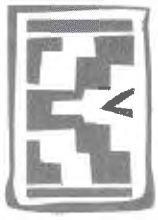

Some factors governing the entry of *Culicoides* spp. (Diptera: Ceratopogonidae) into stables

B.J.H. BARNARD

Onderstepoort Veterinary Institute, Private Bag X5
Onderstepoort, 0110 South Africa

ABSTRACT

BARNARD, B.J.H. 1997. Some factors governing the entry of *Culicoides* spp. (Diptera: Ceratopogonidae) into stables. *Onderstepoort Journal of Veterinary Research*, 64:227–233

The entry of *Culicoides* species into stables was examined by comparing the numbers of midges caught with identical light-traps under different conditions. The comparison was made between collections made inside an empty stable, a regularly cleaned stable and a dirty stable and those made outside the stables in a sleeping space open on two sides. The work was first done in the presence of cattle and sheep in adjoining paddocks and then repeated in their absence.

A positive correlation was found between the numbers of *C. imicola* females caught out of doors and inside a clean stable. Removal of the cattle and sheep resulted in a reduction in the numbers of *C. imicola* caught inside and outside the stables. In contrast, the numbers of *Culicoides* spp. that prefer to feed on birds was not affected by the removal of the cattle and sheep. Their entry into the stable was proportionate to the size of the entrances into the sleeping space and the size of the stable door and presumably occurs passively. On the other hand, the numbers of *C. imicola* females entering the same stables were somewhat enhanced by the presence of horses inside the stables and by odours associated with dirty stables.

Keywords: *Culicoides*, entry, females, horse, stable

INTRODUCTION

Experience by south African farmers indicated that African horsesickness (AHS) can, to a great degree, be prevented by stabling horses some hours before sunset until a few hours after sunrise, and these observations led to the belief that a nocturnal blood-sucking insect was the carrier (Theiler 1921). It is furthermore believed that the unpleasant odour in dirty stables discourages midges from entering. Horse owners are therefore sometimes advised not to clean stables regularly in summer when midges are most active.

The virus of AHS, which primarily affects horses, is spread either by movement of infected equids or by nocturnal *Culicoides* vectors. Although stabling overnight reduces the risk of infection, cases among regularly stabled horses are not uncommon. It is difficult to render the open-fronted and barn-style stables in South Africa *Culicoides*-proof without interfering with ventilation. The importance of ventilation of buildings in the promotion of good health in horses, does not appear to have been well recognized in the design of stables in South Africa (Lund, Guthrie & Killeen 1993). According to these authors, ventilation rates are probably too low for acceptable air quality and the effect of also closing the top door of a conventional stable and the shutters of a barn, results in a decrease in air change to unacceptably low levels. In stables with no ventilation openings, except for doors, shutting of the top half effectively cuts off the supply of fresh air. Studies in England showed that closing the top door is a most unwise practice (Jones,

Accepted for publication 18 July 1997—Editor

McGreevy, Robertson Clarke & Wathes 1987; MacCormack & Bruce 1991).

Some mosquito species are known to be peridomestic and antropophilic and they often enter buildings (Malik 1981). The entry of *Culicoides* midges into buildings has not been investigated. It was therefore considered essential to determine some of the factors affecting the entry of *Culicoides* midges into open-fronted stables.

MATERIALS AND METHODS

Stables

This work was done at the Onderstepoort Veterinary Institute (OVI) in concrete-floored paddocks used to house experimental animals. Three adjacent paddocks, with a single open-fronted stable in each of the two side paddocks, were used (Fig. 1). The floor area of the sleeping space in the centre paddock (± 36 m^2) was similar in size to that of the stables. The stables and the sleeping space were covered by a corrugated-iron roof. The conventional wooden stable doors were replaced with trellis doors made of 10 mm iron rods 150 mm apart.

At the end of January 1995, two full-grown farm horses were put in each of the three paddocks. The horses in the side paddocks were stabled overnight, while the horses in the centre paddock were confined overnight to the sleeping space by means of a trellis divider. The left-hand (clean) stable was cleaned and daily provided with fresh bedding while the right-hand (dirty) stable was not cleaned during February. On the morning of 28 February, the horses in the centre and the right-hand paddock were discharged. The dirty stable was washed thoroughly with running water to remove irritating bad odours. This stable was now renamed the empty stable. In February 1995, several paddocks adjacent to and within 50 m of the three paddocks selected for the horses, accommodated 45 head of cattle and 60 sheep. These were discharged by the end of February.

