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DIPTERA (NEMATOCERA) CULICIDAE

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ALMQVIST & WIKSELLS BOKTRYCKERI AB

Chapter XVI

Diptera (Nematocera): Culicidae

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Although this collection was made a few years ago and was only recently sent to the South African Institute for Medical Research the species present will afford an opportunity of adding some further notes to my papers on culicine distribution, taxonomy and bionomics (MUSPRATT, 1955 and 1956b), in addition to notes on anophelines. Part 3 of this series (MUSPRATT, 1955) includes territories which were visited by the Lund University Expedition, namely the Union of South Africa, South West Africa and the protectorates of Bechuanaland, Swaziland and Basutoland. Unfortunately many of the specimens (i.e. adults) of the Swedish collection were preserved in spirit and it has only been possible to identify the culicine males (from their genitalia) and a few of the females, but the markings of the anophelines were still visible. The classificatory order is that of EDWARDS (1941, pp. 468–485) and the numbers in brackets after the date of collection refer to the locality list of BRINCK and RUDEBECK (1955, pp. 70–100). It is of interest to note that most of the specimens were caught at light in the evening.

1. *Anopheles* (*Anopheles*) *coustani* LAVERAN

Transvaal: Skukusa, 29.4.51 (283).

This is a common swamp and pool breeding anopheline with a wide distribution in the Ethiopian Region of Africa ranging from southern Arabia to the Cape, but it is particularly a common species of east, central and southern Africa (DE MEILLON, 1947, p. 45). It is also found in Madagascar and the Mascarenes. The two varieties *tenebrosus* DÖNITZ and *ziemanni* GRÜNBERG occur on the coastal belt of Natal and the latter has been found near Hermanus in the southern Cape Province. The former occurs in eastern Africa from south western Arabia to Natal, and the latter has a similar distribution to the type form but is commoner on the West Coast (DE MEILLON loc. cit.). The type and varieties are not considered to be malaria vectors and attempts to infect *ziemanni* experimentally were negative (BARBER and OLINGER, 1931, p. 488).

2. *Anopheles* (*Myzomyia*) *demeilloni* EVANS

Cape Prov.: Ladismith, 4.1.51. (115). — **Basutoland:** Nazareth, 24.3.41 (246). — **Natal:** Royal Natal National Park, 3.4.51 (259). — **S. W. Africa:** Kaokoveld, Omutati, 5.6.51 (329).

This is an eastern species extending from Abyssinia in the north to the Cape Province in the south (DE MEILLON, 1947, p. 179). The writer has collected a variety at Piquetberg in the southern Cape Province with four white bands on the female palpi as illustrated by DE MEILLON (1947, p. 176) for a specimen from Johannesburg. All the female specimens collected at Piquetberg had 4-banded palpi which was evidently not just due to individual variation. The species is not considered to be a serious vector of malaria (DE MEILLON, loc. cit., p. 179) although it has been found infected (DE MEILLON, 1951b, p. 422). The larvae are found in a variety of breeding places such as rivers, streams, swamps, ponds, pools and seepages, which may sometimes be shaded.

3. *Anopheles* (*Myzomyia*) *listeri* DE MEILLON

Cape Prov.: Kakamas, 11.11.50 (46). — Kalahari Gemsbok National Park, 16–18.11.50 (53). — Upington, 20.11.50 (59). — Ladismith, 4.1.51 (115). — **S.W. Africa**: Kaokoveld, Anabib (Orupembe), 12–13.6.51 (339). — Kaokoveld, Sanitatas, 14–16.6.51 (340).

This is chiefly a South African and South West African species with small numbers occurring in Southern Rhodesia (DE MEILLON, 1947, p. 219). Although it has not been incriminated as a vector of malaria there were grounds for suspecting it as a possible vector in South West Africa (DE MEILLON loc. cit.). It breeds mostly in exposed pools like the malaria-carrying *Anopheles gambiae*.

