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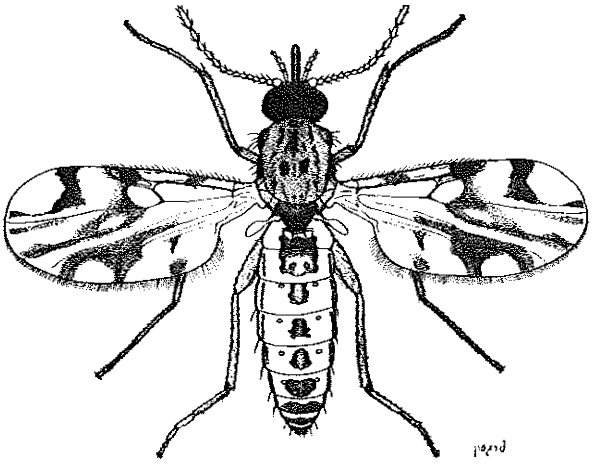

THE ENTOMOLOGICAL SOCIETY OF ISRAEL

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COVER: *Culicoides imicola* Kieffer is a common species of biting midge, which is associated with livestock, and is known as a vector of bluetongue disease of sheep in Africa and the Middle East (Israel and Cyprus). An article on *Culicoides* spp. of Israel. Sinai and the Golan Heights is included in this volume. (Drawing by Walter Ferguson, Department of Zoology, Tel Aviv University).

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The papers published in this journal are abstracted and indexed in the REVIEW OF APPLIED ENTOMOLOGY and in ENTOMOLOGY ABSTRACTS.

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PROCEEDINGS OF THE

FOURTH INTERNATIONAL SYMPOSIUM ON CERATOPOGONIDAE

London, 3-5 September, 1980

Some thirty-five specialists from twelve countries attended the fourth meeting of the World Ceratopogonid Study Group to hear and discuss current research on these small biting midges.

The first two days of this three-day meeting were held in the British Museum (Natural History), London and covered such subjects as morphology, systematics, behaviour, physiology, immature stages, ecology and evolution. Basically, these presentations and discussions were concerned with the midges themselves, including their biting attacks on man. The relationships of ceratopogonid midges, and the genus *Culicoides* in particular, with the parasites they transmit were reserved for the third day, very appropriately held at the Animal Virus Research Institute, Pirbright, Surrey, some 60 km from London. Here interest was based primarily on virus transmission to domestic animals, although bacterial and filarial diseases were discussed.

Several talks showed an interesting interdisciplinary approach and some techniques discussed promise exciting advances in the knowledge of these flies in the near future.

A total of thirty talks were given, abstracts of 28 of which are given here, grouped according to their content. The following acted as chairmen for different sections of the programme: J. Boorman, M. Kremer, J. Linley, D. Kettle, and R. Lane.

Usually, meetings of the World Ceratopogonid Study Group have been held in association with the larger International Congresses of Entomology or Parasitology. The previous three meetings (with details of their résumés and abstracts) were held on the following occasions: 1974, France, Strasbourg (*Annls Parasit. hum. comp.* 49:612-658, 1974); 1976, U.S.A., Washington D.C. and Blacksburg, Virginia (*Mosquito News* 37:276-289, 1977); and 1978, Poland, Warsaw (*Annls Parasit. hum. comp.* 54:247-260, 1979).

Thanks are due to the British Museum (Natural History) for the use of their facilities and to the Director of the Animal Virus Research Institute for generous financial assistance from the Little fund towards expenses on 5th September.

R.P. LANE
(London)

THE ULTRASTRUCTURAL BASIS OF WING PATTERN IN SOME GENERA OF CERATOPOGONIDAE

R.P. LANE

Several genera of Ceratopogonidae were studied to determine whether wing pattern, widespread throughout the family, has any ultrastructural component. Using the scanning electron microscope, it was shown that the spacing of microtrichia on the wing was not responsible for wing pattern in four genera - *Culicoides, Palpomyia, Sphaeromyia* and *Clinohelea* as previously proposed. In the two other genera studied, ultrastructural modifications associated with wing pattern were found. In *Monohelea*, microtrichia are of different size and spacing in light and dark areas of the wing. *Alluaudomyia* show some very interesting features. Not only is there a difference in the size and shape of the microtrichia, but minute papillae 0.20 – 0.25 μm in diameter are present in the dark areas of the wing. These papillae are of the same type and order of magnitude as the corneal nipples found on the surface of insect eyes. It is therefore suggested that these papillae aid the high contrast in the wing pattern, so typical of this genus, by forming an anti-reflective layer.

REVISION OF THE *CULICOIDES* SPECIES RELATED TO *CULICOIDES SCHULTZEI* (ENDERLEIN), IN THE ETHIOPIAN REGION – PRELIMINARY NOTE

M. CORNET

Culicoides schultzei is one of the most frequently recorded taxa in the literature on African *Culicoides* and yet there remains a general discrepancy on the unicity or plurality of this species. After examination of several thousand specimens, six species were recognised: *C. schultzei* (Enderlein, 1908), *C. kingi* Austen,1912, *C. rhizophorensis* Khamala & Kettle,1971 and a further three new species.

The main morphological characters used to separate these species were the wing pattern, the male terminalia, the distribution of male *sensilla trichodea* on the antennae and numerous measurements. These characters were discussed and illustrated for each of the six species and the known geographical distribution given, together with a tentative key for the identification of both males and females. The lectotype of *C. schultzei* and the descriptions of the three new species will be published in a forthcoming definitive paper.

THE FEEDING BEHAVIOUR OF *CULICOIDES* AS INDICATED BY SENSE ORGAN COUNTS AND OTHER MORPHOLOGICAL MEASUREMENTS

Y. BRAVERMAN, K. FRISH & M. REIS

Of the 39 species of *Culicoides* recorded from Israel, accurate information on host range exist for *C. imicola* (mammals), *obsoletus* group (mammals) and *distinctipennis* (avian). The engorged females of other species are rarely caught in suction light traps, suction traps, animal baited traps or electrocuting grids around a bait animal. It is possible that the design of these traps does not fit the host searching behaviour of the *Culicoides* species in this country. Despite these limitations attempts were made to collect data on host range, an important stage in understanding the epidemiology of *Culicoides*-borne pathogens. Counts were made of the bulb shaped sensilla in palpal pits, pit sensilla on the antennae the number of teeth on the maxilla and mandibles, as well as comparing the claws of some species from micrographs. Using those species whose feeding behaviour has been established by precipitin tests, the criteria of pit-bearing antennomeres proved to be the most useful and enabled the classification of the following thirteen species as mammal feeders: *C. derisor, fagineus, fascipennis* group, *imicola, montanus, newsteadi, obsoletus, pulicaris, punctatus, puncticollis, schultzei* group, *shaklawensis* and *tentorius*, and the following species as avian feeders: *agathensis, begueti, brunnicans, cataneii, circumscriptus, cubitalis, distinctipennis, gejgelensis, haranti, indistinctus, maritimus, odiatus, odibilis, pseudopallidus, saevanicus* and *submaritimus*. It was not possible to characterise ten other species which were indeterminate in this character. The number of bulbshaped sensilla in palpal pits, numbers of mandibular and maxillary teeth, proboscis length and claws could not be used for differentiating mammalian and avian feeders. The two useful characters – number of antennomeres bearing pits and the ratio of the third and fourth palpal segments – can only be related to broad host-preference in *Culicoides*. Mixed feeds have been found by precipitin tests, and this opportunistic behaviour may have an important epidemiological bearing.