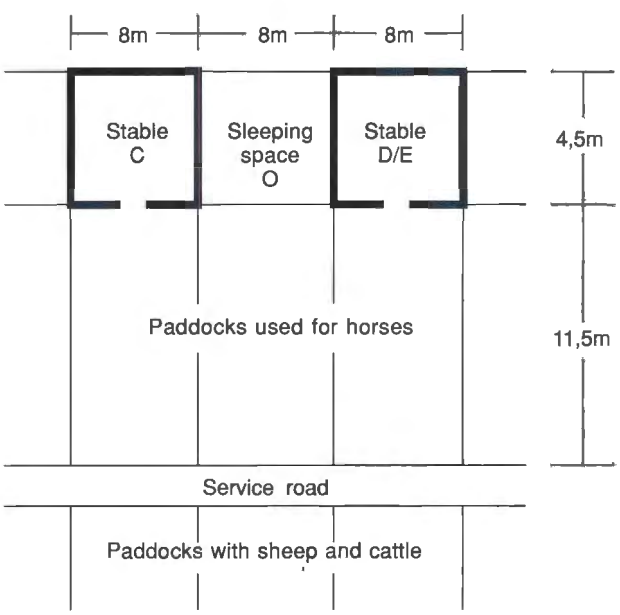

FIG.1 Horse paddocks with the clean stable (C), outside sleeping space (O) and the dirty stable (D) which in March became the empty stable (E)

Collection of *Culicoides*

The stable windows were completely covered with wooden boards to limit the entry of midges through the door opening. A light-trap was set inside each stable by suspending it from the roof in such a way that it was beyond the reach of the horses and also invisible from the outside. A third light-trap was positioned underneath the roof of the sleeping area in the centre paddock. Shields were suspended in front of and at the back of this trap in such a way that it could be seen only from the sleeping space. The traps were set at the same points throughout the collection period. Midges could enter the sleeping space in the centre paddock through the back and the front with a total size of 43,32 m^2. The size of the door openings of the stables was 2,1 m^2.

Light-trap collections

During the period 6 February to 28 March, one week after the horses had been moved into the paddocks, 90 collections were made on 30 nights. Identical down-draught suction light-traps (220 V) equipped with 8-W blacklight tubes were used for the collection of midges in an antiseptic solution of "Savlon" (Johnson & Johnson). Collections were analyzed daily. Prevailing weather conditions on trapping nights were recorded.

RESULTS AND DISCUSSION

As the light-traps were invisible from both outside the stables and the sleeping space in the centre paddock, the midges collected are believed to be those that would normally have entered the sleeping space and the stables. A total of 34 694 *Culicoides* midges were collected and analyzed (Tables 1 and 2). The males (2 515), which do not feed on animals, were not incorporated in the tables and calculations.

Ninety-six percent of the midges collected were identified as *C. imicola*. The rest were identified as other *Culicoides* spp. and 87% of this group consisted of *C. leucostictus* and *C. pycnostictus* which are usually associated with birds (Nevill & Anderson 1972; Nevill, Venter, Edwards, Pajor, Meiswinkel & van Gas 1988). During these 2 months, normal summer-weather conditions were experienced. Wind associated with

TABLE 1 *Culicoides* collected inside and outside horse stables at the Onderstepoort Veterinary Institute on 14 nights in February 1995. Forty-five cattle and 60 sheep were present in adjacent paddocks

Date	Collected outside in sleeping area with two horses				Collected inside clean stable housing two horses				Collected inside dirty stable housing two horses			
Feb.	*C. imicola* parous and nulliparous	*C. imicola* Bloodfeds	*C. imicola* Total	Other *Culicoides* spp.	*C. imicola* parous and nulliparous	*C. imicola* Bloodfeds	*C. imicola* Total	Other *Culicoides* spp.	*C. imicola* parous and nulliparous	*C. imicola* Bloodfeds	*C. imicola* Total	Other *Culicoides* spp.
6	1 202	88	1 290	72	142	4	146	3	234	2	236	0
7	1 424	40	1 464	53	158	0	158	1	266	0	266	1
8	57	0	57	10	11	0	11	1	7	0	7	0
9	109	23	132	27	10	0	10	2	20	0	20	1
13	2 442	58	2 500	34	372	4	376	5	343	5	248	0
14	2 115	73	2 188	35	430	2	432	4	457	4	461	1
15	674	14	688	10	125	1	126	0	107	1	108	3
16	1 490	37	1 527	14	216	3	219	0	362	3	365	0
20	1 691	14	1 705	26	67	1	68	1	293	0	293	1
21	1 081	44	1 125	24	67	1	68	1	168	0	168	2
22	679	17	696	27	30	2	32	2	127	2	129	1
23	524	29	553	49	73	1	74	0	157	5	162	5
27	1 206	146	1 352	74	80	1	81	2	123	0	123	1
28	1 014	91	1 105	78	75	0	75	1	91	2	93	2
Total	15 708	674	16 382	533	1 856	20	1 876	23	2 755	24	2 779	18
Average per night	1 122	48	1 170	38	132	1,4	134	1,6	197	1,7	199	1,3

