

AFROTROPICAL *CULICOIDES*:  
BIOSYSTEMATICS OF THE IMICOLA GROUP,  
SUBGENUS *AVARITIA*  
(DIPTERA: CERATOPOGONIDAE)

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ACKNOWLEDGEMENTS

1.	CONTENTS	.....	i
	SUMMARY	.....	viii
	ABSTRACT/OPSOMMING	.....	x
1.1	INTRODUCTION AND PURPOSE OF STUDY	.....	1
1.2	MATERIALS AND METHODS	.....	7
1.2.1	Collecting methods	.....	7
1.2.2	Mounting <i>Culicoides</i> on glass slides	.....	8
1.2.2.1	Disadvantages of current methods	.....	8
1.2.2.2	Improvements made to current methods	.....	11
1.2.2.3	Coverslipping	.....	13
1.2.3	Species descriptions	.....	14
1.2.4	Taxonomic characters and ratios	.....	16
1.2.5	Illustrations	.....	20
1.3	REFERENCES	.....	22
1.4	TABLES	.....	26
2.	A redescription of <i>C. (Avaritia) imicola</i> Kieffer, 1913 and <i>C. (A.) bolitinos</i> Meiswinkel, 1989, the latter reared from the dung of the African buffalo, blue wildebeest and cattle in South Africa (Diptera: Ceratopogonidae)		
2.1	INTRODUCTION	.....	34
2.2	MATERIALS AND METHODS	.....	37

2.3	RESULTS	38
2.3.1	<i>C. imicola</i> : female	38
	<i>C. imicola</i> : male	40
2.3.2	<i>C. bolitinos</i> : female	44
	<i>C. bolitinos</i> : male	46
2.4	DISCUSSION	61
2.4.1	Taxonomy	61
2.4.2	Larval habitat	64
2.5	CONCLUSION	66
2.6	REFERENCES	66
2.7	TABLES	70
3.	Morphological comparison of <i>Culicoides (Avaritia) nudipalpis</i> Delfinado, 1961 and <i>C. (A.) imicola</i> Kieffer, 1913: reappraisal of their separate species status	
3.1	INTRODUCTION	78
3.2	MATERIALS AND METHODS	79
3.2.1	Statistical analyses	80
3.3	RESULTS	80
3.4	CONCLUSION	85
3.5	REFERENCES	87
3.6	TABLES	89
4.	<i>Culicoides (Avaritia) miombo</i> Meiswinkel, 1991, a widespread species closely allied to <i>C. (A.) imicola</i> Kieffer, 1913	
4.1	INTRODUCTION	91
4.2	RESULTS	92
4.2.1	Phytochoria with which <i>C. miombo</i> is associated	93
4.2.2	Type locality	94

4.2.3	<i>C. miombo</i> : female	99
	<i>C. miombo</i> : male	107
4.3	DISCUSSION	114
4.3.1	Taxonomy	114
4.3.2	Differential diagnosis	115
4.3.3	Larval habitat	118
4.3.4	Vector status	118
4.3.5	Distribution	119
4.4	CONCLUSIONS	120
4.5	REFERENCES	120
4.6	TABLES	124

5. *Culicoides (Avaritia) loxodontis* Meiswinkel, 1992, a member of the Imicola group associated with the African elephant (*Loxodonta africana*)

5.1	INTRODUCTION	132
5.2	MATERIALS AND METHODS	133
5.3	RESULTS	135
5.3.1	<i>C. loxodontis</i> : female	135
	<i>C. loxodontis</i> : male	140
5.4	DISCUSSION	148
5.4.1	Taxonomy	148
5.4.2	Differential diagnosis	148
5.4.3	Larval habitat	154
5.4.4	Distribution	155
5.5	CONCLUSION	158
5.6	REFERENCES	159
5.7	TABLES	161

