calf bait at night. A single *Culex pipiens* Linnaeus was collected at the calf at night.

In conclusion, *Ae. lineatopennis* was the most common species found feeding on both human and calf bait at a dambo 2 weeks after it had flooded. *Aedes lineatopennis* showed an apparent preference for the calf where its biting activity was virtually continuous throughout the day. These observations provide support for the hypothesis that in RVF epizootic areas in Kenya cattle are initially infected with transovarially transmitted virus by *Ae. lineatopennis* shortly after dambos flood.

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References Cited

Ackermann, E. 1936. Dambos in Nordrhodesien. Wiss. Veroff. Dt. Mus. Landerke. Leipzig, NF 4:147–157.

Bailey, N.J.T. 1983. Statistical methods in biology. Hooder and Stoughton, London. 216 p.

Chandler, J.A., P.F.L. Boreham, R.B. Highton and M.N. Hill. 1976. A study of the host selection patterns of the mosquitoes of the Kisumu area of Kenya. Trans. R. Soc. Trop. Med. Hyg. 69:415–425.

Davies, F.G. and R.B. Highton. 1981. Possible vectors of Rift Valley fever in Kenya. Trans. R. Soc. Trop. Med. Hyg. 74:815–816.

Haddow, A.J. 1960. Studies on the biting habits and medical importance of East African mosquitoes in the genus *Aedes*. I.—Subgenera *Aedimorphus*, *Banksinella* and *Dunnius*. Bull. Entomol. Res. 50:759–779.

Linthicum, K.J., F.G. Davies, C.L. Bailey and A. Kairo 1983. Mosquito species succession in a dambo in an East African Forest. Mosq. News 43:464–470.

Mackel, R. 1974. Dambos: A study in morphodynamic activity on the plateau regions of Zambia. Catena 1:327–365.

Pratt, D.J., P.J. Greenway and M.D. Gwynne. 1966. A classification of East African rangeland, with an appendix on terminology. J. Appl. Ecol. 3:369–382.

Williams, C.B. 1937. The use of logarithms in the interpretation of certain entomological problems. Ann. Appl. Biol. 24:404–414.

W.H.O. 1982. Rift Valley Fever: An emerging human and animal problem. W.H.O. Offset Publication No. 63. 69 p. Geneva.

EVIDENCE FOR AUTOGENOUS EGG DEVELOPMENT IN *CULEX PIPIENS* IN BRITISH COLUMBIA

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Culex pipiens Linn. was evidently introduced into the lower mainland of British Columbia around the turn of the century (Hearle 1926) and is now an abundant species, replacing the native *Culiseta incidens* (Thomson) in temporary larval habitats and colonizing sewage lagoons and drainage ditches. Its status as a pest of humans in this area is uncertain and, although it is known to bite indoors late in the year (Belton 1983), there is little evidence that it bites people outdoors.

Our investigations in the greater Vancouver area from August to November 1983 indicate that *Cx. pipiens* will take human blood both when it enters houses and in captivity. Several authorities have suggested that specimens biting humans arise from non-hibernating 'domesticated' and primarily autogeneous populations (the so-called *molestus* form) rather than those from more rural environments that take blood from birds (the *pipiens* form). Such populations were discussed in detail at a seminar on *Cx. pipiens* held in Geneva nearly 20 years ago (see, for example, Barr 1967, Spielman 1967).

The following investigation of this topic is part of a wider study of the species in Canada that will be published in more detail elsewhere.

REARING CONDITIONS: Larvae of *Cx. pipiens*

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were collected from open pools and ditches in Richmond and Burnaby in late August. All stages were kept in a heated trailer at temperatures mainly between 24 and 26°C but reaching 32°C on the afternoons of one or two sunny days. Relative humidity varied from 54 to 80% and the light regime used was 14L:10D from 0600 to 2000 hr Pacific daylight saving time.