4. *Anopheles* (*Myzomyia*) *cinereus* THEOBALD

Cape Prov.: Kalahari Gemsbok National Park, 16–18.11.50 (53).

The species has a wide distribution in Africa from Abyssinia to the Cape Province, but has not been recorded from the western half of the continent. In South Africa it occurs also in the Transvaal, Natal and the Orange Free State. The breedingplaces are very varied, such as pools, swamps, ditches, streams etc. and larvae are usually found in the shade if only of short grass or floating vegetation (DE MEILLON, 1947). Adults are seldom found in human habitations.

5. *Anopheles* (*Myzomyia*) *pretoriensis* THEOBALD

S.W. Africa: Kaokoveld, Ohopoho, 4.6.51 (325). — Kaokoveld, Omutati, 5.6.51 (329).

The species is widespread in the Ethiopian Region of Africa occurring in most territories and also in Madagascar. It is found in South West Arabia in the north to Natal in the south. It has been recorded from several localities in South West Africa (DE MEILLON, 1951a) and the same author (1951b) notes that it has been found naturally infected with malaria parasites in the Transvaal and Southern Rhodesia. It is regarded as a house-frequenting species although it has not been incriminated as a vector of great importance.

Larvae occur in a variety of breeding places, except those heavily shaded. These are commonly seepages and often associated with *A. gambiae* (DE MEILLON, 1951b, p. 436).

6. *Theobaldia* (*Allotheobaldia*) *longiareolata* MACQUART

Cape Prov.: Pofadder, 9.11.50 (38). — Aughrabies Falls, Orange River, 11.11.50 (44). — Kakamas, 12.11.50 (47). — Upington, 25.11.50 (64). — Rhodes 10.3.51 (225). — **Basutoland:** Mamathes, 28.3.51 (251).

This large species has a wide distribution in southern Africa more particularly on the High Veld. It appears to be resistant to drought and is common in the South-West Arid District of the Ethiopian Region. There are several records from the Sudan and it also occurs in Abyssinia, Eritrea and British Somaliland; but there are few records from East Africa, and none to my knowledge from West Africa. EDWARDS (1941, p. 69) states that outside tropical Africa it is widely distributed in the Mediterranean region from the Azores, Canary Islands and Madeira, through Spain to Macedonia, Persia and North-West India and through Morocco and the whole of the northern Sahara to Egypt and Palestine. He also records it from S. W. Arabia (p. 473). MATTINGLY (1954, p. 58) notes that it has penetrated northwards up the Rhone Valley and has appeared in England both at Portsmouth and Epsom. In southern Africa it breeds mainly in veld and river-bed pools including rock pools, and is also found in water tanks and sheep and cattle troughs, the latter perhaps helping its survival in arid districts (MUSPRATT, 1955, p. 155).

7. *Taeniorhynchus* (*Coquillettidia*) *microannulatus* var. *auripennis* EDWARDS

Cape Prov.: Assegaaibos, 28.2.51 (191).

This is the first record of this variety from the Cape Province, previous South African records being from the coast of Natal. It occurs also in the Sudan, Uganda and Tanganyika. The larvae and pupae of this genus remain submerged and obtain oxygen by inserting a specially adapted siphon or trumpets into the roots, stem or leaves of aquatic plants (HOPKINS, 1952, p. 102; GILLETT, 1945; EDWARDS, 1941, p. 382). In East Africa larvae of the species have been found in shallow grassy swamps and in a large papyrus swamp (HOPKINS, loc. cit., p. 110).

8. *Aëdes* (*Ochlerotatus*) *caballus* THEOBALD

Cape Prov.: Kakamas, 10.11.50 (43). — Addo, 15.1.51 (142).

This species has come into prominence in recent years in South Africa on account of it being a proved vector of the sheep disease Rift Valley fever (GEAR et. al., 1955, pp. 515 and 516) and Wesselsbron and Middelburg viruses (KOKERNOT et. al., 1958 and 1957 c). The first named disease can also infect cattle and man and the second, man as well as sheep, cattle and other animals (WEISS et. al., 1956; HEYMANN et. al., 1958).

