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

K. J. LINTHICUM AND F. G. DAVIES

U.S. Army Medical Research Unit (WRAIR), Kenya, Box 401, APO New York 09675, and Veterinary Research Laboratory, P.O. Kabete, Kenya

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 km^2 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 cm^2. 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

Euparal® (G.B.I. Laboratories, England) and examined with a compound microscope to identify species using the keys to females and males of Khamala and Kettle (1971). The 9 male specimens were identified as *C. schultzei* (Enderlein) based upon examination of the male genitalia. The 3 female specimens were identified as belonging to the *C. schultzei* group based upon the absence of radial cells and pattern of dark and pale spots on the wing. The antennae and maxillary palps were damaged. No species determination was made because the species in the group can only be separated in the female by a single variable wing pattern character. The *C. schultzei* group is comprised of *C. schultzei, C. kingi* Austen and *C. rhizophorensis* Khamala and Kettle. No specimens were collected on January 7 or 12.

The total volume of air sampled during the collection flights were approximately 580 m^3. The mean density of all insects sampled was one insect in 48.3 m^3. Rainey (1973) reported a density of one insect (predominantly Thysanoptera) in 230 m^3 in aircraft collections traversing the ITCZ at 30 m and a density of one insect (predominantly Cercopidae and Cicadellidae) in 30 m^3 in collections on a tower at 15 m during the passage of the ITCZ in Sudan. *Culicoides* spp. have been collected at altitudes up to 3000 feet (900m) in Mexico and up to 13,000 feet (4,000 m) in Louisiana (Glick 1939). *Culicoides variipennis* (Coq.), a proven vector of

