent)		
Pandanus (30 per cent)		
Taro (29 per cent)		
Pineapple (4 per cent)		
*p*H, 16 readings		
Range	4.0–6.0	
Mode	5.5	
Average	5.4	

Factor	*Percentage occurrence*
Shaded	49
Exposed	51
Temporary	100
Clear	85
Stagnant	15
Vegetation Absent	100

A. kochi and *Harpagomyia genurostris* were the only species with an absolute affinity for any one habitat. Both were found solely in leaf axils of various plants. *Kochi* occurred to approximately the same extent in *Pandanus*, taro, and banana, and much more rarely in pineapple plants. This corresponds roughly to the relative abundance of these plants in the areas studied. At Amsterdam Island an index of its incidence in *Pandanus* was determined. All leaf axils containing water in 100 scattered *Pandanus* trees were examined and *kochi* was found in only 2 per cent.

It has been reported to breed in half coconuts (Hill, 1925; Stone and Bohart, 1944) and in leaf axils of *Pandanus*, banana, taro, cunjevoi, *Crinum*, pineapple (Heydon, 1931; Taylor, 1934, 1943; Stone and Bohart, 1944; Marks, 1947*a*). It is significant that *Pandanus* and taro leaf axils are mentioned in almost every habitat reference; banana is omitted in

all except one. Yet my collections from banana axils were the most numerous. Similarly, although coconut shells are mentioned in the literature, Taylor (1943) did not find *kochi* among any of the thousands of mosquitoes taken from coconut shells. And *kochi* was not collected from any of the 174 coconut shells which I examined.

It occurred primarily (86 per cent) in pure collections but was collected with *T. bimaculipes*, *U. papua*, *H. genurostris*, and *A. scutellaris*.

Aedes (Finlaya) notoscriptus (Skuse)

Culex notoscriptus Skuse, 1889, Linn. Soc. N. S. Wales, Proc. (2d series) 3: 1738.

DISTRIBUTION: Dutch New Guinea: Merauke (Brug, 1934; Bonne-Wepster, 1938); Toerai (Bonne-Wepster, 1938); Hollandia (King and Hoogstraal, 1946*a*, *c*, *f*); Amsterdam Island (Author); Padaido Islands (A. G. Humes). Northeast New Guinea: Muina, Seleo, Berlinhafen, Madang, Ragetta Island (Theobald, 1905); Lakekamu Gold Field (Breinl, 1915); Finschhafen, Saidor (Author). Papua: Milne Bay (Taylor, 1914*a*; Author); Dobodura (King and Hoogstraal, 1946*c*).

HABITAT:

Total collections, 47

Habitat	*Number of collections*	*Habitat index*
Tree holes	24	51
Artificial containers	16	34
Coconut shells	6	13
Rock holes	1	2

*p*H, 20 readings

Range	4.0–6.5
Mode	4.5
Average	5.1

Factor	*Percentage occurrence*
Shaded	72
Exposed	28
Temporary	100
Clear	63
Stagnant	37
Vegetation	
Absent	94
Present, algae	6

The innumerable references to collections of *notoscriptus* in Australia state that tree holes and artificial containers are the most commonly utilized habitats. My collections further bear out the importance of these two habitats.

In New Guinea, King and Hoogstraal (1946*a*, *c*) recorded *notoscriptus* taken from fallen palm leaves, tin cans, and tree holes with *A. plumiferus*, *A. albolineatus*, and *Toxorhynchites splendens*, and Brug (1934) recorded it from tree holes. However, in my collections it was absent from fallen bracts and leaves. It occurred mostly (60 per cent) in pure collections. Percentages of associates were: *A. albolineatus*, 9; *T. bimaculipes*, 5; *Arm. breinli*, 5; *C. fragilis*, 5; others, 16.

Aedes (Finlaya) novalbitarsis King and Hoogstraal

Leucomyia albitarsis Taylor, 1914, Ent. Soc. London, Trans. 1914 (Part I): 194. [Nec *Anisocheleomyia albitarsis* Ludlow, Canad. Ent. 37: 131 = *Aedes* (*Stegomyia*) *desmotes* (Giles), 1904; synonymy by Edwards, 1922, Indian Jour. Med. Res. 10: 464.] Type locality: Lakekamu Gold Field, Northeast New Guinea.

Aedes (*Finlaya*) *novalbitarsis* new name King and Hoogstraal, 1946, Wash. Ent. Soc. Proc. 48: 146.

DISTRIBUTION: Dutch New Guinea: Hollandia (King and Hoogstraal, 1946*c*, *f*); Padaido Islands (Author). Northeast New Guinea: Lakekamu Gold Field (Taylor, 1914*a*); Finschhafen (King and Hoogstraal, 1946*c*). Papua: Dobodura, Oro Bay (King and Hoogstraal, 1946*c*); Milne Bay (Author).

HABITAT:

Total collections, 12

Habitat	*Number of collections*	*Habitat index*
Rock holes	6	50
Puddles	5	42
Tree holes	1	8

*p*H, 5 readings	
Range	5.0–6.0
Mode	5.0
Average	5.2

Factor	*Percentage occurrence*
Shaded	50
Exposed	50
Temporary	100
Clear	72
Muddy	14
Stagnant	14
Vegetation	
Absent	75
Present	25
Sparse	67
Abundant	33
Algae	67
Overhanging	33

In 49 collections, King and Hoogstraal (1946*c*) obtained 31 from tree holes, artificial containers, and rock holes, and they listed palm bracts, coconut leaves and husks, and a sea shell as occasional habitats. In contrast, 50 per cent of our collections were from rock holes, 42 per cent from puddles, only 8 per cent from tree holes, and none from artificial containers. King and Hoogstraal (1946*c*) give a very long list of associated species. In our surveys, *novalbitarsis* occurred mostly (67 per cent) in pure collections. Associated species were: *An. punctulatus*, *A. papuensis*, *A. notoscriptus*, *C. halifaxi*, and *A. hollandius*.

Aedes (Finlaya) papuensis (Taylor)

Leucomyia australiensis var. *papuensis* Taylor, 1914, Ent. Soc. London, Trans. 1914 (Part I): 193. Type locality: Milne Bay, Papua.

DISTRIBUTION: Dutch New Guinea: Albatrosbivak (Brug, 1927; Bonne-Wepster, 1938); Doromena (King and Hoogstraal, 1946*c*); Padaido Islands (A. G. Humes). Northeast New Guinea: Lakekamu Gold Field (Breinl, 1915); Finschhafen (King and Hoogstraal, 1946*c*; Author); Gusiko (King and Hoogstraal, 1946*c*); Morobe (Author). Papua: Milne Bay (Taylor, 1914*a*; Author); Higatura (King and Hoogstraal, 1946*c*).

HABITAT:

Total collections, 61

Habitat	*Number of collections*	*Habitat index*
Rock holes	23	38
Puddles	16	26
Artificial containers	9	15
Tree holes	6	10
Coconut shells	5	8
Borrow pits	2	3

*p*H, 9 readings	
Range	5.0–6.5
Mode	6.0
Average	5.2

Factor	*Percentage occurrence*
Shaded	46
Exposed	54
Temporary	96
Semi-permanent	4
Clear	62
Muddy	21
Stagnant	17
Vegetation	
Absent	85
Present	15
Moderate	67
Abundant	33
Algae	84
Floating	16

A. papuensis has been recorded from rock pools, tree holes, on paper, drum heads, sunlit ruts, sunlit coral pools (Lee, 1944*a*; King and Hoogstraal, 1946*c*).

A. papuensis and *A. novalbitarsis* were the only *Aedes* with high habitat indices for both surface water and water in containers, and the only *Aedes* with fairly high indices for puddles. *Papuensis* occurred mostly (64 per cent) in mixed collections. Percentages of associates were: *A. albolineatus*, 8; *C. pullus*, 8; *C. halifaxi*, 8; *An. punctulatus*, 6; *Toxorhynchites* spp., 5; others, 29.

Aedes (Finlaya) wallacei Edwards

Aedes wallacei Edwards, 1926, Bul. Ent. Res. 17: 105.

DISTRIBUTION: Dutch New Guinea: Assike, Merauke, Sorong, Tanahmerah (Bonne-Wepster, 1938); Hollandia (King and Hoogstraal,

1946*c*). Northeast New Guinea: Draeger Harbor, Cape Cretin (Edwards, 1926); Bulwa (Taylor, 1934); Lae (Marks, 1947*a*). Papua: Wasima Island, Yule Island (Hill, 1925); Lalapipi, Dobodura (Marks, 1947*a*); Milne Bay (Marks, 1947*a*; Author).