A short review of Rift Valley fever in East Africa is given by the writer in a monograph on the *Stegomyia* subgenus (MUSPRATT, 1956a, pp. 14–16). *A. caballus* would appear to have a wide distribution on the High Veld of the Transvaal and Orange Free State, also in parts of the Karroo, Natal and southern Cape Province

(STEYN and SCHULZ, 1955), lack of collecting probably accounts for gaps in certain areas, but it does not appear to be common on the coastal belt of Natal and the eastern Cape Province. The species also occurs in South West Africa, Southern Rhodesia, East Africa and Persia (EDWARDS, 1941, p. 118). The breeding places are usually temporary veld pools or pans, also rock pools, a stream and water furrows (HOPKINS, 1952, p. 125).

9. *Aëdes* (*Finlaya*) sp. indet.

Orange Free State: Zastron, 20.3.51 (242).

It was not possible to tell from the male terminalia of a specimen preserved in spirit to which species this belongs. It may be *A.* (*F.*) *barnardi* EDWARDS which is a tree-hole breeding species with a wide distribution in the montane and coastal timber forests from the north-eastern Transvaal to the Cape. It does not occur outside South Africa. Females have been taken biting (MUSPRATT, 1955, p. 162).

10. *Aëdes* (*Aëdimorphus*) *dentatus* THEOBALD

Cape Prov.: Storms River Mouth, 12–14.1.51 (136).

There are records from widely separated localities of South Africa in the Transvaal, Orange Free State, Cape Province and Natal (MUSPRATT, 1955, p. 167). It would appear from this record from the Tzitzikama Mountains district that both this species and the closely allied *A. pachyurus* frequent the forests and will bite man. In Uganda females were taken biting near the ground in the daytime (HADDOW et al., 1951, p. 224). The species occurs in the Belgian Congo, East Africa and Abyssinia. Larvae are found in ground pools, which may be shaded, and at the edges of swamps (HOPKINS, 1952, p. 195).

11. *Aëdes* (*Aëdimorphus*) sp. indet.

Cape Prov.: Lootsberg (25 miles S. of Middelburg) 17.1.51 (47).

Larvae (from a pond) belong to the *fowleri* and *durbanensis* group of the *Aëdimorphus* subgenus. They resemble the former in having minute spicules on the thorax, abdomen and siphon and also in most other respects, but two interesting features are that the antennal tuft is single or double and head setae A single, double or with not more than three branches. They may belong to a new species.

12. *Aëdes* (*Banksinella*) *lineatopennis* LUDLOW

Transvaal: Skukusa, 29.3.51 (283).

From the male terminalia of one specimen (in spirit) it would appear to belong to this species, but it may possibly be the closely allied *A.* (*B.*) *circumluteolus*. This latter species has recently been shown to be an important vector in South Africa of certain virus diseases. In 1955 fifteen isolations of virus agents were made from

females of *circumluteolus* collected by a team of workers (SMITHBURN and DE MEILLON, 1957) on the northern coastal plain of Natal (Tongaland). There were five viruses concerned; two of these were the known viruses Rift Valley fever (see also under *A. caballus*) and Bunyamwera virus, which occur in East Africa (KOKERNOT et al. 1957 a). A third, Pongola virus, was found to be closely related to Bwamba fewer of Uganda (KOKERNOT et al., 1957 b) and a fourth is now known to be Wesselsbron virus, the causative agent of sheep and human disease, which also infects other domestic animals (WEISS et al., 1956; SMITHBURN et al., 1957). The fifth virus is one not hitherto known, which has been named Simbu virus (WEINBREN et al., 1957). Transmission of Wesselsbron virus to infant mice by bite was demonstrated with laboratory-reared *circumluteolus* (MUSPRATT et al., 1957). This work is in full progress and for recent information the reader is referred to Rep. S. Afr. Inst. Med. Res., 1957, pp. 60–63 and 69–70.