TABLE 2 *Culicoides* collected inside and outside horse stables at the Onderstepoort Veterinary Institute on 16 nights in March 1995. No cattle or sheep present in adjacent paddocks

Date	Collected outside in sleeping area with two horses				Collected inside clean stable housing two horses				Collected inside dirty stable housing two horses			
March	*C. imicola* parous and nulliparous	*C. imicola* Bloodfeds	*C. imicola* Total	Other *Culicoides* spp.	*C. imicola* parous and nulliparous	*C. imicola* Bloodfeds	*C. imicola* Total	Other *Culicoides* spp.	*C. imicola* parous and nulliparous	*C. imicola* Bloodfeds	*C. imicola* Total	Other *Culicoides* spp.
1	1 001	80	1 081	65	83	1	84	1	41	1	42	1
2	904	79	983	68	53	0	53	0	20	0	20	1
3	791	62	8 530	50	74	0	74	1	37	1	38	2
5	456	43	499	31	45	1	46	0	26	1	27	1
6	501	70	571	40	40	1	41	2	23	1	24	2
7	357	14	371	65	42	3	45	10	20	2	22	6
8	596	45	641	78	99	1	100	1	39	1	40	2
9	93	28	121	24	7	2	9	1	9	4	13	1
13	981	56	1 037	32	133	4	137	3	65	1	66	2
14	430	36	466	30	58	1	59	1	19	0	19	2
15	148	42	190	15	26	0	26	1	14	3	17	0
16	189	19	208	4	46	0	46	0	15	0	15	0
22	323	4	327	15	33	0	33	0	35	0	35	2
23	261	15	276	18	22	0	22	0	21	4	25	1
27	766	24	790	73	81	0	81	5	45	0	45	3
28	119	19	138	37	13	0	13	0	9	1	10	0
Total	7 916	636	8 522	645	855	14	869	26	438	20	458	26
Average per night	495	40	534	40	53	1	54	1,6	27	1,3	29	1,6

heavy rain was recorded on 2 nights in February and 1 in March.

The positive correlation between the numbers of *C. imicola* females caught out of doors in the sleeping space and inside the clean stable was remarkable (Fig. 2). Both traps yielded large numbers on the same nights. When small numbers, associated with heavy rains and windy conditions just before and after sundown, were caught out of doors, comparable catches were made inside the stable. The numbers caught inside and outside the stables dropped by the end of February. In February, nine of 14 catches yielded more than 1 000 females, while in March, only two catches exceeded 1 000, and nine of 16 produced less than 500. This drop coincided with the discharge of the cattle and sheep from the adjacent paddocks, together with four of the six horses. This reduction strongly suggests that in February the midges were attracted to the paddocks by the cattle, sheep and horses resulting in more midges entering the stables.

In contrast to the smaller numbers of *C. imicola* collected in March (Fig. 2), the numbers of other *Culicoides* spp. (Fig. 3) remained constant throughout the collection period. This pattern probably relates to the host preferences of *C. leucostictus* and *C. pycnostictus* which usually associate with birds (Nevill & Anderson 1972; Nevill *et al.* 1988). It therefore seems doubtful that removal of the cattle, sheep and horses from the paddocks could have had a significant impact on their numbers.

If midges enter stables passively, the ratio of midges collected inside and outside the stables is expected to be similar to the ratio of the sizes of the entrances. Therefore the ratios between the number of midges collected inside and outside the stables were compared with the ratio between the size of the door openings and that of the entrance into the sleeping space in the centre paddock (Table 3).