MISE EN SYNONYMIE DE *C. KIROVABADICUS*

M. KREMER, E. CHAKER & J.C. DELECOLLE

A partir d'un grand nombre d'exemplaires très variés de *C. circumscriptus* et d'exemplaires femelles de *C. kirovabadicus* (espèce identique morphologiquement à *C. circumscriptus* excepté la couleur des ailes claires, et classée par Gutzevich en 1974 parmi les espèces douteuses), nous avons étudié d'une part les mensurations des deux espèces et d'autre part les variations des taches claires de *C. circumscriptus*. Nous avons pu distinguer quatre types d'ailes de *C. circumscriptus* en fonction de l'extension des taches claires; elles représentent les étapes principales qui permettent le passage d'une aile normale de *C. circumscriptus* à une aile claire de *C. kirovabadicus*.

D'autre part, les mesures des longueurs et des rapports sont semblables dans les différents types d'ailes et dans tous leurs intermédiaires.

Nous pensons qu'il s'agit d'une seule espèce *C. circumscriptus* avec deux variations extrêmes de taches claires et tous les intermédiaires possibles.

CHOROLOGIE DES *CULICOIDES* DE TUNISIE

E. CHAKER, J.C. DELECOLLE & M. KREMER

Lors de deux prospections faites en Tunisie en juin 1979 et juin 1980, nous avons effectué 74 prélèvements dans différents gites larvaires – bords de mares, berges des oueds, sol de marécage, vase. Les stations visitées sont réparties comme suit: 1) en Tunisie septentrionale – Nous avons exploré la région de Tabarka, Ain Draham, Boussalem, Téboursouk, Béja, Medjez El Bab, Tunis et Hammamet. 2) en Tunisie centrale – Les prélèvements ont été effectués essentiellement dans les régions de plaines côtières: région d'Enfidaville, de Sousse, et de Sfax. 3) en Tunisie méridionale – Les régions explorées sont celles de Gabès, d'El hamma de Gafsa, de Tozeur. Résultats: sur 74 prélèvements, 55 contenaient les *Culicoides* et ce sont les boues provenant des bordures d'oued ont donné le nombre le plus élevé d'éclosions. Nous avons mis en évidence 14 espèces qui sont: *C. circumscriptus* - identifiée dans la presque totalité des prélèvements et sous tous les climats; *C. puncticollis* - fréquente dans les étages subhumides; *C. coluzzii* - espèce des étages semi-arides et arides, retrouvée aussi sous climat subhumide; *C. longipennis* - rencontrée essentiellement au nord du pays dans les zones très humides; *C. cataneii* – fortement représentée au nord dans les régions humides; *C. geljgelensis* – retrouvée au nord sous climat humide; *C. langeroni* – les exemplaires conformes à la description originale de Kieffer sont retrouvés sous climat aride; par contre, la variété décrite par Gutzevich est retrouvée dans le nord du pays sous climat humide; *C. parroti* – retrouvée sous climat continental humide et aride; *C saevus* – n'est connue que par un exemplaire mâle (région de Medjez El Bab); *C. heteroclitus* – rencontrée dans l'extrême nord-ouest; *C. marcleti* - retrouvee à l'étage humide; *C.* du groupe *kingi* – semble trouver son optimum écologique à l'étage aride; *C.* du groupe *jumineri* – semble rechercher le climat méditerranéen aride, signalée aussi au nord du pays sous climat subhumide; *C. lailae* – espèce des étages humides, abondante au nord.

RECOGNITION OF IMMATURE STAGES OF CERATOPOGONINAE

D.S. KETTLE & M.M. ELSON-HARRIS

Larvae and pupae of Australian Ceratopogoninae, including species from 13 genera, were studied of which one was undescribed. Excluding *Culicoides*, larvae of 27 species and pupae of 31 species were characterised, 21 of these were new to science.

The Culicoidini were represented by many species of *Culicoides* and two species of *Paradasyhelea*. Larvae of this tribe have no branched head setae. The head capsule is normally fully sclerotised but in sand-dwelling larvae only anterior and posterior hoops joined by struts may be present. In most species, the pharynges are lightly built, except in *Monoculicoides* where they are massive. Perianal setae are usually short but may be long in tree hole species. Larvae and pupae of the subgenus *Avaritia* deviate more from the *Culicoides* norm than do those of *Paradasyhelea*.

Larvae of the Ceratopogonini (represented by *Alluaudomyia, Brachypogon* and *Ceratopogon*) have at least two setae (*s* and posterior *o*) branched, the frontal suture extending almost the entire length of the head and relatively long perianal setae. The Stilobezziini (represented by *Monohelea* and *Stilobezzia*) have branched head setae, a long frontal suture and short perianal setae. In the Heteromyiini (represented by *Clinohelea* and *Pellucidomyia*) the larvae have branched head setae and the frontal suture is shorter, terminating at sensillum *k*. The Sphaeromyiini (represented by *Nilobezzia* and *Lanatomyia*) are characterised by the collar being expanded posteriorly in the mid-ventral line. Pigment is present in both the splanchnic fat layer bordering the gut and in the superficial fat layer underlying the hypodermis. The Palpomyiini were represented by *Bezzia* and an undescribed genus which have larvae with branched head setae, a very short frontal suture and dark pigment in the superficial and deep layers of the fat body.

SAPROBITY OF RUNNING WATERS AND THE DISTRIBUTION OF *CULICOIDES* LARVAE

B. OVERGAARD NIELSEN & S. ACHIM NIELSEN

The distribution of *Culicoides* larvae in mud flats accumulated along the banks of Danish watercourses was recorded. The watercourses were classified according to: bottom deposits; velocity of flow; and saprobity. Primarily, the effect of saprobity on the larval distribution pattern was studied. Mud samples from about 1000 sites were examined and 20,000 *Culicoides* larvae collected. In unpolluted and almost unpolluted watercourses *C. odibilis* and *C. lupicaris* were predominant, in slightly to strongly polluted sites *C. circumscriptus, C. salinarius,* and *C. nubeculosus* were present. Moderate pollution limited the population to a few species, which occurred in high densities in some sites. Compared to brooks and streams, ditches were less suited as breeding sites. No relationship between bottom deposits or velocity of flow and the distribution of larvae was observed. Some mud-dwelling species were found in slightly to strongly polluted sites. The heavy sewage discharge means a significant reduction in the abundance of larvae in strongly and extremely polluted sites. In the research area about 75% of all watercourses were slightly to strongly polluted, providing favourable breeding habitats for the extremely abundant mud-dwelling species.