A. lineatopennis was shown by NIESCHULZ et al. to be able to retain the virus of blue-tongue disease of sheep, but transmission by bite was doubtful and it is not thought to be a vector (see MUSPRATT, 1956, p. 17). Both species have been recorded from Bechuanaland, the Transvaal and Natal. There are also records for *lineatopennis* from the Orange Free State and South West Africa. Recently *circumluteolus* has been collected at Kroonstad in the Orange Free State but the marking of the female venter is less pale than the Tongaland form, and its exact status has not yet been determined. Middelburg virus has been isolated from a pool of *Aëdes* (*Banksinella*) containing *lineatopennis* and *albothorax* (KOKERNOT et al., 1957 c, p. 147). Both *circumluteolus* and *lineatopennis* also have a wide distribution in Central, East and West Africa and the Sudan. They breed in pools or at the edges of swamps and in hoofprints in soft ground (HOPKINS, 1952, p. 210). These usually contain much grass or other vegetation.

13. *Aëdes* (*Diceromyia*) *taylori* EDWARDS

Transvaal: Letaba Camp, Kruger National Park, 6.5.51 (259).

This is the first record for the Transvaal, although the species has been found in one locality in Natal. It was a suspected yellow fever vector in nature in the Sudan and a proved laboratory carrier of the virus (see MUSPRATT, 1956 a, p. 13). It occurs also in N. Rhodesia and East and West Africa. The above determination is from male terminalia. The larvae are found in tree holes.

14. *Culex* (*Lutzia*) *tigripes* GRANDPRÉ & CHARMOY

Cape Prov.: Knysna, 11.1.51 (295).

The predacity of the larva is discussed in a previous paper (MUSPRATT, 1956 b, p. 44).

15. *Culex* (*Neoculex*) *péringueyi* EDWARDS

Cape Prov.: Hout Bay (Skoorsteenkop), 13.12.50 (82).

This *Culex* appears to be confined to the southern Cape Province (MUSPRATT, 1955, p. 178) where it is fairly common. A description and a figure of the larvae, with notes and a figure on adult ornamentation are given in the latter paper (pp. 171 and 178). Nothing is known about the habits of the adults. The larvae are found in pools (including rock pools) and in pools of river beds (MUSPRATT, loc. cit.).

16. *Culex* (*Neoculex*) *salisburiensis* THEOBALD

Cape Prov.: Hout Bay (Skoorsteenkop), 26.12.50 (95). — Rhodes 10.3.51 (225).

There are several records from the Transvaal, Natal, Basutoland and the Cape Province. It is common in the southern part of the latter province (MUSPRATT, 1955, p. 179).

The species is also widely distributed over the eastern part of the Ethiopian Region including the Sudan. The habits of the adults are unknown. The breeding places are pools of various kinds and stagnant or slow-flowing streams and their backwaters (HOPKINS, 1952, p. 225).

17. *Culex* (*Culex*) *theileri* THEOBALD

Cape Prov.: Kakamas, 12.11.50 (47). — Hout Bay (Skoorsteenkop), 9.12.50 (78). — Swellendam district, 3.1.51 (110). — Storms River Mouth, 12–14.1.51 (136). — Bredasdorp, 1.1.51 (106). — Mount Frere, 5.3.51 (207). — **Basutoland**: Quthing, 12–13.3.51 (232).

This common *Culex* has a wide distribution in all parts of Southern Africa except the very arid regions. It has been shown that it can harbour the virus of Rift Valley fever, but transmission by bite was not obtained, so it is not known if it is ever a vector (GEAR et al. 1955, pp. 515 and 516; Rep. S. Afr. Inst. Med. Res., 1956, pp. 54–55 and 59). This species was also included in a pool of mosquitoes from which a Sindbis-like virus was isolated (WEINBREN et al., 1956, p. 663). These latter mosquitoes were collected at Springs (Transvaal).