The larvae were reared in pans containing approximately 1 liter of tap water, its temperature varying from 21.0 to 27.6°C but mainly holding between 22 and 25°C. They were fed with ground Purina Guinea Pig Chow #5025. Pupae were picked from the larval pans daily, placed in petri dishes and transferred to adult cages. Adults reared from field-collected larvae were kept in a cage, 51 × 51 × 91 cm high, constructed from wood and wire mesh covered with a vinyl film. A sleeve on the front of the cage was large enough to admit a restrained guinea pig or hen. Second generation adults were kept in a similar cage but samples of the third generation adults were kept in ten smaller holding cages of wood or wire frame covered with fabric screening or in 15 × 15 × 15 cm (128 oz) glass jars. This generation had no access to a blood meal. Cubes of sugar and some fruit (tomato, plum or sliced apple) and water were provided in all cages.

DISSECTION. Females were dissected, five or more days after emergence, in a solution of 0.6% NaCl. Observations were made of the state of ovarian development and the presence of sperm in the spermathecae. Photographs were taken of fresh material in saline using a Jena Ergoval phase-contrast microscope with a Polaroid film back.

REARING HISTORY. The first adults were kept from August 23 to September 20. A guinea pig was provided as a blood source from 1630 (August 31) to 0930 (September 1) and a hen was provided as blood source from 1630 (September 8) to 1000 (September 9). Second generation adults were kept from September 24 to October 27 and the hen was available as a blood source on three nights. From October 22 to November 21, 424 males and 508 females emerged from egg rafts laid by the second generation and were kept in the smaller holding cages. Four hundred and fifty-one of the females were dissected between November 1 and 24.

Two females reared from field collected larvae fed on the guinea pig but did not lay eggs. Many others fed on the hen one week later and 17 egg rafts were deposited. The mean number of eggs per raft was 184±17 (S.E.) but no larvae hatched from two of the rafts; the mean percentage hatching from the remainder was 93% (range 28–100%).

A sample of adults reared from these larvae, with the opportunity to feed on the hen on three separate nights, deposited 25 egg rafts containing a mean of 213±14 eggs. Four of these rafts showed no emergence but of the remainder, 94% (range 53–100%) of the eggs hatched.

Eggs from the rafts that did not hatch showed no embryonic development and a total of six rafts from these two generations was therefore probably unfertilized. Of the remaining 36 fertilized egg rafts, six had one to five dead embryos and 28 had one to 200 infertile eggs. A *t*-test showed no significant difference ($P > 0.05$) between the number of eggs per raft and the percentage of eggs that hatched in the two generations.

The 424 males and 508 females reared from eggs of the second generation of adults, with no access to a blood meal, produced no egg rafts. Four hundred and fifty-one of the females were dissected five or more days after emergence and 32 of them had mated; 6 females were mated out of 54 in 128 oz jars (the smallest containers). The ovaries of most showed development only to the 8-cell stage (Fig. 3) but one ovary was found with three fully-developed eggs (Figs. 1 and 2). This female was dissected 11 or 12 days after emergence and had not been inseminated, but three others (out of 40) in the same cage, 20 × 20 × 20 cm, had active sperm in all three of their spermathecae.

We found no evidence that reproductively-isolated autogenous strains of *Cx. pipiens* occur in the Greater Vancouver area. The observation of one example (in 451) of autogenous egg development in an otherwise uniform culture of birdfeeding females is consistent with Barr's (1967) prediction that genes for autogeny may be found at a low level in most populations, as they seem to be in *Culex tarsalis* Coq. (Bellamy and Corbett 1973).

In Japan, similar autogenous egg development was found after blood-fed specimens of *Cx. pipiens pallens* Coq. were reared in the laboratory for five generations (Ishii 1983). Possibly, as Clements (1963) suggested, well nourished larvae may favor the expression of autogeny in adults.

Adults flew and mated in 15 × 15 × 15 cm containers but preliminary experiments to see if they would mate on contact (without being able to fly) were not successful. This characteristic may not be linked closely with autogeny or may take more generations to develop.