HABITAT: *Wallacei* has been recorded from leaf axils of banana, taro, pineapple, and *Pandanus*, and from fallen palm leaves (Taylor, 1934; King and Hoogstraal, 1946*c*; Marks, 1947*a*).

My three collections were all from leaf axils—two from pineapple and one from *Pandanus*—in clear, shaded water. *Wallacei* occurred once in a pure collection, once with *U. papua*, and once with *T. bimaculipes*.

Aedes (Skusea) dasyorrhus
King and Hoogstraal

Aedes (*Skusea*) *dasyorrhus* King and Hoogstraal, 1946, Ent. Soc. Wash. Proc. 48 (4): 100. Type locality: Cape Tjeweri, Jatufa Bay, Hollandia, Dutch New Guinea.

DISTRIBUTION: Dutch New Guinea: Hollandia, Biak (King and Hoogstraal, 1946*e*). Papua: Milne Bay (Author).

HABITAT: *Dasyorrhus* has been reported by King and Hoogstraal (1946*e*) from cans at the edge of a mangrove swamp, possibly with partially salt water, and from a metal container.

Our five collections were all from holes in low, horizontally placed tree trunks extending out over the waters of Milne Bay and obviously receiving salt water spray. Three salinity readings showed 30, 50, and 65 per cent of sea water. *A. dasyorrhus* and *C. sitiens* were the only species collected from this very unusual habitat. *Dasyorrhus* occurred primarily in exposed, clear water with sparse amounts of algae, and always in pure collections.

Aedes (Stegomyia) albolineatus
(Theobald)

Scuteomyia albolineata Theobald, 1904, Entomologist 37: 77.

DISTRIBUTION: Dutch New Guinea: Hollandia (Knight and Rozeboom, 1946; King and Hoogstraal, 1946*a*, *c*); Toem (Knight and Rozeboom, 1946); Padaido Islands, Amsterdam Island (Author). Northeast New Guinea: Finschhafen, Saidor (Knight and Rozeboom, 1946; Author); Morobe (Author). Papua: Dobodura (Knight and Rozeboom, 1946); Milne Bay (Knight and Rozeboom, 1946; Author).

HABITAT:

Total collections, 71

Habitat	*Number of collections*	*Habitat index*
Tree holes	37	52
Coconut shells	18	25
Artificial containers	11	16
Leaf axils	2	3
Rock holes	2	3
Swamp	1	1

*p*H, 44 readings

Range	4.5–7.0
Mode	5.0
Average	5.6

Factor	*Percentage occurrence*
Shaded	95
Exposed	5
Temporary	99
Permanent	1
Clear	52
Muddy	4
Stagnant	42
Polluted	2
Vegetation	
Absent	100

Albolineatus and *A. scutellaris* were the only species present in every area studied.

Taylor (1934), Lee (1944*a*), and Knight and Rozeboom (1946) record *albolineatus* from tree holes, coconut shells, artificial containers, leaf axils, fallen leaves, and rock pools. My habitat indices are in agreement with the literature and demonstrate the high affinity of *albolineatus* for tree holes.

Albolineatus occurred almost equally in pure (44 per cent) and in mixed (56 per cent) collections. Percentages of associated species were: *A. scutellaris*, 11; *T. bimaculipes*, 7; *A.*

notoscriptus, 6; *A. papuensis*, 5; *Toxorhynchites* spp., 4; *U. nigerrima*, 4; *C. fragilis*, 4; *T. brevipalpis?*, 4; others, 11.

Aedes (Stegomyia) scutellaris (Walker)

Culex scutellaris Walker, 1859, Linn. Soc. London, Proc. 3: 79. Type locality: Aru Islands.

Culex zonatipes Walker (1861: 229). Synonymy in Stone (1947: 85).

Aedes (Stegomyia) variegatus Doleschall. Hill (1925: 70); Bonne-Wepster and Brug (1932: 83).

Aedes (Stegomyia) hebrideus Edwards. Farner and Bohart (1945: 46).

Aedes scutellaris scutellaris King and Hoogstraal (1946*c*: 154); Forbes and Horsfall (1947: 602–603).

Aedes (Stegomyia) scutellaris Walker. Stone (1947: 85). A topotypic male: Dobo, Aru Islands.

DISTRIBUTION: Dutch New Guinea: Aru Islands (Walker, 1859); Dore (Walker, 1861); Fakfak (Bonne-Wepster, 1938); Doromena (King and Hoogstraal, 1946*c*); Hollandia (King and Hoogstraal, 1946*c*; Toffaleti and King, 1947; Forbes and Horsfall, 1947); Biak (Forbes and Horsfall, 1947); Padaido Islands, Amsterdam Island (Penn, 1947*a*; Author). Northeast New Guinea: Seleo, Berlinhafen, Astrolabe Bay, Bogadjim, Muina (Theobald, 1905); Lakekamu Gold Field (Taylor, 1914*a*; Breinl, 1915); Madang (Hill, 1925); Wau, Salamaua, Bulwa, Bulolo (Taylor, 1934); Saidor (Farner and Bohart, 1945; Penn, 1947*a*; Author); Draeger Harbor (Penn, 1947*a*); Lae (Mackerras, 1946); Finschhafen (Mackerras, 1946; Author); Morobe (Author). Papua: Boirawe, Samarai, Kaile, Yule Island, Wasima (Hill, 1925); Cape Endaiadere (Farner and Bohart, 1945); Milne Bay (Farner and Bohart, 1945; Mackerras, 1946; Penn, 1947*a*; Author); Dobodura (King and Hoogstraal, 1946*c*, *f*); Oro Bay (Forbes and Horsfall, 1947); Moresby (Hill, 1925; Mackerras, 1946).

Taylor (1914*b*) and Breinl (1915) recorded *Stegomyia pseudoscutellaris* Theobald from Samarai Island, Papua. This record probably refers to *A. scutellaris*, since this locality would extend the range of *pseudoscutellaris*—as defined by Farner and Bohart (1945)—several thousand miles westward.

HABITAT: The majority of these data have previously been given by Penn (1947*a*).

Total collections, 251

Habitat	*Number of collections*	*Habitat index*
Artificial containers	114	45
Coconut shells	80	32
Tree holes	27	11
Puddles	15	6
Spathes and leaves	11	4
Leaf axils	3	1
Wells	1	0

*p*H, 172 readings

Range	4.5–8.0
Mode	6.5
Average	6.1

Factor	*Percentage occurrence*
Shaded	66
Exposed	34
Temporary	93
Permanent	7
Clear	45
Muddy	12
Stagnant	41
Polluted	2
Vegetation	
Absent	94
Present, algae	6

Along with *A. albolineatus*, *scutellaris* was present in my collections in every area studied, and ranked second only to *C. pullus* in number of collections.

Brief mention of habitats utilized has been given by Hill (1925), Bonne-Wepster and Brug (1932, 1937, 1939), Taylor (1934), Lee (1944*a*), Farner and Bohart (1945), and King and Hoogstraal (1946*c*). Tree holes, coconut shells, and artificial containers are the habitats most commonly recorded, but fallen leaves, forest pools, and rock holes have also been mentioned.

After its role as a dengue vector was established (Daggy, 1945; Mackerras, 1946) rather

detailed studies of the biology of *A. scutellaris* were published by Mackerras (1946), Forbes and Horsfall (1947), and Penn (1947*a*). All detailed studies have demonstrated that artificial containers are the primary habitat of this important dengue vector.

Scutellaris occurred mostly (73 per cent) in pure collections. The main associate was *A. albolineatus* (6 per cent), but there was an extremely long list of 20 other associates which has been given by Penn (1947*a*).

Aedes (Aedimorphus) vexans (Meigen)

Culex vexans Meigen, 1830, Syst. Bechr. 6: 241.

DISTRIBUTION: Dutch New Guinea: Merauke (Bonne-Wepster, 1938). Northeast New Guinea: Finschhafen, Saidor (Author). Papua: Milne Bay (Lee, 1944*a*; Author).

