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AFROTROPICAL *CULICOIDES*: A REDESCRIPTION OF *C. (AVARITIA) KANAGAI* KHAMALA & KETTLE, 1971, REARED FROM ELEPHANT DUNG IN THE KRUGER NATIONAL PARK, SOUTH AFRICA

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ABSTRACT

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The discovery of *Culicoides kanagai* in South Africa represents a new record for this species. The female is redescribed, and the male is described for the first time. *Culicoides (A.) dasyops* Clastrier, 1958 is shown to be closely related to it but *C. (A.) alticola* is only superficially related. Short notes on the larval habitat of *C. kanagai*, the dung of the African elephant, *Loxodonta africana*, are given. The dung of both the white rhinoceros, *Ceratotherium simum*, and the black rhinoceros, *Diceros bicornis*, is considered to be a possible alternative site for the immatures of *C. kanagai*.

INTRODUCTION

The abbé J. J. Kieffer (1913) described *Culicoides alticola* from a single female collected at an altitude of between 2700 and 2800 m at the upper edge of the forest on Bismarckhügel, Kilimanjaro, Tanzania. Because of the lack of descriptive detail this species remained enigmatic until its type was rediscovered in the Paris Museum some 60 years later and redescribed by Krêmer (1972). In their review of the East African *Culicoides* Khamala & Kettle (1971) described *C. kanagai* from 2 females taken near Nairobi, Kenya. Their superficial description and the fact that, like *C. alticola*, this species had only 2 pale wing spots raised the possibility of the former being a synonym of the latter. From the descriptions it seemed as if size was the only real difference between *C. alticola* and *C. kanagai*, but the large size of *C. alticola* may have been the result of a cooler larval habitat.

Occasional specimens that were provisionally identified as *C. kanagai* have over the last 8 years been taken at light in the Kruger National Park, South Africa. The low elevation of the area (approximately 300 m) and attendant high temperatures are in contrast to the climatic regime that prevails at high altitudes on Kilimanjaro. The South African material was therefore only provisionally identified, firstly because of its small size and secondly because a search for it in the cooler mountainous regions of South Africa had thus far proved fruitless.

Greater clarity regarding these questions was reached when, from October 1985–April 1986, a field study was conducted in the Kruger National Park to investigate those species of *Culicoides* breeding in large mammal dung. This led to a study of southern African, Kenyan and Ethiopian slide material; a description of the male of *C. kanagai*; a redescription of its female; a comparison of the taxonomy and biology of *C. alticola*, *C. kanagai* and *C. dasyops*, and the conclusion that each species is unique.

MATERIALS AND METHODS

Study area (Fig. 1)

The study took place in the Kruger National Park, which has a summer rainfall. This game sanctuary of 1 945 528 ha forms almost the entire eastern boundary of the Transvaal, lying between the Crocodile River in the South and the Limpopo River in the north. Its total length south to north is a little over 380 km and its width from east to west averages 60 km. It has been divided into 35 landscape zones (Gertenbach, 1983).

The 3 main centres of study were:

(i) In the south in and around Skukuza. This falls into the landscape zone classified as thickets of the Sabie and Crocodile Rivers. It is a rather densely bushed area which lies at an altitude of 200–350 m above sea level, with an average daily maximum temperature of over 31 °C (17,5–44,5 °C) for the summer months of November to March. In winter there is a great variation between day and nighttime temperatures with sporadic frosts. The annual average rainfall for Skukuza is 546 mm. The densest population of the black rhinoceros, *Diceros bicornis*, occurs here (approx. 10/100 000 ha) and in places this species is found in sympatry with the white rhinoceros, *Ceratotherium simum* (A. Hall-Martin, personal communication, 1986). Elephant (*Loxodonta africana*) are not commonly encountered in the immediate area of Skukuza, the nearest breeding herds being in the Nwatimhiri area some 35 km to the east. Buffalo (*Syncerus caffer*) are numerous.

(ii) In the north near Punda Maria in the Shisha and Magamba areas east of the Dzundwini Hills. Although 2 or more landscape zones meet here, the dominant vegetation is *Colophospermum mopane* forest and shrubveld. The area consists largely of flat to concave plains some 300–400 m above sea level. The summers are hot to very hot (19–41,4 °C) with cool winters (9,8–36 °C). Frost is the exception. Rainfall averages between 450–600 mm per year. In the shrubveld elephant bulls are common while breeding herds will move through to other landscapes. Buffalo are present in large numbers while the rhinoceros is either rare or absent.