DISTRIBUTION OF *CULICOIDES* LARVAE IN NATURAL AND DISTURBED COASTAL HABITATS

D.S. KETTLE, C. HAGAN & E.J. REYE

The distribution of *Culicoides* larvae in three coastal habitats have been studied. The first, Moogurrapum Creek, is a relatively natural belt of intertidal mangroves with

four species of *Culicoides* present. The dominant mangrove was *Avicennia*. A raised levee bordering the creek carried *Rhizophora* mangroves on the creek side and *Brugera* mangroves on the landward side. Inland of the levee there was a marked zone of *Ceriops*. *Culicoides henryi* was associated with a muddy substrate and occurred on both the creek side and the land side of the levee. *C. subimmaculatus* was associated with a sub surface tunnelling soldier crab. Two species, *C. marmoratus* and *C.* n.sp. 1 were widely distributed throughout the area with *C. marmoratus* having the greater range, occurring with *C. subimmaculatus* at the swamp margin.

In the rapidly developing area known as the City of Gold Coast, south of Brisbane, mangroves have been cleared, canals excavated, a retaining sea wall erected and the enclosed area filled with sand for residential development. The sea wall is placed near high water and there is an area of almost pure intertidal sand between the wall and the still water of the canal, providing an ideal breeding site for the man-biting *C. molestus*.

The third area involves the reclaimation of a mangrove island in the Noosa River at Noosa, a rapidly expanding tourist centre, 100 miles north of Brisbane. The area has long experienced a biting midge problem, but reclaimation of the swamp eliminated breeding sites of *C. subimmaculatus*. However, the reclaimation had an adverse effect on water flow which caused undesirable erosion. Realigning the river outlet to the sea has created a large area of calm water which has stabilised a large sand spit, one side of which has extensive areas of intertidal sand in calm water and provides ideal breeding sites for *C. subimmaculatus* and *C. molestus*. The populations of these biting midges are expected to build up over the next few years and the final problem promises to be worse than it was before development. Control measures will certainly be needed because residential areas have moved closer to extensive breeding sites than they were before.

LA PONTE CHEZ *MALLOCHOHELEA SETIGERA, M. REMOTA* ET *PROBEZZIA SEMINIGRA*

J.P. RIEB

Le vol de ponte de ces trois espèces a été observé en juin et juillet 1980, en fin d'après-midi, par une luminosité de 1200 à 30 Lux pour *Mallochohelea* et de 30 à 4 Lux pour *Probezzia*. Les femelles volent sur place entre 20 cm et 130 cm au-dessus de la rivière et émettent 200 à 300 oeufs agglutinés en un ruban long de 3 à 4 cm. Ce ruban tombe au fond de l'eau, dans la vase immergée qui constitue le gîte larvaire. L'ovariole est formé de 4 éléments: germarium – follicule stade 1 – follicule stade 3 – follicule stade 5. L'ovocyte, dont le micropyle est au pôle antérieur, est entouré de 2 enveloppes: une interne ou chorion, et une externe contenant des sphérules adhésives et que nous appelons oophore. L'oeuf est pondu avec ses 2 enveloppes; à la sortie de l'orifice de ponte, il se dirige vers l'arrière en glissant sur des soies spatulées situées sous le dernier segment abdominal, il est rendu par les tarses postérieurs, puis poussé en avant et maintenu entre 2 éventails de soies raides situées sur le 8ème sternite et formant une corbeille de préhension. Les oeufs sont successivement poussés dans cette

corbeille: les oophores s'accolent et forment le ruban. Les oeufs sont placés en oblique et font, par rapport à l'axe du ruban, un angle propre à l'espèce: *M. setigera* = 45°, *M. remota* = 26°, *P. seminigra* = 25°. La forme de l'oophore et des sphérules adhésives est également caractéristique de chaque espèce. Par la suite, la tête de l'embryon est située du côté du micropyle (pôle antérieur). L'embryon a donc la même orientation que l'ovocyte dans l'organisme maternel.

THE MAIN EVOLUTIONARY TRENDS OF CERATOPOGONIDAE IMMATURE STAGES

V.M. GLUKHOVA

For a clear understanding of the evolution of Ceratopogonid immature stages it is necessary to study their principal adaptations, both morphological and ecological. Three aspects have contributed most to the evolution of this group: feeding mechanisms, habitat and method of locomotion.

A study of larval adaptation to the three principal habitats in which they are found has shown that the greatest morphological diversity is found in species inhabiting the semiaquatic environment and those larvae in terrestrial and totally aquatic habitats are highly specialised. Closely associated with this environmental radiation, are modifications to the saprophagous, omnivorous and predaceous life styles. These modifications take the form of changes in head shape, mouthparts, and to some extent, shape of the body.

Of the extant genera, the larvae of *Dasyhelea* are morphologically most similar to the saprophagous ancestoral larva which is thought to have inhabited the semiaquatic habitat. From this habitat, radiation into waterfilms and deep bodies of water followed, with an associated change in the mode of locomotion. Pseudopods for clambering and streamlining for swimming were developed. Ceratopogonids have been limited in their invasion of some habitats e.g. stagnant and putrid water, fast flowing water, etc., restricted by the biology of the pupa which has little mobility and an open tracheal system (connected to the atmosphere via prothoracic horns projecting through the water surface).

In moving to the terrestrial habitat, presumably from water margins, the larvae have reduced spiracles, and, as a consequence of moving through such dense substrates as decaying wood, increased their chaetotaxy to play a more sensory role. The type of feeding remained close to that of the original type – picking or scraping up small particles of substrate. The only adaptation was the development of saprophagy to feeding on the mycelium and spores of lower fungi and small algae.

Therefore, radiation into different habitats concomitant with specialisation in feeding and locomotion has led to the formation of four larval types corresponding to the four subfamilies of Ceratopogonidae - Palpomyinae, Ceratopogoninae, Dasyheleinae and Forcipomyiinae.