Beyond Southern Africa *theileri* has a wide distribution through Eastern Africa and the Sudan. It occurs in the Canary Islands, Madeira, all countries bordering the Mediterranean, Mesopotamia, Persia, Baluchistan, north-west India and the Himalayan foothills to Northern Assam and Burma (EDWARDS, 1941, p. 306). Larvae are found in a variety of pools, stagnant or slow-flowing streams, ditches, drains, backwaters of rivers etc., and dipping tanks (HOPKINS, 1952, p. 291).

18. *Culex* (*Culex*) *univittatus* THEOBALD

Cape Prov.: Ladismith, 4.1.51 (115). — Storms River Mouth, 12–14.1.51 (136). — Mount Frere, 5.3.51 (207). — **Basutoland**: Makheke Mnts, 8.4.51 (269).

This species has been found to be involved in the cycle of West Nile virus in Egypt (TAYLOR et al., 1956, pp. 615 and 618) and also of Sindbis virus (TAYLOR et al., 1955)

becoming probably infected from birds. The variety *neavei* has also been suspected of being a possible vector of yellow fever in monkeys in Uganda (LUMSDEN and VAN SOMEREN, 1953, p. 22). *C. univittatus* (? var. *neavei*, see below) is also known to be capable of transmitting a South African virus similar to Uganda S in the laboratory (Rep. S. Afr. Inst. Med. Res. 1956, p. 54) and an undetermined virus has also been isolated from the species (Rep. S. Afr. Inst. Med. Res. 1957, p. 62). It would appear that the type form and variety have different biting habits (LEWIS, 1947, p. 552).

In the Union of South Africa differences in the male terminalia suggest that var. *neavei* may be present, particularly in northern Natal, but the ornamentation of the abdomen is like the typical form. A comparison of the male terminalia with other African and European forms of *univittatus* has been given in a later paper (MUSPRATT, J. ent. Soc. S. Afr. 1959).

The species, or different forms of it, has a wide distribution throughout the African Continent including even the central Sahara and it also occurs in Madagascar. It is widely distributed throughout the Mediterranean region from Spain and Algeria to the Punjab (EDWARDS, 1941, p. 308; MATTINGLY, 1954, pp. 56–58). The breeding places are usually stagnant pools of various kinds, also the edges of swamps, semi-stagnant streams, ditches and borrow-pits. These usually contain vegetation but are not in dense shade. In North Africa larvae are occasionally found in saline water (HOPKINS, 1952, p. 293).

19. *Culex (Culex) pipiens* LINNÆUS

Cape Prov.: Kakamas, 12.11.50 (47). — Storms River Mouth, 12–14.1.51 (136). — Mount Frere, 5.3.51 (207). — **S. W. Africa**: Kaokoveld, Sanitatas, 14–16.6.51 (340).

It is outside the scope of these notes to enter into a discussion on the *Culex pipiens* complex (see MATTINGLY et al., 1951), with the complications of hybridization with what is now regarded as the subspecies *fatigans*. In Southern Africa, and probably in most of the rest of the Ethiopian Region, however, the type and subspecies behave as two quite distinct species and there is no definite evidence of hybridization in nature. In Egypt *pipiens* is thought, like *univittatus*, to play a part in the cycle of West Nile virus particularly in infecting human beings at certain times of year (TAYLOR et al., 1956, pp. 615–616).

Culex pipiens has a wide distribution in Southern, Central and Eastern Africa extending through the Sudan to Egypt. It occurs in Madagascar and has a world-wide distribution in North America, Europe, the Orient, Eastern Australia and part of South America (MATTINGLY et al., 1951, p. 332). It is not, however, known to occur in West Africa. The breeding places are very varied being mostly similar to *univittatus* (see above) sometimes also with a high organic content. Larvae are found occasionally in barrels and tanks and rarely in tree holes (HOPKINS, 1952, p. 302).