6.	A redescription of <i>Culicoides (Avaritia) pseudopallidipennis</i> Clastrier, 1958 with description of its fruit-inhabiting sister species <i>C. (A.) tuttifrutti</i> sp. nov.		
6.1	INTRODUCTION	.....	167
6.2	MATERIALS AND METHODS	.....	168
6.2.1	Statistical analyses	.....	169
6.3	RESULTS	.....	169
6.3.1	Brief notes on holotype and paratypes of <i>C. pseudopallidipennis</i>	..	169
6.3.2	<i>C. pseudopallidipennis</i> : female	.....	172
	<i>C. pseudopallidipennis</i> : male	.....	174
6.3.3	<i>C. tuttifrutti</i> sp. nov.: female	.....	177
	<i>C. tuttifrutti</i> sp. nov.: male	.....	180
6.4	DISCUSSION	.....	194
6.4.1	Differential diagnosis	.....	194
6.4.2	Taxonomy	.....	198
6.4.3	Distribution	.....	199
6.4.4	Abundance and prevalence	.....	201
6.5	CONCLUSION	.....	202
6.6	REFERENCES	.....	202
6.7	TABLES	.....	204
7.	<i>Culicoides (Avaritia) kwagga</i> sp. nov., a potential vector of African horsesickness virus (AHSV) reared from the dung of the plains zebra, the white rhinoceros and the horse in South Africa		
7.1	INTRODUCTION	.....	216
7.2	RESULTS	.....	217
7.2.1	<i>C. kwagga</i> sp. nov.: female	.....	217
	<i>C. kwagga</i> sp. nov.: male	.....	222
7.3	DISCUSSION	.....	230
7.3.1	Differential diagnosis	.....	230

7.3.2	Taxonomy: brief history of its discovery and larval habitat . . . . .	232
7.3.3	Seasonal prevalence . . . . .	235
7.3.4	Abundance . . . . .	239
7.3.5	Distribution . . . . .	239
7.4	CONCLUSION . . . . .	240
7.5	REFERENCES . . . . .	241
7.6	TABLES . . . . .	242
8.	African horsesickness epidemiology: five species of <i>Culicoides</i> collected live behind the ears and at the dung of the African elephant in the Kruger National Park, South Africa	
8.1	INTRODUCTION . . . . .	250
8.2	MATERIALS AND METHODS . . . . .	252
8.2.1	Culling sites, vegetation and prevailing weather . . . . .	252
8.2.2	Elephant culling . . . . .	255
8.2.3	Collection of <i>Culicoides</i> . . . . .	255
8.2.4	Age-grading . . . . .	256
8.2.5	Taxonomy . . . . .	256
8.3	RESULTS AND DISCUSSION . . . . .	256
8.3.1	What is known about the wild host preferences of Afrotropical <i>Culicoides</i> ? . . . . .	256
8.3.2	Live <i>Culicoides</i> found behind the ears of elephants . . . . .	259
8.3.3	Live <i>Culicoides</i> attracted to the intestinal dung of disembowelled elephants . . . . .	262
8.3.4	Geographic distribution of dung-inhabiting <i>Culicoides</i> species . . . . .	265
8.3.5	Light-trapping . . . . .	266
8.3.6	Taxonomy . . . . .	268
8.4	CONCLUSIONS . . . . .	271
8.5	REFERENCES . . . . .	272
8.6	TABLES . . . . .	277

9.	African horsesickness epidemiology: A two-year light-trap survey of the <i>Culicoides</i> of the southern Kruger National Park and adjoining livestock farms in the eastern Transvaal lowveld, South Africa	
9.1	INTRODUCTION	282
9.2	MATERIALS AND METHODS	284
9.2.1	Light-trap collections	284
9.2.2	Classification of sites	286
9.2.3	Subsampling and classification of species	286
9.2.4	Discussion of species	288
9.3	RESULTS	288
9.4	<i>CULICOIDES</i> IN THE SATARA AREA	298
9.5	CONCLUSIONS	299
9.6	AHS EPIDEMIOLOGY IN SOUTH AFRICA	301
9.7	REFERENCES	307
9.8	TABLES	313
10.	The 400 km <sup>2</sup> sandy dune field west of Port Elizabeth: the only <i>Culicoides imicola</i> -free zone in South Africa?	
10.1	INTRODUCTION	326
10.2	MATERIALS AND METHODS	327
10.2.1	Climate	328
10.2.2	Geomorphology	328
10.2.3	Vegetation	329
10.3	RESULTS AND DISCUSSION	329
10.4	CONCLUSIONS	331
10.5	RECOMMENDATIONS	332
10.6	REFERENCES	333
10.7	TABLES	335