(iii) In the far north in the Pafuri area. Here there is also a mixture of landscape zones, the 3 most important being Punda Maria sandveld, baobab-mopane rugged veld and Limpopo-Luvuvhu floodplains. The vegetation is largely unique to the K.N.P. and includes many rare species. This generally thickly bushed area varies from being strongly undulating with many outcrops and koppies to low-lying floodplains along the Limpopo and Luvuvhurivers. *Acacia albida*/*Ficus sycomorus* forests with a closed canopy at some 20–30 m occur on their banks. This very hot area with summer temperatures of 40 °C (19–43,2 °C) and mild winters (6,7–37,2 °C) has a rainfall averaging between 450–590 mm per year. The altitude varies between 200 and 370 m above sea level. In the late summer months, following the breeding season, either lone bull elephants or small family groups will enter the area. These will be culled in winter to protect many rare plants, especially the baobab *Adansonia*

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FIG. 1 A map of the Kruger National Park indicating localities where *C. (Avaritia) kanagai* was either reared from elephant dung or collected by light- or truck-trap

digitata. Buffalo are present throughout the year but in low numbers. Neither species of rhinoceros occurs here.

Collection methods

Full details of the methods and results of this study will form the subject of another paper. Light-trapping involved the use of a commercially available modified New-Jersey-type downdraught trap fitted with an 8-watt U.V. tube. Truck-trapping was done using a trap based on the design of Dyce, Standfast & Kay (1972). Mammal dung was collected into cardboard boxes, then stored in fine gauze nets to await the emergence of *Culicoides* if present.

RESULTS

In mid-November 1985 light- and truck-trapping was done in the northern Kruger National Park in the mopane shrubveld east of the Dzundwini Hills in the Shisha and Magamba areas (Fig. 1). Here a number of *C. (A.) kanagai*, in company with 5 other species of *Avaritia*, were taken in close proximity to a breeding herd of 50 elephants. These catches suggested that *C. kanagai* and the other species were feeding on the elephants. The high percentage of midge males and nulliparous females also implied local breeding activity. Elephant dung was collected for rearing but a bout of malaria for my wife terminated the study for 3 weeks. In December, after our return to Skukuza, some 270 km south of the Dzundwini Hills area, the 1st *C. kanagai* specimens were reared in significant numbers (±120) from 2 separate lots of elephant dung collected in the vicinity of Skukuza. This discovery closed the circle of the *C. kanagai–Loxodonta africana* association.

Confirmation of this association came from the unlikely area of Pafuri 40 km north of the Dzundwini Hills (Fig. 1). Pafuri is kept free of elephants in order to spare its unique vegetation, particularly the baobab. The absence of *Loxodonta* is reflected in the fact that, after 2 seasons of light- and truck-trapping during the height of summer, no *C. kanagai* have been caught in the area. However in April 1986, at the beginning of the winter season, the 1st *C. kanagai* were reared from elephant dung collected near the anthrax camp at Pafuri. This apparent contradiction can be explained by the fact that, after the breeding season, lone elephant bulls and small family groups break away from the main herds and roam. Some of these will enter the Pafuri area but their sojourn is short-lived as they will be culled during the winter months of June and July. The rearing of *C. kanagai* during the short time that the elephants are in no man's land is further evidence linking these 2 species, indicating that the distribution of this *Culicoides* is dependent on the whereabouts of *Loxodonta*.

Finally, no *C. alticola* were reared from elephant dung or collected in light- and truck-traps in the Kruger National Park.