It is not clear from these observations how or where the *Cx. pipiens* that bother people indoors in British Columbia originate. Perhaps they have undergone selection for autogeny in as yet undiscovered warm subterranean breeding

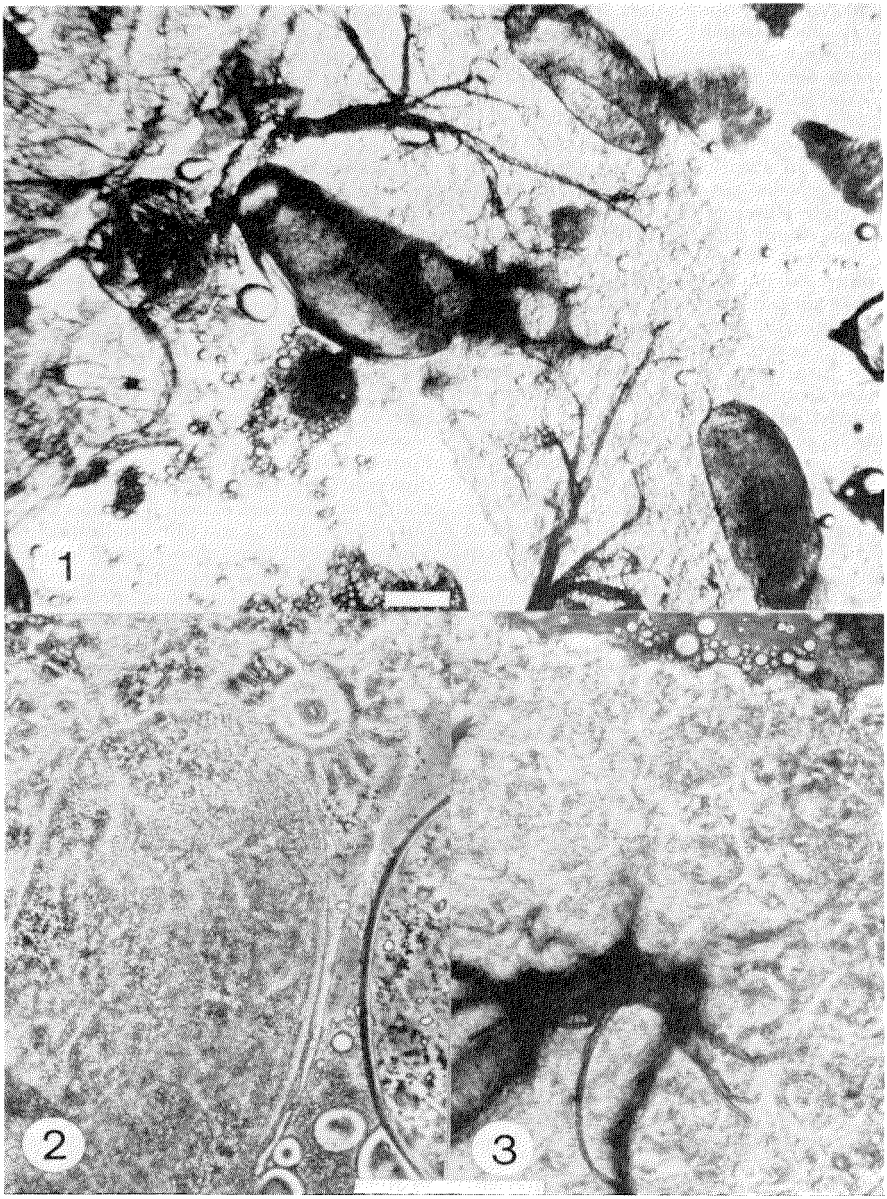

Fig. 1. Ovary showing three fully developed eggs.
Fig. 2. Lower right egg at higher magnification showing micropylar cup.
Fig. 3. Part of ovary of a different specimen showing development to the 8-cell stage, (Scale 0.1 mm, Figs. 2 and 3 at same magnification).

places, similar to the 'enclosed' sites that Spielman (1971) described in Boston. On the other hand, the observations do not rule out the possibility that normally ornithophilous, anautogenous females can enter houses and bite humans under favorable conditions.

References Cited

Barr, A. R. 1967. Occurrence and distribution of the *Culex pipiens* complex. Bull. W. H. O. 37:293–296.