HABITAT:

Total collections, 12

Habitat	*Number of collections*	*Habitat index*
Puddles	11	92
Borrow pits	1	8
*p*H, one reading	6.5	

Factor	*Percentage occurrence*
Shaded	28
Exposed	72
Temporary	92
Semi-permanent	8
Clear	89
Muddy	11
Vegetation	
Absent	57
Present	43
Moderate	100
Emergent	67
Overhanging	33

Vexans was widely distributed but an uncommon species. The above records are the first for Northeast New Guinea. My limited data and records of Bonne-Wepster and Brug (1937, 1939) and Lee (1944*a*) show that it is exclusively a surface breeder. However, Bonne-Wepster and Brug (1939) found it in fresh, brackish, and salt water, whereas my specimens were entirely from fresh water. It occurred primarily (75 per cent) in mixed collections. Percentages of associates were: *An. punctulatus*, 25; *C. pullus*, 17; others, 33.

Aedes (Aedes) funereus (Theobald)

Skusea funerea Theobald, 1903, Mon. Cul. 3: 292.

DISTRIBUTION: Dutch New Guinea: Wamal, Tanahmerah, Merauke, Assike (Bonne-Wepster, 1938); Hollandia (Toffaleti and King, 1947). Northeast New Guinea: Saidor, Finschhafen (Author). Papua: Mekeo District (Taylor, 1914*a*; Edwards, 1924); Milne Bay (King and Hoogstraal, 1947; Author).

HABITAT:

Total collections, 7

Habitat	*Number of collections*	*Habitat index*
Puddles	3	43
Swamps	2	29
Pond	1	14
Borrow pit	1	14
*p*H, one reading	5.0	

Factor	*Percentage occurrence*
Shaded	71
Exposed	29
Temporary	86
Permanent	14
Clear	86
Muddy	14
Vegetation	
Absent	33
Present	67
Abundant	100
Overhanging	100

These records from Saidor and Finschhafen are the first from Northeast New Guinea. Hill (1922) recorded it in an algae- and grass-covered seepage, in fresh water pools, and in salt puddles in mangrove swamps. Lee (1944*a*) lists it from fresh water swamps. In my collections also, *funereus* occurred in surface water only, and was never found in salt or brackish water. It occurred mostly in

mixed (57 per cent) collections. Percentages of associates were: *An. punctulatus*, 16; *C. pullus*, 10; others, 31.

Aedes (Aedes) lineatus (Taylor)

Skusea funerea Theo. var. *ornata* Theobald, 1905, Mus. Nat. Hungarici Ann. 3: 79. [Nec *Culex ornatus* Meigen, 1818 = *A.* (*Finlaya*) *geniculatus* Oliver, 1791. Synonymy by Edwards, 1921, Bul. Ent. Res. 12: 319.]

Lepidotomyia lineatus Taylor, 1914, Ent. Soc. London, Trans. 1914 (Part I): 191. Type locality: Lakekamu Gold Field, Northeast New Guinea; Mekeo, Papua.

Aedes ornatus Theobald. King and Hoogstraal (1946*c*: 118); Toffaleti and King (1947).

Aedes (*Aedes*) *lineatus* (Taylor). King and Hoogstraal (1947: 118).

DISTRIBUTION: Dutch New Guinea: Toerai, Tanahmerah, Merauke, Assike (Bonne-Wepster, 1938); Hollandia (King and Hoogstraal, 1946*c*; Toffaleti and King, 1947). Northeast New Guinea: Satelberg Mt., Madang (Theobald, 1905); Lakekamu Gold Field (Taylor, 1914*a*); Finschhafen, Saidor (Author). Papua: Mekeo District (Taylor, 1914*a*; Edwards, 1924); Port Moresby (Lee, 1944*a*; Mackerras, 1946); Milne Bay (Author).

HABITAT:

Total collections, 7

Habitat	*Number of collections*	*Habitat index*
Puddles	4	57
Creeks: Pot holes	1	14
Swamps	1	14
Rock hole	1	14
*p*H, one reading	6.5	

Factor	*Percentage occurrence*
Shaded	29
Exposed	71
Temporary	72
Semi-permanent	14
Permanent	14
Clear	86
Muddy	14
Vegetation	
Absent	33
Present	67
Sparse	50
Abundant	50
Algae	67
Emergent	33

All literature records (Hill, 1925; Taylor, 1934; Bonne-Wepster and Brug, 1937; Lee, 1944*a*) are from surface water. Likewise, my collections were entirely from surface water. *Lineatus* occurred mostly (86 per cent) in mixed collections. *An. farauti* was the only common (21 per cent) associate.

Aedes (Aedes) parasimilis King and Hoogstraal

Aedes (*Aedes*) *parasimilis* King and Hoogstraal, 1947, Wash. Acad. Sci. Jour. 37: 125. Type locality: Hollandia, Dutch New Guinea.

Aedes (*Aedes*) *similis* Theobald. Lee (1944*a*: 78). Synonymy in King and Hoogstraal (1947: 125).

DISTRIBUTION: Dutch New Guinea: Hollandia (King and Hoogstraal, 1947); Padaido Islands (A. G. Humes). Northeast New Guinea: Finschhafen (King and Hoogstraal, 1947; Author); Morobe (Author). Papua: Dobodura (King and Hoogstraal, 1947); Milne Bay (Lee, 1944*a*; King and Hoogstraal, 1947; Author).

HABITAT: Lee (1944*a*) reported *parasimilis* from clear pools in marshes, and King and Hoogstraal (1947) reported it from a crayfish hole and from pools at the edge of a swamp. In my five collections it also occurred entirely in surface water, three times from puddles, once from a rock hole, and once from a creek pot hole. The majority of the collections were taken from clear, temporary, shaded water. It occurred mostly (80 per cent) in mixed collections. Percentages of associates were: *C. pullus*, 22; *C. halifaxi*, 14; others, 44.

Aedes (Leptosomatomyia) aurimargo Edwards

Aedes (*?Skusea*) *aurimargo* Edwards, 1922, Bul. Ent. Res. 13: 94.

Leptosomatomyia lateralis Theobald [nec Meigen] (1905: 110).
Aedes (Leptosomatomyia) lateralis Theobald [nec Meigen]. Edwards (1924).

DISTRIBUTION: Dutch New Guinea: Hollandia (King and Hoogstraal, 1946*c*). Northeast New Guinea: Muina (Theobald, 1905; Edwards, 1924); Finschhafen (Penn, 1947*b*; Author); Lae (Mackerras, 1946).

HABITAT: Of the four collections of *aurimargo*, three were from coconut shells and one from a tree hole. It occurred usually in clear, shaded water and always without vegetation. *Aurimargo* occurred entirely in mixed collections, twice with *Toxorhynchites* spp. and once each with *T. bimaculipes*, *A. scutellaris*, *A. albolineatus*, and *T. argenteiventris*.

Armigeres (Armigeres) breinli (Taylor)

Neosquamomyia breinli Taylor, 1914 (female only), Ent. Soc. London, Trans. 1914 (Part I): 186. Type locality: Milne Bay, Papua.

DISTRIBUTION: Dutch New Guinea: Fakfak (Brug, 1934; Bonne-Wepster, 1938); Hollandia (King and Hoogstraal, 1946*f*); Padaido Islands (Author). Northeast New Guinea: Lae (Lee, 1944*b*; Mackerras, 1946); Finschhafen (Mackerras, 1946; Author); Morobe (Author). Papua: Milne Bay (Taylor, 1914*a*; Lee, 1944*b*; Author); Oro Bay, Dobodura (Lee, 1944*b*).

HABITAT:

Total collections, 32

Habitat	*Number of collections*	*Habitat index*
Coconut shells	30	94
Spathes and leaves	1	3
Artificial containers	1	3

*p*H, 14 readings

Range	4.5–7.5
Mode	4.5
Average	5.2

Factor	*Percentage occurrence*
Shaded	25
Exposed	75
Temporary	100
Clear	9
Muddy	33
Stagnant	16
Polluted	42
Vegetation	
Absent	100

Breinli has been reported from tree holes, coconut shells, and artificial containers, and with *Arm. milnensis* and *C. fragilis* from putrid water in tips of fallen betel nut palms (King and Hoogstraal, 1946*f*). All of the above habitats are represented in my collections. The habitat index of 94 for coconut shells calculated for *breinli* ranks second only to that for *A. kochi* and *H. genurostris*, each of which had an index of 100 for leaf axils. *Breinli* occurred frequently in very highly polluted coconut shells with a strikingly foul smell.

It was collected mostly (86 per cent) in pure collections and in tremendous concentrations of individuals. Associates were: *U. nigerrima*, 4 per cent, and others, 10 per cent.