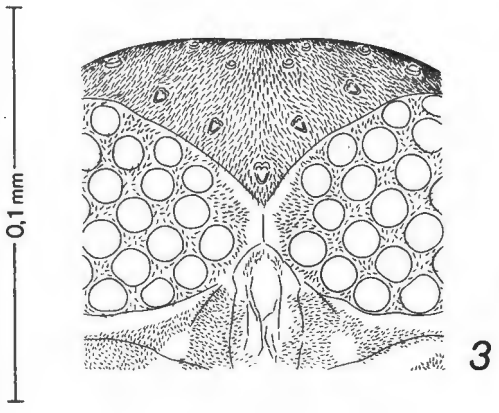
Culicoides (Avaritia) kanagai Khamala & Kettle 1971

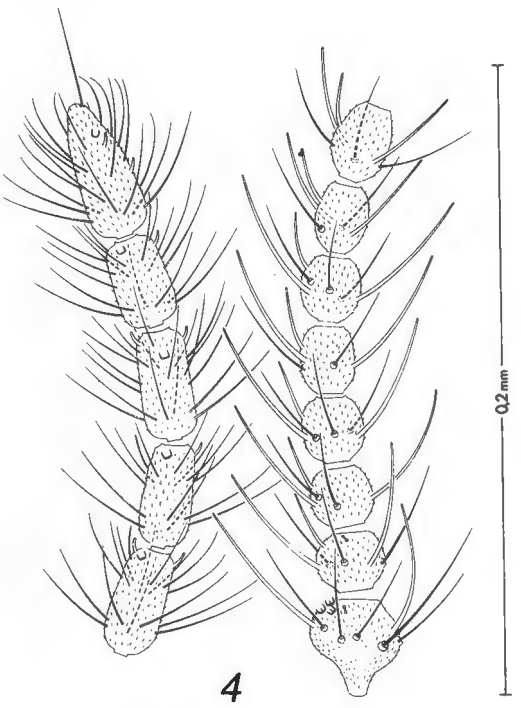
Culicoides kanagai Khamala & Kettle 1971: 49. Kenya.

Female (Fig. 2–7)

A fairly small shiny, black-brown species with a very faint wing pattern; an obvious dark spot partially covering radial cells.

Head. Eyes (Fig. 3): strongly hairy, contiguous for a distance of between 1 and 2 facets. Antenna (Fig. 4, Table 1): relative lengths of antennal segments III–XV: 13–9–9–9–9–9–9–10–15–14–14–14–18; AR 0,89–0,95 (n = 10); sensilla coeloconica on segments III, XI–XV with 3 sensilla on III and 1 on each of segments XI–XV; sensilla chaetica distribution on segments III–XV;





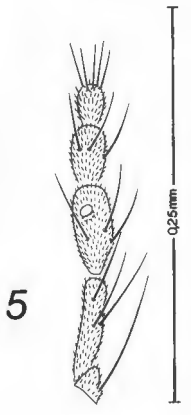


FIG. 2 *C. (Avaritia) kanagai*. Wing, female
FIG. 3 *C. (Avaritia) kanagai*. Eyes, female
FIG. 4 *C. (Avaritia) kanagai*. Antenna, female: segments XI–XV on left, segments III–X on right
FIG. 5 *C. (Avaritia) kanagai*. Palp, female

4–3–2–3–2–3–2–3–0–0–0–0–0; sensilla trichodea distribution of the LLc type i.e. each of segments IV–X with 2 long and 1 short blunt-tipped trichodea; segment III with only 2 long blunt-tipped trichodea; segments XI–XV each with 10–15 sharp-tipped sensilla trichodea of varying lengths as also 4–5 short blunt-tipped basiconica per segment. The distributions of the sensilla coeloconica, chaetica and trichodea appear in Table 1. Palp (Fig. 5): slender; relative lengths of palpal segments I–V: 7–15–15–10–10; PR 2,0–2,33, mean 2,19 (n = 11). Legs: dark brown, tibiae faintly banded subbasally; TR 1,5–1,63 (n = 12); comb on hind tibia with 5 spines, the 1st being the longest (n = 12). Wing (Fig. 2): length 0,68–0,79 mm (n = 8); breadth 0,36–0,43 mm (n = 8); CR 0,53–0,55 (n = 8); macrotrichia scanty confined to extreme distal regions of cells R5, M1 and M2 only; microtrichia dense and coarse. Wing grey, patterned with 2 almost imperceptible pale spots near or on anterior wing margin, the 1st a round spot covering r–m crossvein but not reaching anterior wing margin, the 2nd pale spot, also round, is found distad of but adjoining 2nd radial cell and anterior wing margin; a dark, obvious spot covers most of the 1st radial cell and entire 2nd cell. Abdomen (Fig. 6): 2 small pyriform spermathecae nearly equal in size 36 × 26 μm and 28 × 22 μm each with rather wide but short necks, at the base of which are a few small hyaline punctations, rudimentary 3rd spermatheca 8 × 3 μm. Common spermathecal duct 5 × 4 μm, in the shape of a rectangle and smooth, approximately half the length of the rudimentary spermatheca. Thorax: scutellum (Fig. 7) with 2 long median bristles and 1 shorter bristle on each corner (n = 11).