20. *Culex (Culex) pipiens* ssp. *fatigans* WIEDEMANN

Cape Prov.: George, 27.2.51 (186).

As noted above this former species is now regarded as a subspecies of *pipiens* on account of its ability of hybridize with the latter (MATTINGLY et al. 1951; KNIGHT,

1953; ROZEBOOM and GILFORD, 1954). It has been shown to be able to transmit yellow fever in the laboratory, but is not an efficient carrier, and it has also been shown to be able to carry *Filaria* in the laboratory, although results were contradictory (EDWARDS, 1941, p. 4). It has not been incriminated as a vector of any importance of either of these diseases. In Australia viruses of the bird pox group have been isolated from pools of *fatigans* (FRENCH and REEVES, 1954).

This common domestic mosquito has a wide distribution in the Ethiopian Region of Africa from Khartoum in the north to Cape Town and including parts of West Africa. It is also present in Madagascar and other islands of the Indian Ocean. In other parts of the world it occurs in Arabia, India and southern countries and islands of the Orient, also in Australia and South, Central and North America. It is found together with *pipiens* in the Ethiopian Region except in the west, in Madagascar, in parts of Russia, Persia and the Orient, in Eastern Australia and parts of North and South America (see MATTINGLY et al., 1951, p. 332). The breeding places are usually more domestic than those of *pipiens*, larvae being found in all kinds of domestic utensils including barrels, tins, tanks, discarded machinery and motor tyres; also in boats, and canoes. The water may be very foul and rich in organic matter. Larvae are also found occasionally in pools or other breeding places suitable for *pipiens*, the water sometimes being brackish. For further details see HOPKINS (1952, p. 305).

21. *Culex* (*Culex*) *trifilatus* EDWARDS

Cape Prov.: Hout Bay (Skoorsteenkop), 13.12.50 (82).

This member of the *pipiens* group has a wide distribution in the Transvaal, Natal and the Cape Province, but not in the arid parts of the latter (MUSPRATT, 1955, p. 188). It occurs in the eastern and central part of the Ethiopian Region as far north as the Sudan. It usually breeds in pools of various kinds, including rock pools, and occasionally in tree holes. In South Africa larvae are frequently found in pools in the indigenous forests. The habits of the adults are unknown.

22. *Culex* (*Culex*) *andersoni* ssp. *bwambanus* EDWARDS

Cape Prov.: Hout Bay (Skoorsteenkop), 26.12.50 (95).

This is also a member of the *pipiens* group and is a common species of the Cape. Elsewhere in South Africa it has only been found in the Drakensberg Range of Natal and in Basutoland (MUSPRATT, 1955, p. 188). Outside South Africa the type form and the two varieties appear to be confined to the Belgian Congo, Uganda, Kenya and Abyssinia. The type form and the varieties are known to breed in ground pools, rock pools, tree holes and a bucket of rain water (HOPKINS, 1952, p. 312). In the forests of the Cape larvae abounded in tree holes as well as in pools and were once collected from discarded tins (MUSPRATT, loc. cit.). The habits of the adults are unknown.

References

BARBER, M. A. & OLINGER, M. T. (1931). Studies on malaria in southern Nigeria. Ann. trop. Med. Parasit. 25, pp. 461–501.

BRINCK, P. & RUDEBECK, G. (1955). List of localities investigated by the Swedish Expedition to southern Africa. South African Animal life 1, pp. 344–360.

DE MEILLON, B. (1947). The anophelini of the Ethiopian geographical region. Publ. S. Afr. Inst. med. Res. 10 (No. 49).

—— (1951a). Malaria survey of South West Africa. Bull. World Hlth Org. 4, pp. 333–417.

—— (1951b). Species and varieties of malaria vectors in Africa and their bionomics. Bull. World. Hlth. Org. 4, pp. 419–441.