Arm. breinli and *Arm. milnensis* were undoubtedly the most spectacular species collected, because of their large size and the great concentration of individuals, often in a minute amount of putrid, semi-liquid material.

Armigeres (Armigeres) milnensis Lee

Armigeres milnensis Lee, 1944, Linn. Soc. N. S. Wales, Proc. 69: 215. Type locality: Milne Bay, Papua.
Neosquamomyia breinli Taylor [type male only] (1914*a*: 186).
Armigeres ?breinli Taylor. Hill (1925: 70).
Armigeres obturbans var? Edwards. Lee (1944*a*: 83).

DISTRIBUTION: Dutch New Guinea: Hollandia (King and Hoogstraal, 1946*c*, *f*). Northeast New Guinea: Lakekamu Gold Field (Taylor, 1914*a*; Lee, 1944*b*); Lae (Lee, 1944*b*; Mackerras, 1946); Finschhafen (Mackerras, 1946); Morobe (Author). Papua: Mekeo District (Hill, 1925; Lee, 1944*b*); Bulldog, Lalapipi (Lee, 1944*b*); Milne Bay (Edwards, 1924; Lee, 1944*b*; Author).

HABITAT:

Total collections, 38

Habitat	*Number of collections*	*Habitat index*
Coconut shells	19	50
Artificial containers	9	24
Tree holes	7	18
Borrow pits (one was a urinal pit)	3	8

*p*H, 11 readings

Range	4.0–7.0
Mode	6.5
Average	5.8

Factor	*Percentage occurrence*
Shaded	43
Exposed	57
Temporary	92
Semi-permanent	8
Clear	20
Muddy	11
Stagnant	32
Polluted	37
Vegetation	
Absent	100

Hill (1925) records *milnensis* from tree holes, Lee (1944*a*) from coconut shells, and King and Hoogstraal (1946*c*) report it associated with *Arm. breinli* and *C. fragilis* in putrid water in tips of fallen betel nut palms. My collections demonstrate the importance of coconut shells. However, *milnensis* utilized this habitat to a lesser degree (50) than did *breinli* (94).

As with *breinli*, the present species often occurred in polluted water and in great concentrations of individuals. In one collection the larvae were found in dense masses in a small pit filled with urine. Feng (1938*b*) states that in China the usual habitat of *Arm. obturbans* is tubs of fermenting urine. *Milnensis* occurred mostly (84 per cent) in pure collections. Percentages of associates were: *Arm. breinli*, 3; *T. bimaculipes*, 3; *A. scutellaris*, 3; others, 7.

Culex (Lutzia) halifaxi Theobald

Culex halifaxi Theobald, 1903, Mon. Cul. 3: 231.

DISTRIBUTION: Dutch New Guinea: Albatrosbivak (Brug, 1927; Bonne-Wepster, 1938); Manokwari (Brug and Haga, 1923); Toerai (Brug and Haga, 1923; Bonne-Wepster, 1938); Assike, Fakfak, Merauke, Tanahmerah (Bonne-Wepster, 1938); Hollandia (King and Hoogstraal, 1946*b*, *f*); Padaido Islands (Author). Northeast New Guinea: Finschhafen, Saidor, Morobe (Author). Papua: Mekeo District (Hill, 1925); Milne Bay (Author).

HABITAT:

Total collections, 183

Habitat	*Number of collections*	*Habitat index*
Puddles	118	65
Artificial containers	26	14
Creeks: Pot holes	22	12
Ditches	5	3
Borrow pits	5	3
Rock holes	2	1
Pond	1	–
Swamp	1	–
Well	1	–
Coconut shell	1	–
Tree holes	1	–

*p*H, 31 readings

Range	4.0–8.0
Mode	6.5
Average	6.0

Factor	*Percentage occurrence*
Shaded	32
Exposed	68
Temporary	81
Semi-permanent	17
Permanent	2
Clear	41
Muddy	28
Stagnant	25
Polluted	6
Vegetation	
Absent	68
Present	32
Sparse	33
Moderate	45
Abundant	22
Algae	59
Emergent	24
Overhanging	11
Floating	4
Submerged	2

Halifaxi was common in every locality studied and ranked third in total number of

collections. These are apparently the first records from Northeast New Guinea.

Hill (1925), Bonne-Wepster and Brug (1937), and Lee (1944*a*) list a great variety of habitats: wells, marshes, jungle pools, roadside ditches, tree holes, swamps, rock pools, wheel ruts, slit trenches, and artificial containers. However, Bonne-Wepster and Brug (1939) record *halifaxi* mostly from "earthbound" breeding places, and King and Hoogstraal (1946*b*, *f*) mention only pools. In my collections it was found also in a great variety of habitats, but the figure (65 per cent) for puddles far surpasses that of any other habitat.

It occurred mostly (82 per cent) in mixed collections. Percentages of associates were: *C. pullus*, 25; *An. punctulatus*, 14; *An. farauti*, 11; *U. argyrotarsis*, 6; *C. annulirostris*, 6; *C. papuensis*, 5; others, 15.

Culex (Neoculex) brevipalpis (Giles)

Stegomyia brevipalpis Giles, 1902, Handbook Gnats, 2d ed., p. 384.

DISTRIBUTION: Dutch New Guinea: Hollandia (King and Hoogstraal, 1946*c*, *f*). Papua: Milne Bay (Author).

HABITAT: *Brevipalpis* is a rare species and the above record is the first from Papua. Both of my collections were from tree holes. One was from clear, exposed water; the other from clear, stagnant, shaded water. It was found with *Aedes papuensis* and *Aedes scutellaris*. Brug (1932) and King and Hoogstraal (1946*c*) have also recorded *brevipalpis* from tree holes.

Culex (Lophoceratomyia) fraudatrix (Theobald)

Lophoceratomyia fraudatrix Theobald, 1905, Mus. Nat. Hungarici Ann. 3: 94. Type locality: Madang and Bogadjim, Northeast New Guinea.

DISTRIBUTION: Dutch New Guinea: Assike, Tanahmerah (Bonne-Wepster, 1938); Hollandia (T. K. Ruebush). Northeast New Guinea: Madang, Bogadjim (Theobald, 1905); Finschhafen, Saidor (Author). Papua: Milne Bay (Author).

HABITAT:

Total collections, 37

Habitat	*Number of collections*	*Habitat index*
Swamps	9	24
Creeks: Pot holes	9	24
Puddles	6	16
Ponds	4	11
Creeks: Running	3	8
Artificial containers	3	8
Rock holes	1	3
Ditch	1	3
Spathes and leaves	1	3

*p*H, 14 readings

Range	4.5–8.0
Mode	5.0
Average	5.6

Factor	*Percentage occurrence*
Shaded	76
Exposed	24
Temporary	30
Semi-permanent	27
Permanent	43
Clear	73
Muddy	1
Stagnant	26
Vegetation	
Absent	44
Present	56
Sparse	15
Moderate	55
Abundant	30
Algae	21
Emergent	28
Overhanging	37
Submerged	7
Floating	7

It is rather surprising that this common species has not been previously recorded from Papua.

Lee (1944*a*) reported *fraudatrix* from shallow wells. Knight *et al.* (1944) list it from leafy pools, footprints, and brackish mangrove or fresh water pot holes. My collections also were mostly from surface water but they were not collected in brackish situations.

Culex fraudatrix was one of the few species found to a high degree in permanent water

collections, and one of the very few occurring in a significant measure in extensive swampy areas. It was found mostly (84 per cent) in mixed collections. Percentages of associates were: *An. farauti*, 26; *U. argyrotarsis*, 17; *An. punctulatus*, 7; *Bironella* spp., 7; *C. annulirostris*, 6; *An. bancrofti pseudobarbirostris*, 6; *C. halifaxi*, 4; others, 11.

Culex (Lophoceratomyia) uniformis Theobald

Culex uniformis Theobald, 1905, Bombay Nat. Hist. Soc. Jour. 16: 245.

A limited number of specimens closely resembling *C. uniformis* were collected from Woendi Island. Since no recent comprehensive comparative study of the subgenus *Lophoceratomyia* has been undertaken and since, apparently, all definite records of *uniformis* are limited to the Indian Region, it seems best to note that my material was similar in a general way to *uniformis*. My specimens, which have been placed in the U. S. National Museum, may properly represent an undescribed species.

DISTRIBUTION: Dutch New Guinea: Hollandia (King and Hoogstraal, 1946*c*); Padaido Islands (Author).