11. Subgenus *Avaritia* Fox, 1955: Redescription of the *Orientalis* and *Imicola* groups based on morphological separation of the adults (*Culicoides*; Diptera: Ceratopogonidae)

11.1 INTRODUCTION	338
11.2 MATERIALS AND METHODS	340
11.3 RESULTS AND DISCUSSION	341
11.3.1 Character states defining the <i>Orientalis</i> and <i>Imicola</i> groups	342
11.3.2 Anomalies in the literature on the <i>Orientalis</i> group	354
11.4 CONCLUSIONS	360
11.5 REFERENCES	362
11.6 TABLES	366

12. Subgenus *Avaritia* (*Culicoides*; Ceratopogonidae): key to nine world species of the *Imicola* group

12.1 INTRODUCTION	374
12.2 KEY	375

## SUMMARY

Bloodsucking flies of the genus *Culicoides* Latreille, 1809 came to world prominence in 1944 when Du Toit's research at Onderstepoort revealed that *C. imicola* Kieffer, 1913 transmitted the orbiviruses of bluetongue (BT) and African horsesickness (AHS); *C. imicola* is not only the most effective vector of these viruses in the Old World but it is also the most widespread species. To date, some 50 viruses have been isolated from species of the genus worldwide, and also certain filarial and protozoal parasites.

*Culicoides* are found almost anywhere on earth; there are  $\pm$  1 300 described species in 27 subgenera. One of these subgenera, *Avaritia* Fox, 1955 was erected for the distinctive Holarctic *Obsoletus* group. The taxonomy of *Avaritia* is complex as it comprises at least 10 species groups; 75 % of the 70 known world species are found in the Afrotropical and Oriental Regions. The *Imicola* group is the most important; its biosystematics form the subject of this thesis.

Fiedler (1951) recorded 22 species of *Culicoides* from South Africa. During this study, 112 species were collected; 23 belong to the subgenus *Avaritia*. While half are new to Science only the true congeners of *C. imicola*, constituting the *Imicola* group, are treated here. Due to confusion in the literature, the *Imicola* and *Orientalis* groups are redefined and distinguished, and nine Old World species are assigned to the firstnamed group (Chapter 11). The five presently recognized African species, i.e. *C. imicola*, *C. pseudopallidipennis* Clastrier, 1958, *C. bolitinos* Meiswinkel, 1989, *C. miombo* Meiswinkel, 1991 and *C. loxodontis* Meiswinkel, 1992, are redescribed (Chapters 2, 4–6), and two new species, *C. tuttifrutti* sp. nov. and *C. kwagga* sp. nov. described (Chapters 6, 7). The remaining two species, *C. brevitarsis* Kieffer, 1917 and *C. nudipalpis* Delfinado, 1961, occur outside Africa and are briefly compared with, and distinguished from, their respective sister species *C. bolitinos* (Chapter 2) and *C. imicola* (Chapter 3).

In Europe, the immature stages of three *Avaritia* species were first shown to inhabit animal dung (Kettle & Lawson 1952); later, in Australia, the abundant *C. brevitarsis* of the *Imicola* group was also reared from cattle dung. Coprophily in *Culicoides* occurs on all continents but is exclusive to some 10 species. These coprophiles are scattered amongst six of the 10 groups in *Avaritia*; four of them belong in the

Imicola group.

A bloodsucking insect developing in the dung of an animal is but a few wingbeats away from biting that animal; the transmission of viruses may form part of this association. Despite African diseases affecting domesticated livestock being harboured by indigenous game animals, no research has been done on *Culicoides* associated with wild herbivores in Africa. This thesis, to a modest extent, examines this association (Chapter 8). Emphasis is placed on unravelling the life-cycles of three species inhabiting the dung of the elephant, both species of rhinoceros, the buffalo, the blue wildebeest and the plains zebra (Chapters 2, 5 and 7); two of these have expanded their resource range and adapted to the dung of domesticates i.e. cattle and horses. This has obvious implications for disease transmission.