GROWTH OF *CULICOIDES MELLEUS* AND *C. FURENS* LARVAE ON SELECTED FOOD ORGANISMS

J.R. LINLEY

An outstanding problem in research with Ceratopogonidae is that very few species have been cultured successfully in the laboratory. One of the principal reasons is that techniques have not been developed for providing small organisms required as larval food by many species. Recently, attempts have been made to isolate and evaluate potential food organisms from commercial sources and by isolation from the natural larval habitats. Using the simple growth criteria of larval length and dry weight, comparisons have been made between a number of cultured organisms for suitability as larval food. To date, only *Culicoides melleus* larvae have been tested, with the following results: While *C. melleus* will eat protozoa constantly available in the larval medium in very large densities, larval growth was very poor, with only a few individuals reaching the second instar. Among three nematode species evaluated, larvae completed development rapidly on the two larger species, but showed some difficulty in sustaining growth in the forth instar when fed on a somewhat smaller species, even though very large numbers of nematodes were constantly present. A large marine rotifer is readily eaten and likely to prove useful as a dietry constituant. However, satisfactory conditions to assure its survival during the full course of the rearing experiments have yet to be resolved. Results indicate that *C. melleus* larvae require fairly large prey. More work is required to show the extent to which species differ in their ability to develop successfully on smaller organisms. Much of the future success that may be hoped for in the colonisation of *Culicoides* will depend on a knowledge of such details. This will be the key to developing a carefully chosen inventory of food organisms that are easily and prolifically maintained in the laboratory.

STUDIES OF POPULATIONS OF *ALLUAUDOMYIA* SPP. LARVAE AT LAC SERPENT, QUEBEC, CANADA

A.M. PUČAŤ

Populations of *Alluaudomyia* spp. larvae were followed for four seasons in the area of Lac Serpent, Quebec. Larvae of four species were found in two types of habitat: (a) in debris on sandy beaches of the lake, and (b) in muddy edges of streams. A portion of the larval population was measured. Fluctuations in the populations of mainly *Alluaudomyia megaparamera* were recorded.

ELAPHRUS CUPREUS (COLEOPTERA, CARABIDAE) UN PREDATEUR DES NYMPHES DE DIPTERES CERATOPOGONIDES

J.B. RIEB & J.C. DELECOLLE

Un film (16 mm) montrant la prédation d'*Elaphrus cupreus* a été présenté. Le Coléoptère a été trouvé sur un banc de vase, gîte larvaire de *Culicoides* en forêt d'Ichtratzheim. Sa densité y est de 2 à 3 individus par mètre carré. La prédation du Coléoptère a été étudiée expérimentalement en lui présentant des nymphes de *Culicoides riethi* d'élevage.

Le Coléoptère saisit la nymphe, indifféremment par la région antérieure, médiane ou postérieure, puis il la triture avec les mandibles et l'avale complètement. Le même Coléoptère a mangé le 1er jour 18 nymphes, le 2ème jour 19 nymphes en 30 minutes, et le 3ème jour 24 nymphes en 19 minutes. La durée d'ingestion d'une nymphe varie entre 25 secondes et 1 minute 16 secondes. *Elaphrus cupreus* dont le biotope spécifique est le bord vaseux des rivières et les roselières où il se déplace rapidement, intervient certainement pour une part dans la régulation numérique des populations de Cératopogonidés.

LA SECRETION DE PHEROMONE CHEZ LA FEMELLE FECONDEE PAR RAPPORT A LA FEMELLE VIERGE DE *CULICOIDES NUBECULOSUS*

M. KREMER, M.T. ISMAIL & M. KRIEGEL

L'influence de la fécondation sur la sécrétion de phéromone chez les femelles de *Culicoides nubeculosus* a été étudiée.

La sécrétion de phéromone chez ces femelles fécondées est appréciée par l'observation des vrais et faux accouplements chez 15 couples de *C. nubeculosus* âgés de 24 heures, soumis à l'influence d'un courant d'air en provenance d'un bocal contenant uniquement des felles fécondées. Ainsi, l'étude comparative de la sécrétion de phéromone chez les femelles fécondées et vierges montre que les femelles fécondées émettent moins de phéromone que les femelles vierges.

Des expériences ont montré que le simple contact des femelles vierges avec les mâles, sans vrais accouplements possibles, ne diminue pas leur sécrétion de phéromone. Seule la fécondation ou la copulation est responsable de cette diminution.

LES MODIFICATIONS DE LA SECRETION DE PHEROMONE CHEZ LA FEMELLE VIERGE ET CHEZ LA FEMELLE FECONDEE DE *C. NUBECULOSUS*, SOUS L'INFLUENCE DU REPAS SANGUIN

M.T. ISMAIL, M. KRIEGEL & M. KREMER

Nous avons étudié, pendant 8 jours consécutifs, les variations de la production de phéromone chez les femelles vierges et fécondées de *C. nubeculosus* sous l'influence du repas sanguin.

Les observations de l'effet stimulant l'accouplement ont été fondées sur le comptage du nombre d'accouplement se produisant dans un bocal sous l'effet d'un courant d'air provenant de ces femelles. Nous avons obtenu, sous l'effet du repas sanguin, une variation importante du taux de phéromone chez les femelles vierges. Ce taux de phéromone monte dans un premier temps (cf. travaux précédents) puis diminue dans les heures qui suivent le repas sanguin pendant que débute l'ovogénèse. Quarante huit heures après, nous constatons de nouveau une augmentation de la sécrétion de phéromone lorsque les oeufs sont mûrs et, surtout, le pic devient plus évident pendant la période de ponte. Par contre, chez les femelles fécondées, nous n'assistons pas à une telle variation; le taux de phéromone reste bas après la fécondation et le repas sanguin le laisse à peu près stable, même après la ponte. Cela peut rendre compte de la réserve de spermatozoïdes dans la spermathèque qui assure la fécondation des oeufs des pontes ultérieures comme chez les autres diptères hématophages. En outre, nous avons constaté que la ponte des femelles fécondées était plus précoce que la ponte des femelles vierges. L'accouplement a pour effet d'accélérer la ponte.

NIGHTLY ACTIVITY PATTERNS OF *CULICOIDES FURENS* (POEY) IN GRAND CAYMAN

J.E. DAVIES

Flight activity of *C. furens* was studied using half-hourly suction and light traps and an hourly sampling goat-baited trap. The light trap was very inefficient at twilight and in moonlight and was more attractive to midges after midnight than before. Nightly activity was very variable. Dusk activity peaks occurred in 60%, dawn peaks in 20% and nocturnal peaks in 57% of nights. Nocturnal peaks usually occurred only once or twice per night at any time although 61% were after midnight. A third were larger than the dusk peak that preceded them. Three general activity patterns accounted for 73.3% of nights: (1) most activity at dusk, (2) activity fairly uniform throughout, (3) most activity between midnight and dawn. Activity patterns varied in a similar way in the gravid and the blood-seeking sections of the population suggesting that physiological factors do not affect activity pattern. Moonlight had no effect on activity except possibly at rise and set. Temperature was negatively related above and positively related about 24°C. Saturation deficiency was negatively related above and positively related below 4.5 g/m^3. These changes of sign with range led to negative relationships at dusk and positive relationships in the dark periods of the night. They also led to increased dusk activity in winter and nocturnal activity in summer. Activity was negatively related to wind over 5 knots and nocturnal peaks often followed reductions in wind speed even when the initial wind speed was very low.