HABITAT: The four collections of this species were from temporary water: two from artificial containers, one from a tree hole, and one from a puddle. It was found to the same extent in shaded and exposed, clear and stagnant water. Algae were present in one collection. *Uniformis?* was always in mixed collections with *A. scutellaris*, *T. brevipalpis?*, *U. papua*, *A. albolineatus*, and *C. pullus*.

Culex (Culiciomyia) fragilis Ludlow

Culex fragilis Ludlow, 1903, N. Y. Ent. Soc. Jour. 11: 142.

Culex (*Culiciomyia*) *papuensis* of Lee [nec Taylor] (1944*a*: 96). Synonymy in King and Hoogstraal (1946*f*: 148).

DISTRIBUTION: Dutch New Guinea: Hollandia (King and Hoogstraal, 1946*f*); Padaido Islands (Author). Northeast New Guinea: Finschhafen, Saidor (Author). Papua: Milne Bay (Lee, 1944*a*; Author).

HABITAT:

Total collections, 80

Habitat	*Number of collections*	*Habitat index*
Artificial containers	50	63
Coconut shells	9	11
Puddles	8	10
Creek: Pot holes	4	5
Tree holes	3	4
Ponds	2	2
Spathes and leaves	1	1
Rock holes	1	1
Ditch	1	1
Creek: Running	1	1

*p*H, 40 readings

Range	5.0–7.0
Mode	6.0
Average	5.8

Factor	*Percentage occurrence*
Shaded	62
Exposed	38
Temporary	90
Semi-permanent	6
Permanent	4
Clear	12
Muddy	24
Stagnant	21
Polluted	43
Vegetation	
Absent	92
Present	8
Sparse	84
Moderate	16
Algae	63
Emergent	12
Submerged	25

The records given here are apparently the first for Northeast New Guinea.

King and Hoogstraal (1946*f*) stated that, of 62 larval collections, about half were taken from temporary and semi-permanent ground pools, especially with stagnant, more or less foul or algae-filled water, in all degrees of shade, whereas the others were obtained from tree holes and artificial containers, usually with rotting vegetation and in shade. Three collections were made from putrid water in the tips of fallen betel nut palms. Lee (1944*a*)

recorded it from coconut shells, polluted water in tins, refuse pits, and butts of sago palms. My data show a greater use of artificial containers than is indicated in the records of King and Hoogstraal. Both surface water and water in containers were utilized but the index of 63 for artificial containers far surpasses that of any other habitat. More than half of the collections were in shade, as mentioned by King and Hoogstraal; furthermore, the figure for polluted water (43 per cent) was higher than for any other species.

Fragilis occurred mostly in mixed (63 per cent) collections. Percentages of associates were: *C. pullus*, 12; *C. halifaxi*, 10; *A. scutellaris*, 10; *A. albolineatus*, 7; *A. notoscriptus*, 5; *Toxorhynchites* spp., 4; *U. nigerrima*, 4; others, 11. This list of associates is essentially similar to that given by King and Hoogstraal (1946*f*).

Culex (Culiciomyia) papuensis (Taylor)

Melanconion papuensis Taylor, 1914, Ent. Soc. London, Trans. 1914 (Part I): 201. Type locality: Lakekamu Gold Field, Northeast New Guinea.

Culex (Culiciomyia) pallidothorax of Lee [nec Theobald] (1944*a*: 95). Synonymy in King and Hoogstraal (1946*f*: 147).

DISTRIBUTION: Dutch New Guinea: Assike, Merauke, Tanahmerah (Bonne-Wepster, 1938); Hollandia (King and Hoogstraal, 1946*f*). Northeast New Guinea: Lakekamu Gold Field (Taylor, 1914*a*); Finschhafen (Author). Papua: Dobodura (King and Hoogstraal, 1946*f*); Milne Bay (Author).

HABITAT:

Total collections, 46

Habitat	*Number of collections*	*Habitat index*
Artificial containers	18	39
Puddles	11	24
Creeks: Pot holes	8	17
Borrow pits	4	9
Ditches	3	6
Rock hole	1	2
Tree hole	1	2

*p*H, 5 readings

Range	5.0–7.0
Mode	5.5
Average	5.9

Factor	*Percentage occurrence*
Shaded	56
Exposed	44
Temporary	67
Semi-permanent	33
Clear	45
Muddy	11
Stagnant	16
Polluted	22
Vegetation	
Absent	92
Present	8
Sparse	33
Moderate	33
Abundant	33
Algae	33
Emergent	33
Overhanging	33

Lee (1944*a*) and King and Hoogstraal (1946*f*) have recorded *papuensis* from a long list of habitats which may be grouped into artificial containers of many types, tree holes, surface pools, and wells. In my collections it was one of the few species which occurred quite frequently in both surface water and in water in containers. It must be noted that the collections from creek pot holes were nearly all in polluted water from a near-by shower drain.

Papuensis was found mostly (74 per cent) in mixed collections. Percentages of associated species were: *C. pullus*, 27; *C. halifaxi*, 21; *An. punctulatus*, 5; *An. farauti*, 5; *U. argyrotarsis*, 5; others, 11. Associates given by King and Hoogstraal (1946*f*) agree only roughly with the above.

Culex (Culiciomyia) pullus Theobald

Culex pullus Theobald, 1905, Mus. Nat. Hungarici Ann. 3: 87. Type locality: Muina, Northeast New Guinea.

Culex muticus Edwards. Edwards (1924: 6). Synonymy in Edwards (1926: 121); Hill (1925: 74); Brug (1927: 358); Brug (1934: 517); Bonne-Wepster (1938: 206–212).

Culex (*Culiciomyia*) *pallidothorax* of Bonne-Wepster [nec Theobald] (1938: 206–212). Questionable synonym in King and Hoogstraal (1946*f*: 143, 149).

DISTRIBUTION: Dutch New Guinea: Merauke (Edwards, 1924; Edwards, 1926; Bonne-Wepster, 1938); Mamberano River (Edwards, 1926); Pionierbivak (Edwards, 1926; Bonne-Wepster, 1938); Albatrosbivak (Brug, 1927; Brug, 1934; Bonne-Wepster, 1938); Fakfak (Brug, 1934; Bonne-Wepster, 1938); Manokwari, Tanahmerah, Assike, Toerai (Bonne-Wepster, 1938); Hollandia (King and Hoogstraal, 1946*c*, *f*); Padaido Islands (Author). Northeast New Guinea: Muina (Theobald, 1905); Finschhafen (King and Hoogstraal, 1946*c*; Author); Saidor, Morobe (Author). Papua: Milne Bay (Lee, 1944*a*; Author).

HABITAT:

Total collections, 289

Habitat	*Number of collections*	*Habitat index*
Puddles	178	62
Artificial containers	38	13
Creeks: Pot holes	33	11
Borrow pits	12	4
Ditches	12	4
Swamps	5	2
Creeks: Running	3	1
Coconut shells	3	1
Tree holes	2	1
Marsh	1	–
Rock holes	1	–
Spathes and leaves	1	–

*p*H, 52 readings

Range	4.0–7.0
Mode	5.5
Average	5.7

Factor	*Percentage occurrence*
Shaded	33
Exposed	67
Temporary	77
Semi-permanent	20
Permanent	3
Clear	49
Muddy	20
Stagnant	24
Polluted	7
Vegetation	
Absent	61
Present	39
Sparse	29
Moderate	47
Abundant	24
Algae	46
Emergent	23
Overhanging	18
Submerged	7
Floating	6

Pullus ranked first in number of collections. It was found in every locality studied except Amsterdam Island.

It has previously been recorded from a great variety of habitats. Brug (1934) lists a beached canoe, a tree hole, a jungle pool. Lee (1944*a*) gives fresh-water wheel ruts, grassy drains, coconut shells, tarpaulins. King and Hoogstraal (1946*f*) state that, in 150 collections, 16 were from tree holes and artificial containers, the others from shaded and sunlit ground water of all types except from permanent ponds and brackish water. My collections were also from a wide range of habitats, but the index of 62 for puddles far outweighs any other habitat. *Pullus* was found most often in clear water exposed to full sunlight, where vegetation was entirely absent.

It must be emphasized that the puddles so widely used by *pullus* were, almost entirely, recently formed ruts of vehicles or footprints. Such habitats were most numerous in the low coastal strips, on the sites of abandoned coconut plantations which were the principal centers of military activity in these areas. These habitats are the source of man-made malaria now so widely discussed in the literature in connection with habitat observations on *Anopheles punctulatus* and *Anopheles farauti*. However, little mention has been made thus far of the very general occurrence of both *Culex pullus* and *Culex halifaxi* with the anophelines in such situations.