TABLE 1 Relative lengths and distributions of sensillae on the male and female antennae of *C. (Avaritia) kanagai*

	Antennal segments												
	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
Female:													
Sens. coeloconica	3	0	0	0	0	0	0	0	1	1	1	1	1
Sens. chaetica	4	3	2	3	2	3	2	3	0	0	0	0	0
Sens. trichodea	LL	LLc	LLc	LLc	LLc	LLc	LLc	LLc	—	—	—	—	—
Relative lengths of segments	13	9	9	9	9	9	9	10	15	14	14	14	18
Male:													
Sens. coeloconica	2	0	0	0	0	0	0	0	0	0	1	2	2
Sens. chaetica	5	0	0	0	0	0	0	0	0	0	3	2	0
Sens. trichodea	LL	LLc	LLc	LLc	LLc	c	LLc	LLc	c	c	—	—	—
Relative lengths of segments	29	15	15	15	15	15	16	16	14	12	36	30	35

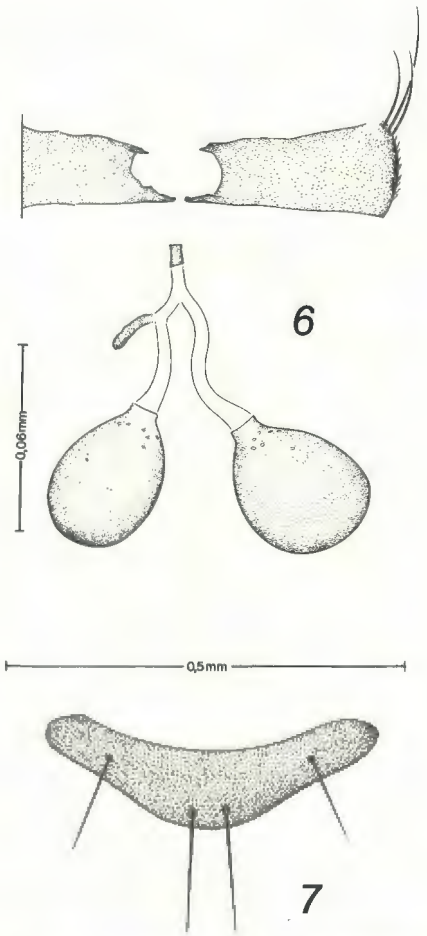


FIG. 6 *C. (Avaritia) kanagai*. Genitalia, female: spermathecae and genital sclerotization