VERTICAL DISTRIBUTION OF BITING MIDGES IN A DANISH BEECH WOOD

S. ACHIM NIELSEN

The investigation was carried out in a 3 hectare beech stand in a mixed coastal forest surrounded by saltmarsh and agricultural land. The vegetation consists of three main strata: (a) an overstorey layer of beech (*Fagus sylvatica* L.) (20 m); (b) an understorey layer of beech (20 m); and (c) a field layer of herbs and ash (*Fraxinus excelsior* L.) (max. height 0.5 m).

The midges were sampled by means of four light traps, consisting of two metal cones viz. a funnel and a roof, separated by a narrow gap; in this way a very narrow zone of light was emitted from each trap. The lower funnel was placed in a bucket containing sponges moistened with tetrachlorethane. A mercury lamp was placed in the upper cone. The traps were placed in a steel tower; one trap on the ground, one in the stem (or trunk) layer, one in the canopy, and one above the canopy, viz. 0.5, 10, 22, and 30 m above ground level. The traps were tended daily from May to October. About 29,000 specimens of biting midges were sampled and identified – 33 species were recorded, nine of which were regarded as dominant.

The greatest number of specimens as well as the greatest species diversity was observed from mid June to mid August, some species occurred only in spring, some only in autumn, and others throughout the season.

When all *Culicoides* specimens were pooled, a vertical distribution with two peaks was observed. One at ground level (circa 40% of catch), one in the canopy (circa 40%). Only a few specimens were sampled in the stem space (circa 15%) and above the canopy (circa 4%). In order to demonstrate the vertical distribution of individual species, the percentage distribution in the four traps was calculated. Three flight activity patterns were demonstrated viz. species primarily active near the ground, species active from ground level into the canopy, and finally, those only active in the canopy. The very marked distribution patterns with few specimens in the stem layer might be the result of a wind funnel effect owing to the structure of the habitat.

SWARMING IN CERATOPOGONIDAE WITH PARTICULAR REFERENCE TO CANTHEROPHILIC SPECIES IN EUROPE

P. HAVELKA

The first published information on swarming in Ceratopogonids was that of Loew in 1864 who observed *Macropeza albitarsis* swarming in the evening and described the way in which the male hypopygium may be left attached to the abdomen of the female after mating.

Ceratopogonid swarms may be divided into the following groups, based on their function: (1) swarming males for mating, (2) swarming females for either bloodsucking or egglaying, (3) mixed swarms of both males and females over attractants, for example volatile oils and cantharadins.

Swarms of Ceratopogonids of different species have been found in full or half shadow between trees or other plants at heights of 5 cm to 2 m 80 cm. All swarming places are characterised by having significant markers, such as tufts of grass, stones, etc. In *Forcipomyia bipunctata* and *Atrichopogon trifasciatus* swarming is important in bringing males and females together. In *F. bipunctata* mating starts in the swarm, the couple fall to the ground where the female has been observed to walk around dragging the male behind.

Swarming females for feeding have been mostly observed over their prey or host animal. Swarms in connection with egglaying have been only rarely observed, for example in *Palpomyia nemorivaga* and *Mallochohelea inermis*. Midges have been observed swarming over non-vertebrates as well as vertebrates, e.g. oil beetles (*Meloe violaceus*). Ceratopogonids can be attracted with the powder of dried *Meloe* beetles or even with pure cantharadin crystals.

Three cantherophilic species have now been recorded in Europe: *Atrichopogon brunnipes, oedemerarum* and *lucorum*. In April 1980 a further cantherophilic species was observed in the French alps near Chamonix (Argentière) identified as *A. trifasciatus*. It was found with the well known *A. lucorum*, and some males of *lucorum* were observed trying to mate with female *trifasciatus*. Mating couples of *trifasciatus* were also observed. On at least eight occasions it was observed that the mating female of *trifasciatus* held a male *lucorum* in its forelegs as 'prey'. Another, as yet unidentified, species of *Atrichopogon* has been collected from cantharadin traps in the Iberian peninsula.

BIONOMICS OF *CULICOIDES BREVITARSIS*

D.S. KETTLE & M.M. CAMPBELL

Culicoides brevitarsis is a pest of large domestic animals in tropical and subtropical Australia, a vector of Akabane virus to cattle and a potential vector of ephemeral fever to cattle and of blue-tongue to sheep and cattle.

Female *C. brevitarsis* oviposit in dung pats of cattle lying undisturbed in the field. Eggs are deposited all over the upper surface with the greatest density being at the centre of the pat. Larval development is rapid and at summer temperatures adults emerge 11-17 days after oviposition. Peak emergence occurs in the early afternoon: – 1200-1600 h.

The main flight of males takes place in the hour before sunset and declines rapidly after sunset. In this period they form small swarms (*circa* 50) of two types – spherical ones close to the ground (0.9 m) and higher (1.8 m) columnar swarms. Swarms form at low wind speeds (1.11 ms^{-1}) over markers on sunny evenings. Cattle are not required for swarm formation but when they are present, swarms are closer together and mainly spherical. Within 10 s of a swarm being netted it is replaced by another. Similarly, swarms disperse and reform equally speedily when markers are covered and uncovered. The role of swarming in mating is unknown. Although *C. brevitarsis* is anautogenous, most nullipars (97%) collected from cattle are already inse-

minated. Biting activity begins 0.5 h before sunset and rapidly rises to a peak 0.5 h after sunset, which is followed by a steady decline to zero 6 h after sunset. Feeding is concentrated on the dorsal surface of cattle, with maximum density occurring about 40 cm from the base of the tail. From this centre numbers fall sharply down the flank and less abruptly anteriorly.

Maximum eclosion occurs between 1200-1600 hours, swarming and possible mating in the hour before sunset, and bloodfeeding reaches its maximum just after sunset. Therefore a female could emerge in the afternoon, mate before sunset and feed after sunset on the same day. As ovarian development takes 50 h and peak oviposition occurs in the afternoon, the majority of females are likely to oviposit on the third day after a blood-meal. Parous females form 48.5% of the biting population, which, on a 3-day ovarian cycle, represents a daily survival of 79%.