Pullus occurred mostly (76 per cent) in mixed collections. Percentages of associates were: *C. halifaxi*, 17; *An. farauti*, 15; *An. punctulatus*, 13; *U. argyrotarsis*, 6; *C. annulirostris*, 4; *C. papuensis*, 4; *C. squamosus*, 4; others, 13. King and Hoogstraal (1946*f*) give a briefer list of associates.

Culex (Acallyntrum) bicki Stone and Penn

Culex bicki Stone and Penn, 1947, Wash. Acad. Sci. Jour. 37: 89. Type locality: Toem, Dutch New Guinea.
Culex (Acallyntrum) bicki Stone and Penn (1948: 109).

DISTRIBUTION: Dutch New Guinea: Toem (Stone and Penn, 1947). Papua: Milne Bay (Stone and Penn, 1947; Author).

HABITAT: My single collection of *bicki* was a pure collection from a clear, shaded *Pandanus* leaf axil with abundant debris. Stone and Penn (1947) recorded it from sago and taro leaf axils.

Culex (Culex) annulirostris Skuse

Culex annulirostris Skuse, 1889, Linn. Soc. N. S. Wales, Proc. (2d series) 3: 1737.

DISTRIBUTION: Dutch New Guinea: Albatrosbivak (Brug, 1927; Bonne-Wepster, 1938); Assike, Merauke, Tanahmerah (Bonne-Wepster, 1938); Padaido Islands, Amsterdam Island (Author). Northeast New Guinea: Lakekamu Gold Field (Taylor, 1914*a*); Saidor (Author). Papua: Milne Bay (Author).

HABITAT:

Total collections, 64

Habitat	*Number of collections*	*Habitat index*
Puddles	48	75
Creek: Pot holes	4	6
Ditches	4	6
Borrow pits	3	5
Artificial containers	3	5
Ponds	1	2
Wells	1	2

*p*H, 18 readings

Range	5.0–7.0
Mode	5.0, 7.0
Average	6.0

Factor	*Percentage occurrence*
Shaded	96
Exposed	4
Temporary	80
Semi-permanent	17
Permanent	3
Clear	50
Muddy	21
Stagnant	26
Polluted	3
Vegetation	
Absent	57
Present	43
Sparse	25
Moderate	45
Abundant	30
Algae	74
Emergent	16
Submerged	5
Floating	5

Specific locality records for New Guinea are few, the typical reference being "along all coasts of the Australasian Region." No doubt most authors have considered it too common to merit specific records. My collections from Milne Bay are apparently the first records from Papua.

Bonne-Wepster and Brug (1937), Taylor (1943), and Lee (1944*a*) report *annulirostris* mostly from fresh surface water but also from brackish habitats. In my collections it was found almost entirely in surface water (primarily puddles, 75 per cent) but never in brackish situations. The puddles commonly utilized were usually old, large, rather deep, and well vegetated in contrast with the small, shallow, muddy, and non-vegetated puddles so often utilized by *C. pullus*, *C. halifaxi*, and *An. punctulatus*. Furthermore, in contrast with the above species, *annulirostris* was found almost entirely (96 per cent) in shade, the highest per cent recorded for any surface water species.

Annulirostris occurred mostly (74 per cent) in mixed collections. Percentages of associates were: *C. pullus*, 16; *An. punctulatus*, 16; *An. farauti*, 16; *C. halifaxi*, 13; others, 13.

Culex (Culex) fatigans Wiedemann

Culex fatigans Wiedemann, 1823, Aussereur. Zweifl. Insec. 1: 10.
Taeniorhynchus acer Walker. Theobald (1905: 106).

DISTRIBUTION: Dutch New Guinea: Fak-

fak, Manokwari (Brug and Haga, 1923; Bonne-Wepster, 1938); Assike, Merauke, Tanahmerah (Bonne-Wepster, 1938); Hollandia (Toffaleti and King, 1947); Padaido Islands (Author). Northeast New Guinea: Madang (Theobald, 1905; Hill, 1925); Bogadjim, Mount Hansemann, Yomo (Theobald, 1905); Lakekamu Gold Field (Breinl, 1915). Papua: Port Moresby (Taylor, 1914*a*; Hill, 1925); Yule Island, Samarai (Hill, 1925).

HABITAT: Bonne-Wepster and Brug (1937, 1939), Taylor (1943), and Lee (1944*a*) record *fatigans* from a variety of domestic habitats, and emphasize its occurrence in polluted water. I have a single, pure collection from the Padaido Islands, taken from a shaded well in stagnant water without vegetation.

Culex (Culex) sitiens Wiedemann

Culex sitiens Wiedemann, 1828, Aussereur. Zweifl. Insec. 1: 543.

Culicelsa annulirostris Skuse var. *milni* Taylor (1914*a*: 196).

Culex sitiens var. *milni* Taylor. Breinl (1915: 317).

Culex sitiens Edw. Brug and Haga (1923: 640).

Culex (Culex) ?sitiens Wied. Brug (1934: 514).

DISTRIBUTION: Dutch New Guinea: Albatrosbivak (Brug, 1927; Bonne-Wepster, 1938); Pionierbivak (Brug and Haga, 1923; Bonne-Wepster, 1938); Sorong (Brug, 1934; Bonne-Wepster, 1938); Fakfak, Merauke, Tanahmerah, Toerai, Wamal (Bonne-Wepster, 1938); Hollandia (Toffaleti and King, 1947); Padaido Islands, Amsterdam Island (Author). Northeast New Guinea: Madang (Hill, 1925); Lakekamu Gold Field (Breinl, 1915); Finschhafen (Author). Papua: Milne Bay (Taylor, 1914*a*; Author); Yule Island, Samarai, Mekeo District, Moresby District (Hill, 1925).

HABITAT:

Total collections, 123

Habitat	*Number of collections*	*Habitat index*
Coral pools	115	93
Brackish puddles	4	3
Fallen trees on beach	2	2
Ditch	1	1
Artificial container	1	1

*p*H, 117 readings

Mode	7.0
Average	7.0

Factor	*Percentage occurrence*
Exposed	100
Temporary	5
Semi-permanent	95
Clear	88
Muddy	2
Murky	10
Vegetation	
Absent	36
Present	64
Algae	99
Emergent	1
Salinity	
Percentage sea water	
0– 18	66
18– 37	7
37– 55	6
55– 74	5
74– 93	9
93–100	6

Sitiens is apparently widely distributed along the north coast of New Guinea. However, it was common only at Amsterdam Island where 117 collections were obtained. The literature (Hill, 1925; Bonne-Wepster and Brug, 1937, 1939; Taylor, 1943; Lee, 1944*a*) gives a much wider variety of habitats than we have observed, often assigning equal importance to fresh and brackish water. In my collections the association with brackish water was absolute. But, for the most part, it was found in salinities ranging from 0 to 18 per cent sea water. It was found only along the beach in situations fully exposed to sunlight and subjected to salt spray or to storm tides. It occurred almost entirely (98 per cent) in pure collections. Its only associate was *An. farauti*.

Culex (Culex) squamosus (Taylor)

Culicada squamosa Taylor, 1914, Ent. Soc. London, Trans. 1913 (Part IV): 691.

Trichopronomyia annulata Theobald (1905: 98).

DISTRIBUTION: Dutch New Guinea: Upper Digoel River (Brug, 1934); Merauke (Bonne-Wepster, 1938); Padaido Islands (Author). Northeast New Guinea: Madang (Theobald, 1905; Edwards, 1924); Finschhafen (Author). Papua: Milne Bay (Lee, 1944*a*; Author).

HABITAT:

Total collections, 49

Habitat	*Number of collections*	*Habitat index*
Puddles	22	45
Creeks: Running	17	35
Creeks: Pot holes	7	14
Ditches	2	4
Ponds	1	2

*p*H, 9 readings

Range	5.0–7.0
Mode	5.0, 5.5
Average	5.7

Factor	*Percentage occurrence*
Shaded	11
Exposed	89
Temporary	45
Semi-permanent	18
Permanent	37
Clear	76
Muddy	9
Stagnant	15
Vegetation	
Absent	15
Present	85
Sparse	27
Moderate	35
Abundant	38
Algae	61
Emergent	11
Overhanging	2
Submerged	11
Floating	15

Squamosus was recorded from surface water only. It had a high affinity for the more permanent puddles and for creeks. The most striking habitat factor was vegetation, which was present in 85 per cent of the collections and was typically dense masses of algae flourishing in full sunlight. Hill (1925), Brug (1934), and Lee (1944*a*) also list surface water habitats but they apparently did not observe any striking abundance and frequency of vegetation in association with *squamosus*.