FIG. 7 *C. (Avaritia) kanagai*. Scutellum, female

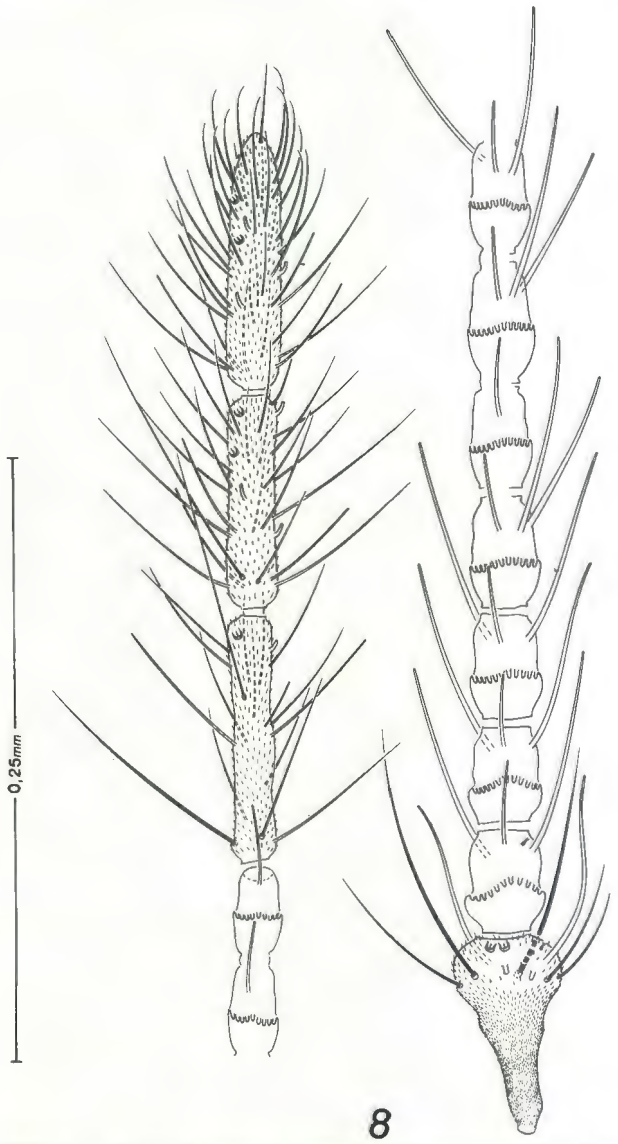


FIG. 8 *C. (Avaritia) kanagai*. Antenna, male: segments XI–XV on left, segments III–X on right

Male (Fig. 8, 9 & 10).

Black-brown as in ♀ and slender with dark, dense antennal plume; dark wing spot covering radial cells obvious; pale spots indistinct.

Head. Antenna (Fig. 8, Table 1): relative lengths of segments III–XV: 29–15–15–15–15–15–16–16–14–12–36–30–35; sensilla coeloconica distribution: 2 on segment III, 1 on XIII and 2 each on XIV and XV; sensilla chaetica distribution: 5 of varying lengths and thicknesses on segment III, 2 basally (1st long and robust, 2nd short and weak) and 1 medianally (short and weak) on XIII, 2 basally (both weak but of markedly different lengths) on XIV, 1 only on apex of XV; sensilla trichodea distribution on segments III–X: III with 2 long blunt-tipped trichodea, segments IV–VII, IX and X with 2 long and 1 short, blunt-tipped trichodea; segments VIII, XI and XII with only 1 short, blunt-tipped trichodea. The distributions of the sensilla coeloconica, chaetica and trichodea appear in Table 1. Abdomen, Genitalia (Fig. 9 & 10): 8th sternite with shallow excavation, membrane

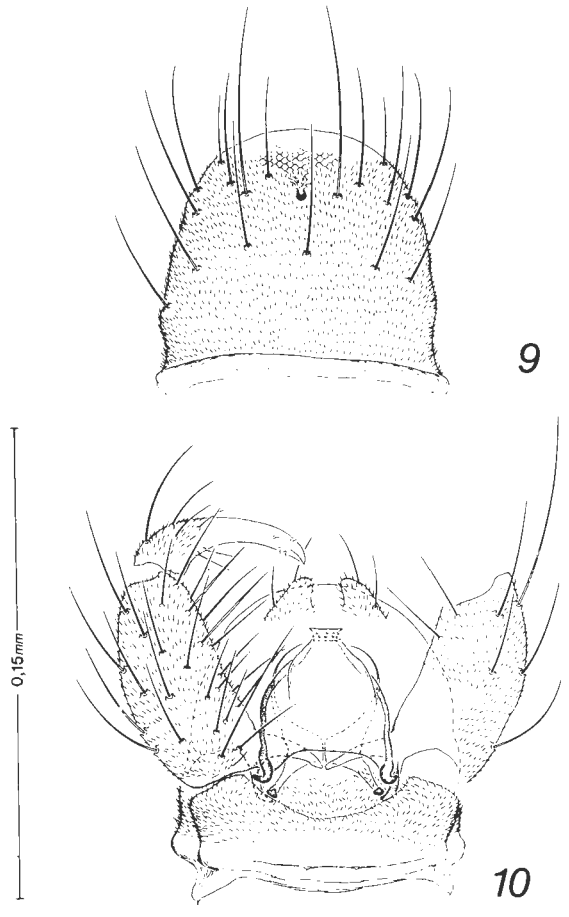


FIG. 9 *C. (Avaritia) kanagai*. Genitalia, male: setae and honeycomb pattern on tergite IX