The study included a two-year survey of the *Culicoides* of the eastern Transvaal lowveld, the African horsesickness ‘hotspot’ of South Africa. Not only was the *Culicoides* fauna of a wilderness area (the Kruger National Park) compared with that found on adjoining farms, but the prevalence and abundance patterns of six species of the Imicola group were also investigated. This study reveals that Man can drive species to local extinction or cause a species to become widespread and superabundant (Chapter 9). In Chapter 10 the first *imicola*-free zone found in Africa is described. This has positive benefits as regards quarantining against AHS, and the holding of gymkhana events both local and international.

Collection methods involving light-trapping, truck-trapping and rearing from dung are briefly described. To improve observation and measurement of bodyparts, to obtain data of statistical value, and to facilitate greater accuracy during illustration, emphasis is placed on the study of long series of both sexes of a species, and on upgrading methods traditionally used in slide-mounting. Weaknesses in the descriptive format currently in use for world *Culicoides* are also addressed, and some new character states are employed (Chapter 1).

Finally, a key is provided for both sexes of the nine known species of the Imicola group (Chapter 12).

## ABSTRACT

A biosystematic study of seven Afrotropical and two Oriental species of the *Imicola* species-group was undertaken; this group of *Culicoides* of the subgenus *Avaritia* includes *C. imicola* the most important vector of the viruses of bluetongue (BT) and African horsesickness (AHS) known in the Old World.

Five African species are redescribed i.e. *C. imicola*, *C. pseudopallidipennis*, *C. bolitinos*, *C. miombo* and *C. loxodontis*. Two new species are described, and the extralimital *C. brevitarsis* and *C. nudipalpis* are discussed where relevant. These nine species comprise the *Imicola* group, one of 10 groups constituting the subgenus worldwide. Due to confusion in the literature, the *Imicola* group is redefined and distinguished from the *Orientalis* group (also redefined); 21 species of approximately 70 world species of *Avaritia* are reassigned to either of the two groups. A key to all nine known species of the *Imicola* group is given; shortcomings in the taxonomy of the *Orientalis* group are discussed.

The adult morphology of both sexes of the nine *Imicola* group species was studied; this revealed deficiencies in the descriptive format currently used in taxonomic studies of world *Culicoides*. Accordingly, greater detail has been introduced into descriptions and includes the use of new character states. Methods for mounting *Culicoides* on glass slides are also improved to ensure more accurate observation and measurement of diagnostic taxonomic features; furthermore, the descriptions are based on long series of each sex. Illustrations were made from specimens mounted symmetrically, and no feature omitted from any bodypart illustrated.

Certain aspects of the life-cycle of most species were investigated but especially those of *C. bolitinos*, *C. loxodontis* and *C. kwagga*. The immatures of these develop exclusively in the dung of the elephant, the buffalo, the blue wildebeest, both species of rhinoceros and Burchell's zebra. Two of these species, *C. bolitinos* and *C. kwagga*, have broadened their resource range as they can invade and mature in the dung of cattle and horses. This has obvious implications for the transmission of viruses, especially where indigenous herbivores are run with domesticated livestock.

In an intensive two-year survey a comparison was made between the *Culicoides* fauna of a natural area,



the Kruger National Park (KNP), and that found in areas changed by Man, namely livestock farms adjoining the KNP. This part of the eastern Transvaal lowveld is a main focus of AHS in South Africa. Light-trapping, rearing from dung, and pootering off live hosts, revealed that some species of the *Imicola* group are exclusively associated with certain herbivores; these include the elephant and the zebra which are suspected or proven reservoir hosts for AHS. The results thus throw further light on the epidemiology of this disease, and also show that Man plays a decisive role in determining the numbers, and distribution, of particular *Imicola* group species under certain conditions. In the case of *C. imicola*, the commonest and most widespread of all species, this range expansion, or establishment of foci, is due to man's maintenance of domesticated livestock in confined species, and especially where these are kept on irrigated pastures. However, the serendipitous discovery of a large *imicola*-free zone in South Africa indicates that edaphic conditions likely play an even more important role than Man and climate in determining the prevalence and abundance of *C. imicola*. This area is the sandy dune field west of Port Elizabeth and holds promise as a natural quarantine zone for the import and export of livestock.