Squamosus occurred to approximately the same degree in pure (43 per cent) and in mixed (57 per cent) collections. Percentages of associates were: *An. farauti*, 18; *C. pullus*, 16; *An. punctulatus*, 12; *C. halifaxi*, 6; others, 5.

SUMMARY

Distribution

Edwards (1924) included 145 species from the Australasian Region and recorded 47 from New Guinea. Bonne-Wepster (1938) listed 121 non-anopheline species from the island. In 1944 Knight *et al.* listed 238 species from the Australasian Region and recorded 124 from New Guinea. I have specific locality records for 47 species. I believe that this discrepancy is due primarily to the fact that I engaged in routine surveys of each area rather than in intensive searching for species in unusual and inaccessible habitats.

In this paper many species are reported for the first time from major subdivisions of New Guinea. First records from Papua are presented for *U. argyrotarsis*, *A. candidoscutellum*, *A. dasyorrhus*, *C. brevipalpis*, *C. fraudatrix*, and *C. annulirostris*. First Northeast New Guinea records are presented for *U. argyrotarsis*, *U. papua*, *A. vexans*, *C. halifaxi*, *C. fragilis*, and *H. genurostris*. The collections of *A. aurantius chrysogaster* from Morobe and Milne Bay are apparently the first New Guinea records of the subspecies.

In assembling the records it became clear that frequently, in past surveys, novelties were recorded to the almost complete neglect of certain common species. Thus *Culex pullus*, one of the species most frequently encountered in my collections and present in every area studied, is represented in the literature by only two records from Northeast New Guinea and by a single one from Papua.

Table 1 summarizes distribution records from the study areas. The following generalizations may be given.

TABLE 1
SPECIES RECORDED FROM THE DETAIL STUDY AREAS

SPECIES	MILNE BAY	MOROBE	FINSCH-HAFEN	SAIDOR	PADAIDO	AMSTER-DAM
B. soesiloi	x					
B. travestitus	x					
An. b. pseudobarbirostris				x		
An. farauti	x		x	x	x	x
An. longirostris	x					
An. punctulatus	x		x	x	x	
Toxorhynchites spp.	x		x	x	x	
T. confusa	x					
T. argenteiventris	x		x			
T. bimaculipes	x					x
T. brevipalpis?			x		x	
H. genurostris				x		
U. albescens	x					
U. argyrotarsis	x		x	x		
U. nigerrima	x		x	x	x	
U. papua	x		x	x	x	
A. a. chrysogaster	x	x			x	
A. candidoscutellum	x					
A. hollandius	x					
A. keefei	x					
A. kochi	x			x		x
A. notoscriptus	x		x	x	x	x
A. novalbitarsis	x				x	
A. papuensis	x	x	x		x	
A. wallacei	x					
A. dasyorrhus	x					
A. albolineatus	x	x	x	x	x	x
A. scutellaris	x	x	x	x	x	x
A. vexans	x		x	x		
A. funereus	x		x	x		
A. lineatus	x		x	x		
A. parasimilis	x	x	x		x	
A. aurimargo			x			
Arm. breinli	x	x	x		x	
Arm. milnensis	x	x				
C. halifaxi	x	x	x	x	x	
C. brevipalpis	x					
C. fraudatrix	x		x	x		
C. ?uniformis					x	
C. fragilis	x		x	x	x	
C. papuensis	x		x			
C. pullus	x	x	x	x	x	
C. bicki	x					
C. annulirostris	x			x	x	x
C. fatigans					x	
C. sitiens	x		x		x	x
C. squamosus	x		x		x	

1. Nearly all of the 47 species recorded were found at Milne Bay. A significant number of species found at Milne Bay dropped from the list only at Amsterdam Island. The apparent spotty distribution of certain species is thought to be due largely to habitat availability at the particular locality rather than to distinct range limitations.

2. A distance of approximately 1,300 miles separates Milne Bay from Padaido and Amsterdam Islands, yet the latter localities added only *C. fatigans*, *C. ?uniformis*, and *T. brevi-*

palpis? to the list for Milne Bay.

3. Four species of Anopheles (*farauti*, *punctulatus*, *bancrofti pseudobarbirostris*, *longirostris*) are recorded. *Bancrofti* and *longirostris* were rare; the former was found only at Saidor and the latter only at Milne Bay. *Farauti* and *punctulatus* were common to extremely abundant in nearly every area. Because of their abundance and widespread distribution it seems that only these could be significant malaria vectors in New Guinea.

4. *Aedes scutellaris* was the only species common in every locality. Because of its abundance and widespread distribution, and considering the results of transmission experiments, this species is of considerably greater significance as a dengue vector than all other culicines.

5. *Aedes albopictus*, so frequently reported as common, was not recorded. *Culex fatigans* was found only in a single collection from the Padaido Islands. *Aedes aegypti* was represented by a single adult collection from Samarai Island.

6. Based on distribution and numerical abundance, *C. pullus*, *C. halifaxi*, *A. albolineatus*, and *A. notoscriptus* are potentially important pest species along the north coast. However, practically nothing on their biting habits has been recorded. In particular areas other species may assume local importance, as *Armigeres milnensis*, which was exceptionally abundant at Milne Bay, and *Culex sitiens* at Amsterdam Island.

Habitats

Table 2 lists the number of collections from

TABLE 2
COLLECTION SUMMARY ACCORDING TO HABITAT AND LOCALITY

	MILNE BAY	MOROBE	FINSCH-HAFEN	SAIDOR	PADAIDO ISLAND	AMSTER-DAM ISLAND	TOTAL	PER CENT
Fresh Surface Water								
Natural								
Creeks: Running.....(P)*	57		1	1			59	3.9
Creeks: Pot holes.....(S)	91		2				93	6.1
Swamps.....(P)	23	2		12			37	2.5
Ponds.....(P)	5			5			10	0.7
Marshes.....(P)	4					12	16	1.1
Artificial								
Puddles.....(T)	320	1	4	28	14	7	374	24.8
Borrow pits.....(S)	18		1	2			21	1.3
Ditches.....(S)	29			1			30	2.0
Wells.....(P)				1	2		3	0.2
Fresh Water in Containers								
Natural								
Shells.....(T)					1		1	0.1
Rock holes.....(T)	34						34	2.2
Leaf axils.....(T)	50			9		5	64	4.2
Spathes and leaves....(T)	9		2	1	5	5	22	1.4
Tree holes.....(T)	76		3	8	20	12	119	7.9
Coconut shells.....(T)	75		4	8	39	48	174	11.6
Artificial.....(T)	241		17	20	43	4	325	21.6
Brackish Water								
Coral pools.....(S)						117	117	7.8
Puddles.....(T)	2						2	0.1
Tree holes.....(T)	5					2	7	0.2
Total collections.....	1,039	3	34	96	124	212	1,508	100.0

*P = Permanent, S = Semi-permanent, T = Temporary.

TABLE 3

SPECIES-HABITAT SUMMARY OF SPECIES REPRESENTED BY MORE THAN 10 COLLECTIONS. FIGURES ARE HABITAT INDICES; THOSE LESS THAN 10 ARE EXCLUDED. SOLID LINES SEPARATE SURFACE HABITATS FROM CONTAINER HABITATS AND SURFACE SPECIES FROM CONTAINER SPECIES. DOTTED LINES SEPARATE NATURAL AND ARTIFICIAL HABITATS

	RUNNING CREEKS	CREEK POT HOLES	SWAMPS	PUDDLES	ROCK HOLES	LEAF AXILS	SPATHES AND LEAVES	TREE HOLES	COCONUTS	ARTIFICIAL CONTAINERS	OTHERS
Surface water											
Natural											
Bironella spp.	41	56									3
U. argyrotarsis		41	15	15							28
C. fraudatrix		24	24	16							36
C. squamosus	35	14		45							6
Artificial											
An. farauti	15	13		52							20
C. pullus		11		62						13	13
C. halifaxi		12		64						14	9
C. annulirostris				75							25
An. punctulatus				83							17
A. vexans				92							8
C. papuensis		17		24						39	19
A. novalbitarsis				42	50						8
A. papuensis				26	38					15	21
Water in containers											
Natural											
A. kochi						100					0
A. keefei								91			9
Arm. breinli									94		6
Natural and artificial											
U. papua							33		12	38	16
U. nigerrima							14		29	53	4
A. albolineatus								52	25	15	7
A. notoscriptus								51	13	34	2
Arm. milnensis								18	50	24	8
Toxorhynchites spp.								15	15	68	2
T. bimaculipes								13	13	68	5
A. scutellaris								11	32	45	11
C. fragilis									11	62	26

each of the habitats by locality. It will be noted that:

1. Nearly every habitat was represented at Milne Bay. This locality was the most productive in both species and numbers of individuals. However, since the collection period here was much longer, strict comparison with the other areas is not warranted.