REPARTITION VERTICALE DES MALES DE CERATOPOGONIDES

J.P. RIEB, J.C. DELECOLLE, M. KREMER

La répartition verticale des mâles a été étudiée en forêt d'Ichtratzeim (au sud de Strasbourg) par des piègeages lumineux à U.V. Dans une expérience d'un soir (29.6.1979), un seul piège fonctionne pendant 4 heures, à partir du coucher du soleil et il est successivement placé pendant 20 minutes en 3 points: au-dessus d'un banc de vase qui est un gîte larvaire, au pied d'un arbre, au sommet de cet arbre à 12 mètres de hauteur. La somme des captures à 12 mètres de hauteur réunit 94% des mâles de *Culicoides (C. clastrieri, odibilis, cubitalis, punctatus, pictipennis. musilator, obsoletus, subfascipennis)* et 68% des mâles de *Forcipomyia*.

En 1980, nous avons utilisé 2 pièges identiques: l'un est placé au-dessus du banc de vase, l'autre est placé dans l'arbre à 13 mètres de hauteur. Les piègeages se font à partir du coucher du soleil pendant une durée de 3 heures (période à maximum de vol). 17 piègeages ont été réalisés entre le 23.4.1980 et le 24.8.1980: la répartition des mâles de *Culicoides* est de 9% en-bas et de 91% à 13 mètres de hauteur.

SURVIVAL RATES IN *CULICOIDES* ADULTS

M.H. BIRLEY

In order to manage a potential outbreak of vector-borne diseases it is necessary to determine which regions of a country are most at risk during different seasons of the year. The risk of transmission depends on the presence of vector species, their density, their survival rate and their biting rate. A robust, simple and sequential

procedure is proposed for estimating the survival and biting rate of a vector population from field data. The relative density of hungry nulliparous and parous vectors is sampled daily and a computation performed whose outcome determines whether additional data should be collected or the sampling procedure terminated. At termination, usually after about 25 days, an estimate of the average survival and biting rate is available which may be compared between locations, species and seasons. The method is particularly suitable for conditions where the population density is changing over time. When the data is collected at one location throughout a season it may be analysed further in order to demonstrate the variation in survival rates with time.

POSSIBLE MARKING TECHNIQUES FOR *CULICOIDES* MIDGES

M.D. MURRAY & J. BOORMAN

Studies on the ecology of the biting midge *Culicoides brevitarsis* in southern and eastern Australia are revealing that this insect is readily dispersed by the wind. Indeed, it appears that its mode of life is one of active flight with drifting on the wind, and a limited ability to orient to objects it may encounter – for example, host animals. Much of the movement of females takes place in the early evening and after dark, when wind drift patterns have become stratified horizontally. It would be possible to determine such dispersal if suitable marking techniques were available for carrying out mark-release experiments.

Insects have been marked with fluorescent powders, paints and dyes, and radioisotopes. Other possible methods involve marking with trace elements detectable by induced X-ray emission, but little is known of even the normal chemical composition of midges. Preliminary experiments were recently carried out at Pirbright (Surrey, England) using colonised *C. nubeculosus* and *C. varripennis*. Fluorescent powders have recently been used by Killick-Kendrick et al to mark sandflies. Midges were easily marked with powder but, when released, spent much time at rest grooming themselves; they appeared to free themselves of particles of powder easily. Despite this, some powder could be detected after 24 hours. A better method was found to be to spray cages of midges with 2% dye in 50% ethanol using a glass atomiser. Sprayed midges survived well and could be easily detected by wetting with ethanol on filter paper. The most satisfactory dyes were crystal violet, methylene blue and fluorescein. Marked midges were not wetted by plain water and midges marked eight days previously were easily detected. This method appears to be satisfactory in the laboratory and field trials are planned.

NEW LIGHT TRAPS FOR CERATOPOGONIDAE

M.W. SERVICE

Two new light traps were demonstrated that were used in both Africa and England to catch medically important Diptera including Ceratopogonidae. The first

was a chemical trap employing a plastic "Cyalume" lightstick (152 mm long) (sold in camping shops) which produces a light of about 50 ft lamberts intensity by chemiluminescence. Although appearing green in colour, the light-stick has a single spectral emission peak at 510 nm and therefore produces a considerable amount of light at the red end of the spectrum. The light lasts for about eight hours. A small fan ("Maxon" of swiss manufacture) mounted in a plastic cylinder sucks up the catch into a fine mesh collection bag. Four 1.5 volt dry cell rechargeable torch batteries connected in series and mounted in a plastic sandwich box provided power for the motor. This trap was used both inside and outside houses (Fig. 1) in Ghana and collected unfed adults of several *Culicoides* species including *C. distinctipennis, C. grahamii,* and *C. shultzei*, while in Kenya they trapped *C. distinctipennis, C. imicola, C. leucostictus, C. similis* and *C. nivosus*. In England they have caught males and unfed females of the *C. obsoletus* group *C. punctatus, C. pulicaris* and *C. impunctatus.*

These preliminary trials indicate that light produced by lightsticks attracts *Culicoides*. It should be possible to incorporate sticky compounds into the trap to retain the catch and thus make the trap independent of electricity.

A second trap was a Monks Wood light trap employing a 32 cm long fluorescent strip operated through a transistor ballast (= inverter) from a 12 volt car battery, but modified to enable the light to repeatedly flash on and off. Both ultraviolet and white

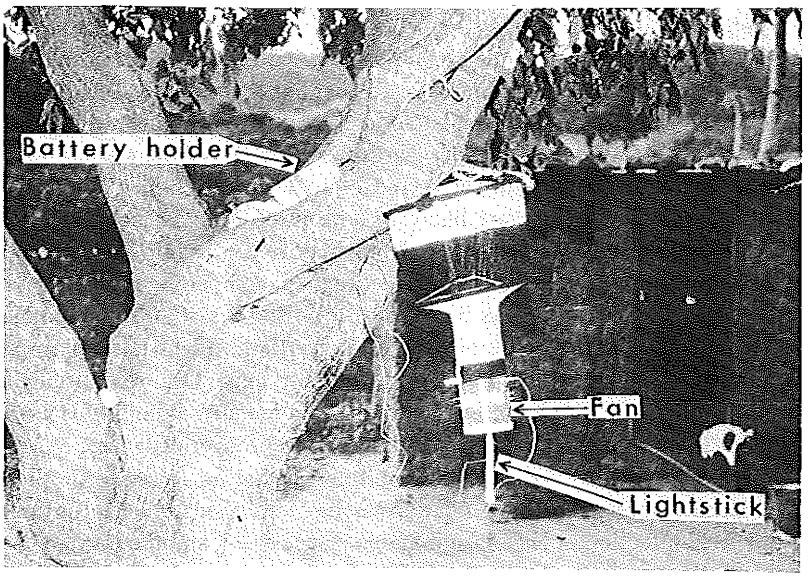

Fig. 1. The chemical light trap in operation in a village compound near Akosombo, Ghana.

light tubes can be used and the duration of the "on and "off" periods varied. In Ghana this trap caught *C. distinctipennis, Forcipomyia* sp., *Bezzia* sp., and *Atrichopogon* sp., while in Kenya, it caught *C. milnei, C. nivosus, C. leucostictus* and *C. imicola*.