With passive entry and the size of the door opening 20 times smaller than that of the entrance into the sleeping space outside the stables, one would expect to collect approximately 20 midges outside for each midge collected inside the stable. This, in fact, was the case for *Culicoides* spp. other than *C. imicola*, with ratios of 1:23 in February and 1:24,8 in

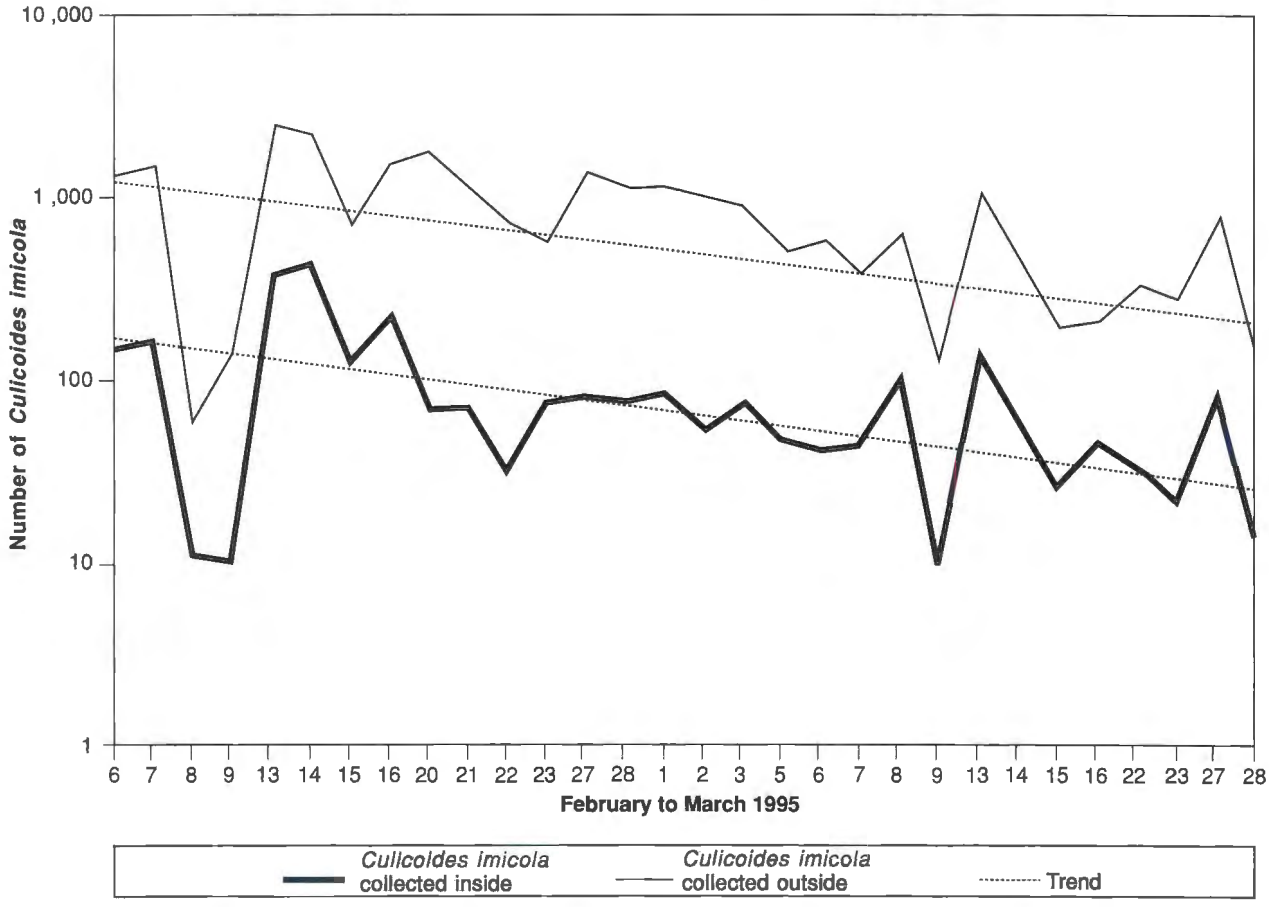

FIG. 2 *C. imicola* collected inside a regularly cleaned stable and in the sleeping space outside the stable at the Onderstepoort Veterinary Institute, February to March 1995. In February, but not in March, 45 cattle and 60 sheep were present in adjacent paddocks

TABLE 3 Ratio of *Culicoides* collected inside and outside stables and that of the entrances openings into the outside sleeping space and the stables at the Onderstepoort Veterinary Institute, February to March 1995