FIG. 10 *C. (Avaritia) kanagai*. Genitalia, male

heavily spiculate right up to and beyond feet of aedeagus; 9th tergite bell-shaped, posterior margin lacking both apicolateral processes and median projection or excavation; posteromedian region of tergite with distinctive honeycomb pattern; tergite with 14–19 setae (n = 4). Basimeres 2× as long as broad and only unusual in that ventrally the entire apical half is spiculate; ventral and dorsal roots well developed of the type typically encountered in the subgenus *Avaritia*. Distimeres stout, curved, blunt-tipped with basal half hairy carrying 6 bristles of varying lengths and thicknesses; extreme apex carrying about 4 very short, fine setae. Aedeagus also bell-shaped, darkly pigmented and with a very low arch; lateral arms chitinized up to apex which is a unique flat-topped expanded projection which has a number of small but obvious papillae around its constricted 'neck'; parameres separate, stems diverging from near base being drawn out into fine, simple recurved tips.

Material examined

Kenya: C. kanagai holotype ♀, Nairobi, March 1966, C. P. M. Khamala.

Zimbabwe: 1 ♀, Rekomitjie cattle kraal, April 1974, R. J. Phelps.

South Africa: 2 ♀♀, Shingwedzi, Kruger National Park, 2. IX.1979, B. de Meillon & R. Meiswinkel, black light.

3 ♀♀ 1 ♂, Shingwedzi, K.N.P., 7–8. IX. 1984, R. Meiswinkel, G. J. Venter & I.T.P. Pajor, black light.

2 ♀♀ 1 ♂, Skukuza, K.N.P., II. III. 1984, R. Meiswinkel & L.E.O. Braack, black light.

3 ♀♀, 2 ♂♂, on H1–8 route between Klopperfontein and Masanje, northern K.N.P., 17. XI. 1985, 18h06–18h22, R. & P. Meiswinkel, truck-trap.

1 ♀, Tshalungwa springs, 20 km north of Punda Maria, northern K.N.P., 7. XI. 1985, 18h30–20h00, L.E.O. Braack & R. Meiswinkel, black light.

15 ♀♀ on H1-7 route east of Dzundwini Hills between Shisha and Magamba, northern K.N.P., 19. XI. 1985, 18h26–18h40, R. & P. Meiswinkel, truck-trap.

12 ♀♀ 4 ♂♂ on H1-7 route between Shisha and Magamba, Northern K.N.P., 20. XI. 1985, 18h30–23h00, R. Meiswinkel, black light.

33 ♀♀ 28 ♂♂ on H2-2 route 20 km east of Pretoriuskop, southern K.N.P., 10. XII. 1985, R. & P. Meiswinkel, ex elephant dung.

30 ♀♀ 21 ♂♂ on H4-1 route 7 km east of Skukuza, southern K.N.P., 9. XII. 1985, R. & P. Meiswinkel, ex elephant dung.

12 ♀♀ 6 ♂♂ on S114 route near Renosterkoppiesdam, southern K.N.P., 18. XI. 1986, R. & P. Meiswinkel, ex elephant dung.

15 ♀♀ 18 ♂♂ on S36 route near Hlangulene, central K.N.P., 26. XI 1986, R. & P. Meiswinkel, ex elephant dung.

6 ♀♀ near old anthrax camp, Pafuri, northern K.N.P., 10. IV. 1986, R. & P. Meiswinkel, ex elephant dung.

Discussion

Taxonomy

In the Afrotropical region 3 species in the subgenus *Avaritia* have the pale wing spots either poorly defined or restricted to 2 spots on the anterior margin only. These species are *C. alticola, C. dasyops* and *C. kanagai*.

As suggested earlier a study of the literature on *C. alticola* and *C. kanagai*, hitherto known from females only, gave the impression that these 2 species were synonymous. There was, however, one tangible difference between the 2: *C. alticola* had a wing-length (1,26 mm) nearly twice that recorded for *C. kanagai* (0,72 mm). The question therefore arose as to whether or not this was merely a size variation resulting from a cooler larval habitat at altitude.