EDWARDS, F. W. (1941). Mosquitoes of the Ethiopian Region, 3. Culicine adults and pupae. Lond.: British Museum (Nat. Hist.).

FRENCH, E. L. & REEVES, W. C. (1954). A group of viruses isolated from naturally infected mosquitoes collected in the Murray Valley area of Victoria and New South Wales. J. Hyg. 52, pp. 551–562.

GEAR, J., DE MEILLON, B., LE ROUX, A. F., KOFSKY, R., ROSE INNES, R., STEYN, J. J., OLIFF, W. D. and SHULZ, K. H. (1955). Rift Valley fever in South Africa. A Study of the 1953 outbreak in the Orange Free State, with special reference to the vectors and possible reservoir hosts. S. Afr. med. J. 29, pp. 514–518.

GILLETT, J. D. (1945). Notes on the subgenus *Coquillettidia* DYAR (Diptera, Culicidae). Bull. ent. Res. 36, pp. 425–438.

HADDOW, A. J., VAN SOMEREN, E. C. C., LUMSDEN, W. H. R., HARPER, J. O. and GILLETT, J. D. (1955). The mosquitoes of Bwamba County, Uganda, VIII. — Records of occurrence, behaviour and habitat. Bull. ent. Res. 42, pp. 207–238.

HEYMANN, C. S., KOKERNOT, R. H. & DE MEILLON, B. (1958). Wesselsbron virus infections in man. S. Afr. med. J. 32, pp. 543–545.

HOPKINS, G. H. E. (1952). Mosquitoes of the Ethiopian Region, I. Larval bionomics of mosquitoes and taxonomy of culicine larvae, 2nd. ed., Lond.: British Museum (Nat. Hist.).

KNIGHT, K. L. (1953). Hybridization experiments with *Culex pipiens* and *C. quinquefasciatus* (Diptera, Culicidae). Mosquito News 13. (2), pp. 110–115.

KOKERNOT, R. H., HEYMANN, C. S., MUSPRATT, J. & WOLSTENHOLME, B. (1957a). Studies on arthropod-borne viruses of Tongaland, V.—Isolation of Bunyamwera and Rift Valley fever viruses from mosquitoes. S. Afr. J. med. Sci. 22, pp. 71–80.

—— SMITHBURN, K. C., WEINBREN, M. P. & DE MEILLON, B. (1957b). Studies ec. No. VI. Isolation of Pongola virus from *Aëdes* (*Banksinella*) *circumluteolus* THEO. Ibid., pp. 81–92.

—— DE MEILLON, B., PATERSON, H. E., HEYMANN, C. S. & SMITHBURN, K. C. (1957c). Middelburg virus. A hitherto unknown agent isolated from *Aëdes* mosquitoes during an epizootic in sheep in the eastern Cape Province. Ibid., pp. 145–153.

—— PATERSON, H. E. & DE MEILLON, B. (1958). Studies on the transmission of Wesselsbron virus by *Aëdes* (*Ochlerotatus*) *caballus* (THEO.). S. Afr. med. J. 32, pp. 546–548.

LEWIS, D. J. (1947). General observations on mosquitoes in relation to yellow fever in the Anglo-Egyptian Sudan. Bull ent. Res. 37 (4), pp. 543–566.

LUMSDEN, W. H. R. & VAN SOMEREN, E. C. C. (1953). Records of *Culex* species (Diptera: Culicidae) from the West Nile district Uganda, with notes on their behaviour. Proc. R. ent. Soc. Lond. (B) 22 (1–2), pp. 19–22.

MATTINGLY, P. F. (1954). The distribution of some African mosquitoes. Proc. Linn. Soc. Lond. 165, pp. 49–61.

—— ROZEBOOM, L. E., KNIGHT, K. L., LAVEN, H., DRUMMOND, F. H., CHRISTOPHERS, S. R. & SHUTE, P. G. (1951). The *Culex pipiens* complex. Trans. R. ent. Soc. Lond. 102. (7), pp. 331–382.