Ratio	Collected inside stables			Collected outside in sleeping space	
	Clean, housing two horses	Dirty, housing two horses	Empty and clean	Without sheep, cattle or horses	With 60 sheep and 45 cattle in adjacent paddocks and two horses in sleeping space
Size of entrances	1	1,0	1,0	20,0	20,0
C. imicola females, February	1	1,0	–	–	8,5
C. imicola females, March	1	–	0,5	9,0	–
Culicoides spp., February	1	0,8	–	–	23,0
Culicoides spp., March	1	–	1,0	24,8	–
C. imicola bloodfeds, February	1	1,2	–	–	33,7
C. imicola bloodfeds, March	1	–	1,5	45,0	–

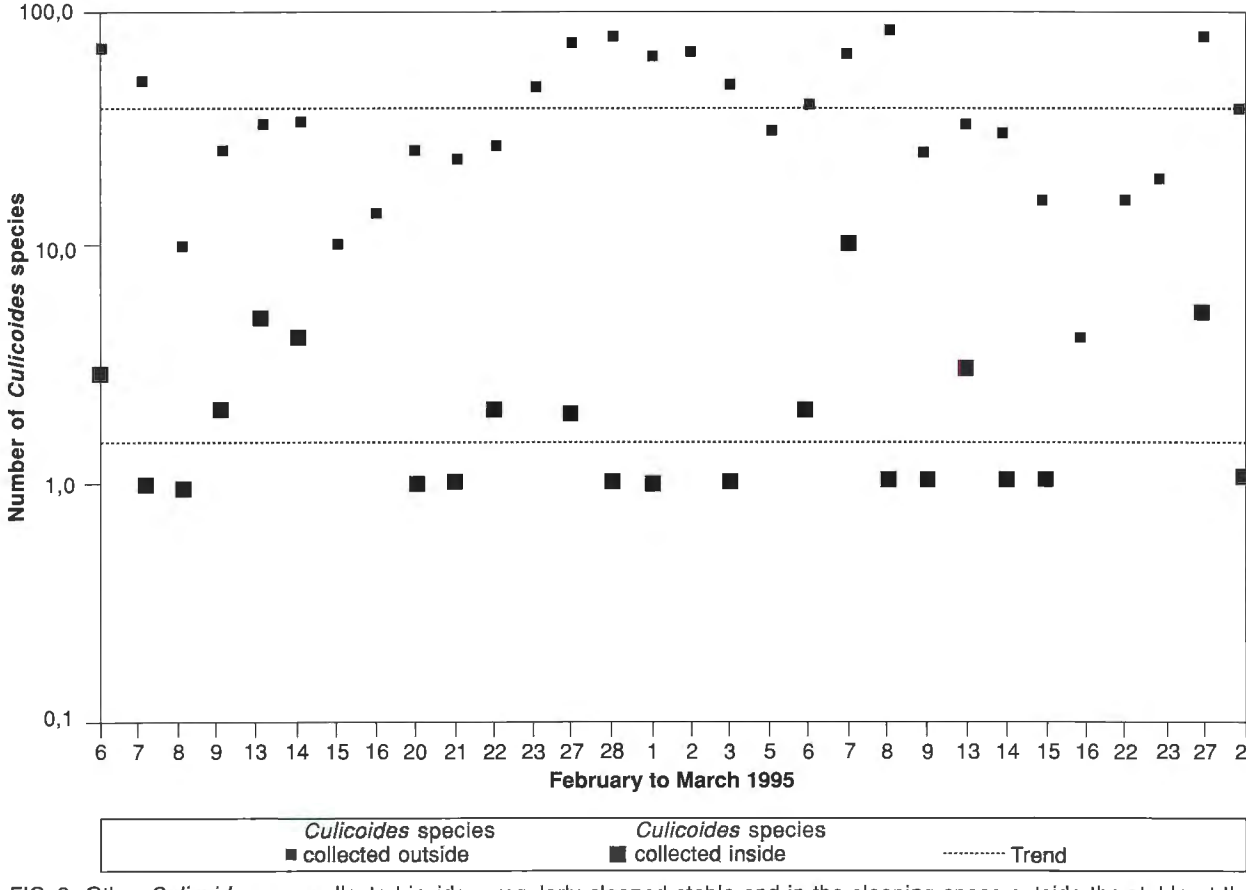

FIG. 3 Other *Culicoides* spp. collected inside a regularly cleaned stable and in the sleeping space outside the stable at the Onderstepoort Veterinary Institute, February to March 1995. In February, but not in March, 45 cattle and 60 sheep were present in adjacent paddocks