Recently, though, a study of more than 20 specimens (on loan from the United States National Museum) of both sexes of *C. alticola* s.s., taken in Ethiopia at an altitude of 2400 m (8000 ft), clearly showed that *C. alticola* and *C. kanagai* are 2 good species, with the former being considerably larger. In fact they belong to different groups within the subgenus *Avaritia*, which is not apparent when one compares the descriptions of Khamala & Kettle (1971) and Krêmer (1972). *C. alticola* will be redescribed elsewhere.

C. (A.) dasyops is, however, closely related to *C. kanagai*. Unfortunately the holotype of *C. dasyops* has dried out (J. Clastrier, personal communication to A.L. Dyce, 1987). From the description it is apparent that there are real differences between the males of these 2 species, as follows:

(i) in *C. dasyops* there are 2 long sensilla trichodea on each of male antennal segments III–XII, in *C. kanagai* these 2 long trichodea are absent from segments VIII, XI and XII.

(ii) the male genitalia of *C. dasyops* are described as having the posterior margin of the 9th tergite smoothly rounded and lacking apicolateral processes; in *C. kanagai* the 9th tergite also lacks apicolateral processes, is also smoothly rounded posteriorly but differs in being posteromedianally

adorned with a conspicuous honeycomb pattern (Fig. 9) not recorded by Clastrier for *C. dasyops*;

(iii) the apex of the aedeagus also differs between the 2 species: in *C. dasyops* it is illustrated as rounded with only the vaguest hint of papillae; in *C. kanagai* the apex of the aedeagus has a clearly constricted, strongly papillose neck which expands into a posteriorly flattened head.

Biology

Earlier it was stated that there is an interdependence between *kanagai* and the African elephant, *L. africana*. This is borne out by the fact that these midges are most abundantly captured in the vicinity of elephants and are absent where these animals do not occur, also because they have more than once been reared from elephant dung. It should be added that the dispersal of *C. kanagai* appears to strongly depend on the seasonal treks of breeding herds and the roaming of lone bulls and small bachelor herds. This explains the fluctuating presence and absence of this species in the small area of Pafuri and why it is not found in large parts of South Africa.

Having established the need of the immatures of *C. kanagai* for a specific breeding medium, how does one explain the capture of this species in the vicinity of Nairobi where no elephants occur? It is here suggested that the dung of either the white rhinoceros (*C. simum*) or the black rhinocerous (*D. bicornis*) will be found to be a suitable habitat for the immatures of *C. kanagai*. In South Africa the dung of the commoner white rhinoceros has, both in the Transvaal and Natal, yielded 3 other species of *Avaritia* also commonly found in elephant dung. Considering the similarity of the eliminate of the 3 large mammals *Loxodonta, Ceratotherium* and *Diceros* it is probably only a matter of time before *C. kanagai* will also be reared from rhinoceros dung. It is well known that the Nairobi National Park, from which the city skyline can be seen, has for the last 20 years or so held between 15–20 black rhinoceroses (A. Hall-Martin, personal communication, 1986). Their dung may well have been the source for Khamala & Kettle's *C. kanagai* which has Nairobi as its type locality.

Elephant are known to occur right up to the snowline at 5000 m (16000 ft) on Kilimanjaro (A. Hall-Martin, personal communication, 1986), where they have been estimated 'to have a population in the order of 1500' (J.F. Millard, unpublished observations cited by Child, 1965). Even though they also undertake seasonal movements up and down the mountain it must not be assumed that *C. alticola*, like *C. kanagai* in the Kruger National Park, has elephant dung as its larval habitat. Furthermore the collection of *C. alticola* in Addis Ababa points to it having no connection with elephant whatsoever as the nearest tuskers are some 300 km away. More correctly *C. alticola* is a high altitude forest species.

It is interesting to note here that in West Africa there is a savanna form of the African elephant (*Loxodonta africana oxyotis*) which is represented by about 500 desert-adapted elephants in the unproclaimed Gourma Reserve in Mali and by only a small pocket of 40 nearby in the Niokolo-Koba National Park, Senegal (Bosman & Hall-Martin, 1986), which is the type locality of *C. dasyops* (Clastrier, 1958; 1961). Thirty years ago, when *C. dasyops* was collected, the elephants there were numbered in their hundreds (A. Hall-Martin, personal communication, 1986). It is almost certain that their dung is the larval habitat of *C. dasyops*.

ACKNOWLEDGEMENTS

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