MUSPRATT, J. (1955). Research on South Africa Culicini (Diptera, Culicidae). III.—A check-list of the species and their distribution, with notes on taxonomy, bionomics and identification. J. ent. Soc. S. Afr. 18 (2), pp. 149–207.

—— (1956a). The *Stegomyia* mosquitoes of South Africa and some neighbouring territories. Mem. ent. Soc. S. Afr. 4, pp. 1–138.

—— (1956b). Research on South African Culicini (Diptera, Culicidae). IV.—Additional distribution records, toxonomic descriptions and miscellaneous notes. J. ent. Soc. S. Afr. 19 (1), pp. 37–46.

MUSPRATT, J., SMITHBURN, K. C., PATERSON, H. E. & KOKERNOT, R. H. (1957). Studies on arthropod-borne viruses of Tongaland. X.—The laboratory transmission of Wesselsbron virus by the bite of *Aëdes* (*Banksinella*) *circumluteolus* THEO. S. Afr. J. med. Sci. 22, pp. 121–126.

NIESCHULZ, O., BEDFORD, G. A. H. & DU TOIT, R. M. (1934). Investigations into the transmission of blue-tongue in sheep during the season 1931–1932. Onderstepoort J. vet. Sci. 2 (2), pp. 509–562.

ROZEBOOM, L. E. & GILFORD, B. N. (1954). Sexual isolation between populations of the *Culex pipiens* complex in North America. J. Parasit. 40 (3), pp. 237–244.

SMITHBURN, K. C. & DE MEILLON, B. (1957). Studies on arthropod-borne viruses of Tongaland. — I. The expedition of April — May, 1955. S. Afr. J. med. Sci. 22, pp. 41–46.

—— KOKERNOT, R. H., WEINBREN, M. P. & DE MEILLON, B. (1957). Studies on arthropod-borne viruses of Tongaland. — IX. Isolation of Wesselsbron virus from a naturally infected human being and from *Aëdes* (*Banksinella*) *circumluteolus*. Ibid., pp. 113–120.

STEYN, J. J. & SCHULZ, K. H. (1955). *Aëdes* (*Ochlerotatus*) *caballus* THEOBALD, the South African vector of Rift Valley fever. S. Afr. med. J. 29. (48), pp. 1114–1120.

TAYLOR, R. M., HURLBUT, H. S., WORK, T. H., KINGSTON, J. R. & FROTHINGHAM, T. E. (1955). Sindbis virus: A newly recognized arthropod-transmitted virus. Amer. J. trop. Med. 4 (5), 844–862.

—— WORK, T. H., HURLBUT, H. S. & RIZK, F. (1956). A study of the ecology of West Nile virus in Egypt. Amer. J. trop. Med. 5 (4), pp. 579–620.

WEINBREN, M. P., KOKERNOT, R. H. & SMITHBURN, K. C. (1956). Strains of Sindbis-like virus isolated from culicine mosquitoes in the Union of South Africa. I. Isolation and properties. S. Afr. med. J. 30, pp. 631–636.

—— HEYMANN, C. S., KOKERNOT, R. H. & PATERSON, H. E. (1957). Studies on arthropod-borne viruses of Tongaland. VII. Simbu virus, a hitherto unknown agent isolated from *Aëdes* (*Banksinella*) *circumluteolus* THEO. S. Afr. J. med. Sci. 22, pp. 93–102.

WEISS, K. E., HAIG, D. A. & ALEXANDER, R. A. (1956). Wesselsbron virus—a virus not previously described associated with abortion in domestic animals. Onderstepoort J. vet. Res., 27, 183–195.

Annual reports

Arthropod-borne Viruses, Rep. S. Afr. Inst. med. Res. (1955), pp. 58 & 65.

Arthropod-borne Viruses. Ibid. (1956), pp. 53 & 59.

Arthropod-borne Viruses. Ibid. (1957), pp. 60–63 & 69–70.