March. The ratios for *C. imicola* were noticeably lower at 1:8,5 and 1:9. This indicates that markedly more *C. imicola* entered the stable. It is very likely that some of them entered the stable deliberately in search of animals to feed on or a place to hide. Significantly more engorged females were caught outside the stables. This was obvious in absence of animals to feed on in March (1:45) before the sheep, cattle and horses were discharged and in February (1:33,7). The cause for this is obscure. But one can speculate that the interior of stables provides an easily accessible and secure place for engorged females in which to hide before rhey relocate to suitable breeding sites, and that females in search of a place to hide may be less inclined to be attracted to light traps.

Under natural conditions, a small proportion of *Culicoides* may be infected with the virus of African horsesickness. Therefore the likelihood of virus transmission is increased when large numbers of midges are present. Of the 30 916 *C. imicola* females collected on 30 nights, 5 982, with nightly averages of 132 in February and 53 in March, were caught inside the regularly cleaned stable and 198 inside the dirty stable (Tables 1 and 2). The larger number of midges caught inside the dirty stable clearly indicates that the smell does not discourage their entry. These small numbers entering stables may seem insignificant, but it must be evaluated against the abundance of midges. In 1995 when this work was done, climatic conditions did not favour the presence of large numbers. Catches made at different localities at the Onderstepoort Veterinary Institute yielded low numbers, while in years with favourable climatic conditions, a single light-trap might yield six to ten times more per night (G. Venter, Onderstepoort Veterinary Institute, unpublished data 1995). In the light of the positive correlation between midges collected inside and outside the stables, significantly more *Culicoides* may enter a stable when climatic conditions favour the presence of large numbers.

CONCLUSIONS

Culicoides spp. enter horse stables passively and the number increases when midges are more abundant. The prescence of animals around stables may boost the abundance. In addition, *C. imicola* intentionally enter stables housing horses, most likely in search of animals to feed on or possibly to hide. This behaviour is probably enhanced by the odours and even the bad smell associated with dirty stables. Species that usually associate with birds do not enter stables voluntarily.

ACKNOWLEDGEMENTS

I wish to thank Mr E.G.R. Elliot for technical assistance and Mr G.J. Venter for assistance with the identification of midges.

REFERENCES

HENNING, M.W. 1956. *Animal diseases of South Africa.* 3rd ed. Pretoria: Central News Agency Ltd.

JONES, R.D., McGREEVY, P.D., ROBERTSON, A., CLARKE, A.F. & WATHES, C.M. 1987. Survey of the designs of racehorse stables in the southwest of England. *Equine Veterinary Journal*, 19:454–457.

LUND, R.J., GUTHRIE, A.J. & KILLEEN, VALERIE M. 1993. Survey of selected design and ventilation characteristics of racehorse stables in the Pretoria, Witwatersrand, Vereeniging area of South Africa. *Journal of the South African Veterinary Association*, 64:149–153.

MacCORMACK, J.A.D. & BRUCE, J.M. 1991. The horse in winter—shelter and feeding. *Farm Building Progress*, 105:1–13.

MALIK, S.K.A. 1981. Epidemiology of Rift Valley fever in domestic animals in Egypt. *Proceedings of the 49th General Session of the Office International des Epizooties, Paris,* 25–30 May. 1981.

MURRAY, M.D. 1987. Local dispersion of biting-midge *Culicoides brevitarsis* Kieffer (Diptera: Ceratopogonidae) in southern Australia. *Australian Journal of Zoology,* 35:559–573.

NEVILL, E.M. & ANDERSON, DORA. 1972. Host preference of *Culicoides* midges (Diptera: Ceratopogonidae) in South Africa as determined by precipitin tests and light-trap catches. *Onderstepoort Journal of Veterinary Research*, 39:147–152.

NEVILL, E.M., VENTER, G.J., EDWARDS, M., PAJOR, I.T.P., MEISWINKEL, R. & VAN GAS, J.H. 1988. *Culicoides* species associated with livestock in the Stellenbosch area of the Western Province, Republic of South Africa (Diptera: Ceratopogonidae). *Onderstepoort Journal of Veterinary Research*, 55:101–106.

THEILER, A. 1921. African horse sickness (*Pestis equorum*). (*Science Bulletin*, no. 19, Department of Agriculture, Union of South Africa).