In addition to Ceratopogonidae, both traps attracted several species of mosquitoes, phlebotomine sandflies and in Ghana the modified Monks Wood trap caught thousands of *Simulium squamosum*.

WINDBOURNE DISPERSAL OF VECTORS OF ANIMAL VIRUS DISEASES WITH PARTICULAR REFERENCE TO *CULICOIDES*

R.F. SELLERS

Insect-bourne animal virus diseases spread either through the movement of host or vector. In the past, most movement over long distances was attributed to movement of the host. However, there are a number of instances where movement of the host was insufficient to explain the introduction of virus and diseases to a new area.

Bluetongue (BT) and African Horse sickness (AHS) are animal virus diseases transmitted by *Culicoides* sp. Analyses of outbreaks of AHS in Cyprus (1960) and Spain (1966) indicated that the disease occurred after a spell of winds unusual for that time of year and that these winds could have carried infected *Culicoides* from areas (Turkey and Morocco) where the disease was present at the time. In 1956, BT suddenly appeared in Portugal. A likely explanation for this appearance was the unusual occurrence of a depression which moved northwards from off the west of Morocco to the west of Portugal, bringing infected midges to Portugal. Similarly, north-easterly winds from Syria and Turkey were likely to have introduced BT into Cyprus in 1965 and 1977 at a time when no animals were being imported.

The conditions for flight show that it occurs at temperatures between 15° and 35°C at the surface and to heights of 1.7 km, for distances of 200 to 800 km and for periods of up to 20 hours. Where movement is over land, flight takes place at night, when conditions are more stable and relative humidity high. Over sea, turbulance does not occur to the same extent as over land and a high relative humidity is maintained, thus flight takes place by night and day and occurs over longer distances.

Analysis of spread is difficult owing to the fact that movement of both host and vector can occur. Nevertheless, a correlation can be established between the appearance of BT and AHS infection in Nigeria and Sudan respectively, and the movements of the Intertropical Convergence Zone. Analysis of other virus diseases transmitted by *Culicoides* and mosquitoes has been made and windbourne dispersal of infected insects would appear to be common throughout the world. Based on these findings, a number of zones have been identified covering the different types of host-vector relationship and the varied occurrence of virus and disease. With virus diseases affecting ruminants, it is suggested that growth of herbage as a result of seasonal change in climate attracts the movements of animals, the insects which feed on them migrate with them and also the virus which cycles between the host and vector.

INTERDISCIPLINARY STUDIES ON THE TRANSMISSION OF SUMMER MASTITIS

S. ACHIM NIELSEN, J. BROCHNER JESPERSEN & B. OVERGAARD NIELSEN

In 1979, interdisciplinary studies on the transmission of summer-mastitis (inflamation of the udder of heifers during the summer) were initiated. The project involving bacteriologists, veterinarians, immunologists and entomologists is supported financially by the Danish Agricultural and Veterinary Research Council.

During the last 20-30 years the frequency of infection has increased in Denmark to a present annual level of 5-10%. Infection is primarily dependent on the breed of heifer.

A four year study is planned to investigate the potential role of insects including *Culicoides*, Simuliidae, Culicidae, Tabanidae and Muscidae in the transmission of the disease. Several topographically different localities are considered, the main investigations being carried out in Store Vildmose in the North of Jutland, where about 3500 heifers are grazed every year. The frequency of summer-mastitis is recorded daily.

In the studies on the biology of potential insect vectors several sampling methods are used, e.g. malaise trap, Manitoba trap, the suspended cone trap, the emergence trap, automatic light-suction trap and hand netting. On cattle, insects are caught by means of a vacuum cleaner and hand netting; further, direct observations on insect activity on the heifers are made. Air temperature, relative humidity, light intensity and wind speed are measured every ten minutes by means of a datalogger. In cooperation with bacteriologists, several insect species have been analysed for the bacteria which cause the infection.

A PRELIMINARY NOTE ON THE INDUCTION OF SALIVATION IN *CULICOIDES* MIDGES

J. BOORMAN

The successful demonstration of laboratory transmission of virus by insects is dependent both upon the readiness of insects to bite and the availability of a suitable susceptible host animal. The technique of using topically applied pilocarpine to ticks to induce salivation has been in use for several years, but the method does not seem to have been applied to biting insects.

Topical application of small amounts of 1% pilocarpine nitrate to midges induced the production of a fluid which rapidly dried to a whitish crystalline deposit on the mouthparts. A very dilute (0.004%) emulsion of malathion in water produced the same effect, but in both cases the results were erratic and less than half the insects treated produced saliva. When malathion in acetone was used, the response of the insects was faster and more uniform; about 75% of those treated reacted. The crystalline

deposit on the mouthparts of insects infected 7-9 days previously with Bluetongue virus was shown to contain virus.

Further work is in progress on these lines and the results will be published in due course.

THE USE OF THE FLUORESCENT ANTIBODY TECHNIQUE FOR THE DETECTION OF BLUETONGUE VIRUS ANTIGEN IN *CULICOIDES VARIIPENNIS*

M. JENNINGS

The indirect fluorescent antibody test (FAT) was used to detect Bluetongue virus (BTV) antigen in tissue smears prepared from laboratory infected *C. variipennis*, the North American vector of the virus. Insects were infected by inoculation. Tissue smears were prepared from the head, thorax and abdomen. Virus was detected by immunofluorescence in all three regions by day five post inoculation when the virus concentration was at least 3.0 $\log_{10}TC1D_{50}$/body part. Smears from the head were easiest to prepare and therefore the test could be carried out on this alone, leaving the remainder of the insect for investigation by other procedures if required. The technique is useful in experiments which involve the screening of large numbers of insects for possible BTV infection, for example in infection rate or transmission studies.

The possibility of using the FAT on paraffin wax sections of *Culicoides* in order to study the distribution of BTV in the insects was discussed. Preliminary experiments, to assess the effect of the histological reagents used in the preparation of paraffin wax sections on the fluorescent antibody procedure were reported.

MULTIPLICATION OF BLUETONGUE VIRUS IN CULICOIDES VARIIPENNIS SIMULTANEOUSLY INFECTED WITH MICROFILARIAE OF *ONCHOCERCA CERVICALIS* AND *O. GUTTUROSA*

P. MELLOR

Culicoides variipennis is an efficient vector of Bluetongue virus (BTV) both in the field and in the laboratory. Although *C. nubeculosus*, a close european relative, is able to transmit the virus after intrathoracic inoculation, it is totally refractory to oral infection. The virus seems unable to penetrate from the lumen of the gut into the haemocoel where replication is possible. The nature of this 'gut barrier' is unknown but it could be due to: virus inactivation by digestive juices; impermeability of the peritrophic membrane; limited number of specific virus receptor sites on the gut cell walls; a surface type defence mechanism or some totally unknown mechanism.