2. Morobe was markedly unproductive largely because natural barriers sharply limited the study area. A light rainfall during the brief collecting period further reduced collection possibilities.

3. Collections from "fresh water in containers" were well represented at nearly every locality, whereas, with the exception of the

ubiquitous puddles, collections from "fresh surface water" had a more scattered distribution. This was directly correlated with the availability of these habitats.

4. Ninety-two per cent of all collections were from fresh water, only 8 per cent from brackish. All brackish habitats were temporary or semi-permanent and were sharply localized. This was due largely to the scarcity and total non-productivity of brackish marshes and swamps. In several areas (especially Gamadodo and Morobe) extensive mangrove swamps were present but mosquito larvae were entirely absent, probably due to a significant daily tidal fluctuation.

5. Seventy-five per cent of the collections were from temporary water, 17 per cent from semi-permanent, and only 8 per cent were from permanent water. Since there was a remarkably high percentage of collections from temporary water, I believe that a significant degree of control could have been achieved by dealing solely with these habitats.

6. Approximately 50 per cent of all collections were from puddles and artificial containers. This figure emphasizes the overwhelming importance of man-made habitats.

Table 3 gives the habitat indices for each fresh-water species represented by more than 10 collections. In each case only habitats with indices greater than 10 are included. It is felt that lower figures represent habitats too rarely utilized to be significant.

The habitats are arranged in a sequence from clear, natural surface water to polluted water in artificial containers. Within this sequence they fall into three major categories, each with its characteristic group of species.

1. In clear, natural surface water, characteristic species were *Bironella* spp., *U. argyrotarsis*, and *C. fraudatrix*.

2. Artificial surface water was almost entirely puddles. Characteristic species were: *An. farauti*, *C. pullus*, *C. halifaxi*, *An. punctulatus*, *A. vexans*, and *C. annulirostris*.

3. In water in containers, characteristic species were: (a) *A. kochi*, *A. keefei*, and *Arm. breinli*, which were found primarily in natural containers; and (b) *U. papua*, *U. nigerrima*, *A. albolineatus*, *A. notoscriptus*, *Arm. milnensis*, *Toxorhynchites* spp., *T. bimaculipes*, *A. scutellaris*, and *C. fragilis*, which were found in both natural and artificial containers.

Very few species bridge the gap between surface and container habitats to a significant degree. Only *C. papuensis*, *A. novalbitarsis*, and *A. papuensis* were frequent in both surface water and in water in containers.

Of the disease vectors, *An. farauti* and *An. punctulatus* occurred primarily in artificial surface water habitats whereas *A. scutellaris* was found primarily in containers.

Habitat Factors

Exposure: In most cases shade or exposure was a natural characteristic of the habitat. For example, tree holes and mountain creeks, by their nature, are shaded, whereas coral pools are exposed. Species with high indices for such habitats showed correspondingly high values for shade or for exposure. In these cases the actual role of this factor could not be determined. However, for several species, exposure seemed significant. *An. punctulatus* and *A. vexans* were common in exposed puddles, whereas *C. annulirostris* was more frequent in shaded puddles. *A. albolineatus* and *C. fraudatrix* were found in a wide habitat range but typically in shaded situations.

Superficial character of water: Based on organoleptic methods, the habitats were divided into four categories: clear, muddy, stagnant, polluted. For the most part, a particular species was not found solely in any one of these categories. This would be expected because of the wide habitat range for nearly every species. However, the following were frequently associated with these water types: Clear—*Bironella* spp., *H. genurostris*, *A. keefei*, and *A. dasyorrhus;* muddy—*An. punctulatus*, *C. halifaxi*, and *C. pullus*; polluted —*Arm. breinli*, *Arm. milnensis*, and *C. fragilis*.

TABLE 4

ASSOCIATION PER CENT OF THE VARIOUS SPECIES. SPECIES REPRESENTED BY LESS THAN 10 COLLECTIONS ARE EXCLUDED AND ALL ASSOCIATION VALUES LESS THAN FOUR HAVE BEEN ADDED AND LUMPED UNDER "OTHERS." READ NUMBERS HORIZONTALLY

	Bironella spp.	*U. argyrotarsis*	*C. fraudatrix*	*C. squamosus*	*An. farauti*	*C. pullus*	*C. halifaxi*	*C. annulirostris*	*An. punctulatus*	*A. vexans*	*C. papuensis*	*A. novalbitarsis*	*A. papuensis*	*A. kochi*	*A. keefei*	*Arm. breinli*	*U. papua*	*U. nigerrima*	*A. albolineatus*	*A. notoscriptus*	*Arm. milnensis*	*Toxorhynchites* spp.	*T. bimaculipes*	*A. scutellaris*	*C. fragilis*	Others
Bironella spp.	68	11	9			4																				8
U. argyrotarsis	5	29	7		10	20	13																			16
C. fraudatrix	7	17	16		26		4	6	7																	17
C. squamosus				43	18	16	6		12																	5
An. farauti		4	5	8	23	21	11	6	16																	6
C. pullus		6		4	15	24	17	4	13		4															13
C. halifaxi		6			11	25	18	6	14		5															15
C. annulirostris					16	16	13	26	16																	13
An. punctulatus				5	15	18	12	6	35																	9
A. vexans						17			25	25																33
C. papuensis		5			5	27	21		5		26															11
A. novalbitarsis												67														33
A. papuensis						8	8		6				36													29
A. kochi														86												14
A. keefei															36				14			14	8	14		14
Arm. breinli																86		4								10
U. papua																	71		4					5		20
U. nigerrima																9		52	7			6	9	6	6	5
A. albolineatus													5					4	44	6		4	7	11	4	15
A. notoscriptus																5			9	60			5		5	16
Arm. milnensis																					84					16
Toxorhynchites spp.																5			5			52	5	6	5	22
T. bimaculipes		5																11	19	7	5	7	16	14		16
A. scutellaris																			6					73		21
C. fragilis						12	10											4	7	5		4		10	37	11

Vegetation: For most species vegetation was a minor factor since it was entirely absent in 41 per cent of the collections. This is not surprising in view of the temporary nature of so many of the habitats. There was a striking correlation between the type of vegetation and a particular species in only one case: *C. squamosus* was found with vegetation in 85 per cent of the collections and, of these, 61 per cent were with green algae.

*p*H: Nearly every species was found within a wide range. Alkaline readings were relatively few, and for no species was the mode or average alkaline. In general, there was little or no correlation between any one species and certain narrow *p*H values.

Species Association

In Table 4 the species represented by less than 10 collections are excluded and all association values less than four are added and lumped under "others."

Conclusions from this table substantiate those of the habitat table. That is, surface water species have high association values for one another, and, likewise, container species have high association values for one another. The separation of surface water species and container species is quite apparent.

However, as with the habitat groups, there is overlapping. The following, which were found both in surface and container habitats, are likewise found with both surface and container associates: *C. papuensis*, *A. novalbitarsis*, and *A. papuensis*. These three are clearly in an intermediate position.

For almost every species the number of pure collections exceeded the number of associations with any other particular species. *A. kochi*, *Arm. milnensis*, and *Arm. breinli* had the highest values for pure collections.

It is usually stated that predatory species are found more commonly in pure collections. My figures were not unusually high for the predatory species, *Toxorhynchites* spp. and *Culex halifaxi*. Indeed, in the case of *halifaxi*, the value 18 was surprisingly low.

The association of a particular species with any one other exceeded 20 in very few cases. It is believed that the concept of indicator species is in no case substantiated by these data. Examples of the highest associations were: *C. papuensis* with *C. pullus* (27), *C. fraudatrix* with *An. farauti* (26), *C. halifaxi* with *C. pullus* (25), and *A. vexans* with *An. punctulatus* (25).

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