## OPSOMMING

'n Biosistematiese ondersoek van sewe Afrotropiese en twee Orientale spesies van die *Imicola* groep is gedoen; by hierdie groep *Culicoides* van die subgenus *Avaritia* word *C. imicola* wat as die mees belangrikste vektor van bloutong-(BT) en perdesiekte (AHS) virus in die Ou Wêreld beskou word, ingesluit.

Vyf Afrika spesies, nl. *C. imicola*, *C. pseudopallidipennis*, *C. bolitinos*, *C. miombo* en *C. loxodontis*, is herbeskryf. Twee nuwe spesies is beskryf asook die suid-oos Asiese spesies *C. brevitarsis* en *C. nudipalpis* word bespreek waar van toepassing. Hierdie nege spesies vorm die *Imicola* groep, een van die 10 groepe waaruit die subgenus *Avaritia* wêreldwyd bestaan. As gevolg van verwarring in die literatuur is die *Imicola* groep hergedefinieer en geskei van die *Orientalis* groep (ook hergedefinieer); 21 spesies van ongeveer 70 wêreld spesies van *Avaritia* is heringedeel in die twee groepe. 'n Sleutel vir al nege wêreld spesies van die *Imicola* groep, asook 'n verspreidingskaart vir elke spesie, word gegee. Tekortkominge in die taksonomie van die *Orientalis* groep word ook bespreek.

Die volwasse morfologie van beide geslagte van die nege *Imicola* groep spesies is bestudeer; dit het gebreke in die formaat wat tans vir die taksonomiese beskrywing van wêreld *Culicoides* gebruik word aan die lig gebring. Gevolglik is daar meer data in die beskrywings, wat nuwe karakterkenmerke insluit. Die metode van die montering van *Culicoides* op glasplaatjies is ook verbeter om meer akkurate ondersoek en meting van die diagnostiese kenmerke te verseker; verder, is beskrywings gebaseer op lang reekse van elke geslag. Illustrasies is gemaak van voorbeelde wat simmetries gemonteer is en geen kenmerk is uitgelaat van enige geïllustreerde liggaamsdeel.

Aspekte van die lewensiklus van die meeste van die spesies, veral *C. bolitinos*, *C. loxodontis* en *C. kwagga* is ondersoek. Die onvolwassenes van hierdie spesies ontwikkel slegs in die mis van olifante, buffels, wildebeeste, renosters en zebras. Twee van die spesies, *C. bolitinos* en *C. kwagga*, het hulle broeimediums van voorkeur vergroot en kan eiers lê en tot volwassenheid ontwikkel in die mis van beeste en perde. Dit het vanselfsprekende gevolge vir virusoordrag tussen inheemse herbivore en vee, veral in gebiede waar die twee groepe saamloop.

In 'n intensiewe twee-jaar studie, is 'n vergelyking gemaak tussen die *Culicoides* fauna soos aangetref in 'n ongerepte deel van Afrika, die Kruger Nasionale Park (KNP), en in gebiede aangrensend aan die KNP wat deur die mens in veeplase omskep is. Die deel van die Oos Transvaalse laeveld is bekend as 'n perdesiekte "hotspot" in Suid-Afrika. Ligvalvangste, uitbroei van *Culicoides* uit mis en versameling vanaf lewendige gashere het aangedui dat sekere spesies van die Imicola groep eksklusief met sekere herbivore geassosieer is; hierby ingesluit is die olifant en zebra wat onderskeidelik verdagte en bevestigde gashere van AHS is. Die resultate dra by tot die verklarings van die epidemiologie van hierdie siekte en wys ook dat die mens 'n beslissende rol speel in die vasstelling van die getalle sowel as die verspreiding van spesifieke spesies van die Imicola groep. In die geval van *C. imicola*, die mees algemeenste en wydverspreidste spesie, is die uitbreiding, of daarstelling van fokuspeunte, te wyte aan die mens se instandhouding van vaste bloedbanke op besproeide weiding. Die toevallige ontdekking van 'n groot *imicola*-vry sone elders in Suid-Afrika dui daarop dat grondtipe moontlik 'n bepalende rol kan speel in die aanwesigheid en volopheid van *C. imicola*. Hierdie "skoon" area is die sandduine-veld wes van Port Elizabeth en lyk belowend as 'n natuurlike kwarantyn gebied vir die invoer en uitvoer van lewende hawe.