Following work on leafhoppers which were converted to plant virus vectors by puncturing the gut wall with a needle, the use of microfilariae to pierce the gut of

Culicoides was investigated. *C. nubeculosus* is the european vector of *Onchocerca cervicalis* and microfilaria of this parasite penetrate the hosts gut wall within two hours of ingestion and therefore might allow a significant number of virus particles to enter the haemocoel and begin replication. Batches of *C. nubeculosus* were membrane fed through a chick skin on suspensions of microfilariae and BTV in mouse blood. Subsequently, about 10% of the midges were found to have supported BTV multiplication, with a virus titre comparable with that found in the normal vector, *C. variipennis*. Transmission was then possible with no evidence of a salivary gland barrier. Similar results were obtained with double infections of *O. gutturosa* and BTV. Control experiments involving the ingestion of BTV alone by *C. nubeculosus* were invariably negative beyond two days after injection.

Although it is unlikely that helminth mediated virus transmission by *Culicoides* is commonplace, nevertheless it is a valid mechanism in this instance at least. The general principle may also be of some importance in the field since *Culicoides* transmitted filarial worms and BTV occur in the same animals in some parts of the world.

ADDRESSES OF AUTHORS

Birley, M. Dept. of Medical Entomology, Liverpool School of Tropical Medicine, Pembroke Place, Liverpool L3 5QU, England.

Boorman, J. Dept. of Entomology, Animal Virus Research Institute, Pirbright, Woking, Surrey GU24 ONF, England.

Braverman, Y. Kimron Veterinary Institute, P.O.Box 12, Bet Dagan 50200, Israel.

Campbell, M.M. Dept. of Entomology, University of Queensland, St. Lucia, Queensland, Australia 4067.

Chaker, E. Institut de Parasitologie et Pathologie Tropicale, Faculté de Médecine, 3 rue Koeberlé, F67000, Strasbourg, France.

Cornet, M. Office de la Recherche Scientifique et Technique Outre-Mer, Centre de Dakar-Hann, B.P. 1386, Dakar, Senegal.

Davies, J.E. 25 Laurel Crescent, Malpas Park, Newport, Gwent NPT 6WQ, United Kingdom.

Delecolle, J.C. Institut de Parasitologie et Pathologie Tropicale, Faculté de Médecine, 3 rue Koeberlé, F67000, Strasbourg, France.

Elson-Harris, M.M. Dept. of Entomology, University of Queensland, St. Lucia, Queensland, Australia 4067.

Frish, K. Kimron Veterinary Institute, P.O.Box 12, Bet Dagan 50200, Israel.

Glukhova, V.M. Zoological Institute, Academy of Sciences, Leningrad 199164, USSR.

Hagan, C. Dept. of Entomology, University of Queensland, St. Lucia, Queensland, Australia 4067.

Havelka, P. Institut für Okologie und Naturschutz, Bannwaldallee 32, D-7500 Karlsruhe 2, West Germany.

Ismail, M.T. Institut de Parasitologie et Pathologie Tropicale, Faculté de Médecine, 3 rue Koeberlé, Strasbourg, France.

Jennings, M. Dept. of Entomology, Animal Virus Research Institute, Pirbright, Woking, Surrey GU24 ONF, England.

Jespersen, J.B. Institute of Zoology and Zoophysiology, Zoological Laboratory, University of Aarhus, Ole Worms allé, Building 135, DK 8000 Aarhus C, Denmark.

Kettle, D.S. Dept. of Entomology, University of Queensland, St. Lucia, Queensland, Australia 4067.

Kremer, M. Institut de Parasitologie et Pathologie Tropicale, Faculté de Médecine, 3 rue Koeberlé, F67000, Strasbourg, France.

Kriegel, M. Institut de Parasitologie et Pathologie Tropicale, Faculté de Médecine, 3 rue Koeberlé, F67000, Strasbourg, France.
Lane, R.P. Dept. of Entomology, British Museum (Natural History), London SW7 5BD, England.
Linley, J.R. Florida Medical Entomology Laboratory, University of Florida, P.O.Box 520, Vero Beach, Florida 32960, U.S.A.
Mellor, P. Dept. of Entomology, Animal Virus Research Institute, Pirbright, Woking, Surrey GU24 ONF, England.
Murray, M.D. C.S.I.R.O McMaster Laboratory, Private bag No. 1. Glebe, N.S.W. 2037, Australia.
Nielsen, B.O. Institute of Zoology and Zoophysiology, Zoological Laboratory, University of Aarhus, Ole Worms allé, Building 135, DK 8000 Aarhus C. Denmark.
Nielsen, S.A. Institute of Zoology and Zoophysiology, Zoological Laboratory, University of Aarhus, Ole Worms allé, Building 135, DK 8000 Aarhus C., Denmark.
Pučať, A.M. Agriculture Canada Information Services, Sir John Carling Building, Carling Avenue, Ottawa, Ontario kIA OC5, Canada.
Reis, M. Dept. of Life Sciences, Bar Ilan University, Ramat-Gan, Israel.
Reye, E.J. CSIRO McMaster Laboratory, Private Bag No. 1, Glebe, NSW 2037, Australia
Rieb, J.P. Institut de Parasitologie et Pathologie Tropicale, Faculté de Médecine, 3 rue Koberlé, Strasbourg, France.
Sellers, R.F. Animal Virus Research Institute, Pirbright, Woking, Surrey GU24 ONF, England.
Service, M.W. Dept. of Medical Entomology, Liverpool School of Tropical Medicine, Pembroke Place, Liverpool L3 5QA, England.

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3. In treating the taxonomy of a described taxon, the following form is recommended for the beginning of a chapter.

Filippia olea (Costa, 1832) (Fig. 1)

Coccus oleae Costa, 1832:21, Green, 1863:42.

Lecanium oleae (Costa); Smith, 1892:15; Brown, 1899:20.

Filippia oleae (Costa); Fernald, 1903:13; Hall, 1943:50;

4. New taxa must be distinguished from related taxa.

5. In describing new species, the complete data of the type-series, together with the collection(s) in which it is deposited will be recorded in the original description as follows:

MATERIAL EXAMINED. Holotype ♀, Israel, Jerusalem, *Ficus carica,* 14.V.1956, G. Levi (BMNH). Paratypes, 2 ♀♀, same data as holotype, (USNM); 8 ♀♀, Tel Aviv, *Acacia* sp., G. Brown (ZTV).

6. Records of described species will be listed at the end of each relevant chapter in the following form:

MATERIAL EXAMINED: Sinai, Dahab, *Phoenix* sp., 13.V.1958, D. Cohen; Israel, Haifa, *Pistacia vera,* 20.II.1967, M. Levi.

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