Bellamy, R. E. and P. S. Corbett. 1973. Combined autogenous and anautogenous ovarian development in individual *Culex tarsalis* Coq. (Dipt., Culicidae). Bull. Entomol. Res. 63:335–346.

Belton, P. 1983. The mosquitoes of British Columbia. B. C. Provincial Museum Handbook #41. Victoria, British Columbia 189 p.

Clements, A. N. 1963. The physiology of mosquitoes. Pergamon Press, Macmillan, New York, 393 p.

Hearle, E. 1926. The mosquitoes of the Lower Fraser Valley, British Columbia, and their control. Nat. Res. Council Can. Rept. 17. 94 p.

Ishii, T. 1983. Reproductive traits of an intermediate strain between *Culex pipiens pallens* and *Cx. pipiens molestus*. (Preliminary report). Akaieka Newslett. 7:15–20.

Spielman, A. 1967. Population structures in the *Culex pipiens* complex of mosquitoes. Bull. W. H. O. 37:271–276.

Spielman, A. 1971. Studies on autogeny in natural populations of *Culex pipiens* II. Seasonal abundance of autogenous and anautogenous populations. J. Med. Entomol. 8:555–561.

AERIAL COLLECTION OF *CULICOIDES SCHULTZEI* GROUP (DIPTERA: CERATOPOGONIDAE) IN KENYA

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The feeding patterns and abundance of species of the *Culicoides schultzei* group strongly suggest that they are vectors of bluetongue and ephemeral fever viruses in Kenya, (Davies and Walker 1974, Walker and Boreham 1976). The spread of bluetongue and ephemeral fever viruses in East Africa is thought to be caused by the movement of infected *Culiocides* which become airborne during the passage of the Intertropical Convergence Zone (ITCZ) (Sellers 1980). However, there has been no direct evidence of *Culicoides* involvement in the ITCZ air movements. The ITCZ is an equatorial belt of low barometric pressure where, at low levels, air flowing from the northern and southern hemispheres converge. Within the ITCZ air rises, expands and cools, producing frequent weather activity (Lamb 1972). The zone moves in East Africa from approximately 20°N in July to 20°S in January and is comprised of a zonal (East-West) branch continuous with a meridional (North-South) branch. This paper describes attempts to make aerial insect collections within this area over Kenya.

Collections were attempted by making 3 flights (January, 7, 9 and 12, 1984) in a Cessna 150 over a 200 km² section of semi-arid bushed grassland with *Acacia* and *Combretum* tree cover (1°S, 37°E; 1500 m) in ecological zone III (Pratt et al. 1966). Each flight was made in the late afternoon and consisted of 15 minutes of collection time at 1800, 1950 and 2100 m above mean sea level. Fine mesh collection nets were placed over the cabin ports of the 2 wing ventilators when over the collection area and were replaced at each change in altitude. The intake surface area of the ventilators totalled about 26 cm². All screens and filters along each of the 30 cm long vent tubes were removed prior to the flight.

Flights were concentrated in areas of upward air movement to maximize the possibility of obtaining specimens. Updrafts were found by observing the flights of 3 species of soaring birds: the Black Kite [*Milvus migrans* (Boddaert)], the Augur Buzzard [(*buteo rufofuscus* (Forster)] and the Maribou Stork [(*Leoptoptilos crumeniferus* (Lesson)]. The velocity of each updraft was determined by noting the degree of change registered on an onboard rate of climb-descent instrument as the updraft was entered. The updrafts encountered on all flights were in the 70–240 m/min range. The plane was trimmed for a slow flight configuration with 10° extended flaps and an indicated air speed of approximately 85 kph (45 knots). The true airspeed was approximately 100 kph at the pressure altitudes and temperatures of the flights. A continuous standard rate turn (360°/2 min) was initiated upon encountering updrafts to remain within their bounds. All collection nets were returned to the laboratory after the flights for examination. The approximate alignment of the ITCZ between January 7 and 12, 1984, in relation to the collection area, is illustrated in Fig. 1.

Twelve specimens (9 males and 3 females) of the *C. schultzei* group (sensu Khamala and Kettle 1971), were collected on January 9 at 1950 m. Voucher specimens were mounted in