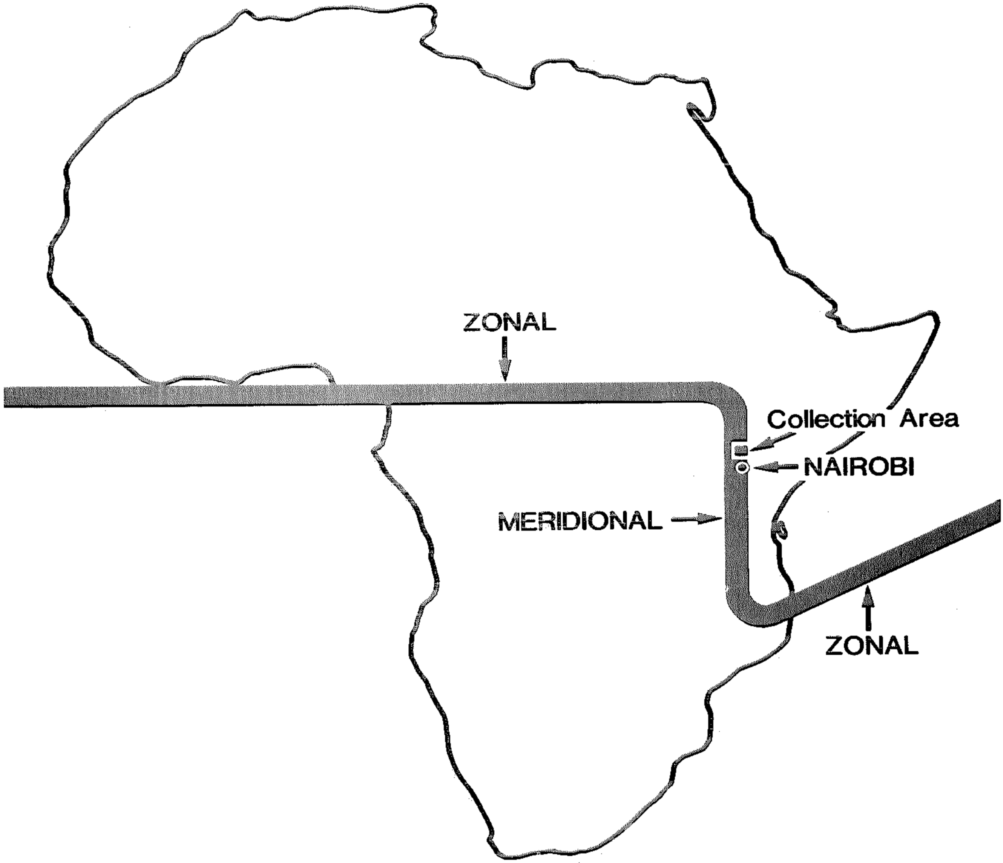

Fig. 1. The approximate alignment of the Intertropical Convergence Zone (ITCZ) between January 7 and 12, 1984 in relation to collection area. The position of the ITCZ was interpreted from surface and 850 milibar synoptic weather charts, and from visible and infrared image data collected by the satelite Meteosat 2.

bluetongue in North America, has been collected up to 1000 feet (Glick and Noble 1961). The collection of a possible vector of bluetongue and ephemeral fever virus at 1950 m (450 m above ground level) lends support to the theory that wind carriage of *Culicoides* spp. is a means of disease dissemination within the ITCZ.

The authors are grateful to Dr. M.J. Reardon and Dr. R.A. Ward for review of the manuscript and to the Kenya Meteorological Department for their assistance in interpreting the synoptic chart and Meteosat 2 data. The results are published with the approval of Dr. A.R. Njogu, Director, Kenya Trypanosomiasis Institute, Government of Kenya. This work was supported by Research Grant No. DAMD17–84G–4002 from the U.S. Army Medical Research and Development Command, Ft. Detrick, MD 21701.

References Cited

Davies, F. G. and A. R. Walker. 1974. The distribution in Kenya of bluetongue virus and antibody, and the *Culicoides* vector. J. Hyg. 72:265–272.

Glick, P. A. 1939. The distribution of insects, spiders and mites in the air. USDA Technical Bulletin 673. 151 p.

Glick, P. A. and L. W. Noble. 1961. Airborne movement of the Pink Bollworm and other arthropods. USDA Technical Bulletin 1255. 20 p.

Khamala, C.P.M. and D. S. Kettle. 1971. The *Culicoides* Latreille (Diptera: Ceratopogonidae) of East Africa. Trans. R. Entomol. Soc. London 123:1–95.

Lamb, H. H. 1972. Climate: Present, past and future. Vol. 1. Fundamentals and climate now. Methuen and Co. Ltd., London, 289 p.

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

Rainey, R. C. 1973. Airborne pests and the atmospheric environment. Weather (London) 28:224–239.

Sellers, R. F. 1980. Weather, host and vector-their interplay in the spread of insect-borne animal virus diseases. J. Hyg. 85:65–101.

Walker, A. R. and P.F.L. Boreham. 1976. Blood feeding of *Culicoides* (Diptera, Ceratopogonidae) in Kenya in relation to the epidemiology of bluetongue and ephemeral fever. Bull. Entomol. Res. 66:181–188.

EVIDENCE OF INCREASED DEVELOPMENTAL PERIOD IN LARVAE OF HOMOZYGOUS PYRETHROID-RESISTANT *CULEX QUINQUEFASCIATUS*

W. R. HALLIDAY[1] AND G. P. GEORGHIOU[2]

Division of Toxicology and Physiology, Department of Entomology, University of California, Riverside, CA 92521

The development of insecticide resistance in a population is a dynamic process influenced by many variables. Georghiou and Taylor (1976) have enumerated three main factors which influence the evolution of resistance: genetic, biological and operational (how the pesticide is applied). They pointed out that only the operational factors can be manipulated for the purpose of delaying the onset of resistance. One of the strategies that has emerged from this line of thought is the use of insecticides in optimal rotational sequences (Georghiou et al. 1983). Among the requirements for this approach is the absence of cross resistance between the insecticides that are used, and a lower biotic fitness in the resistant individuals when selection pressure by the respective insecticides is not applied.

Differences in the reproductive potential between resistant and susceptible strains of some species have been found to be small or absent (Roush and Hoy 1981, Roush and Plapp

[1] Present Address: Department of Entomology, Oregon State University, Corvallis, OR 97331.

[2] This study was supported by Special Funds for Mosquito Control Research appropriated annually by the California Legislature.