Survey of blackfly (Diptera: Simuliidae) annoyance levels and abundance along the Vaal and Orange Rivers, South Africa

Authors:
Chantel J. de Beer[1]
Karin Kappmeier Green[1,2]

Affiliations:
[1]Parasites, Vectors and Vector-borne Diseases, Agricultural Research Council, Onderstepoort Veterinary Institute, South Africa

[2]Department of Veterinary Tropical Diseases, University of Pretoria, South Africa

Correspondence to:
Chantel de Beer

Email:
debeerc@arc.agric.za

Postal address:
Private Bag X05, Onderstepoort 0110, South Africa

Dates:
Received: May 2011
Accepted: Jan. 2012
Published: 16 July 2012

How to cite this article:
De Beer CJ, Kappmeier Green K. Survey of blackfly (Diptera: Simuliidae) annoyance levels and abundance along the Vaal and Orange Rivers, South Africa. J S Afr Vet Assoc. 2012;83(1), Art. #5, 6 pages. http://dx.doi.org/10.4102/jsava.v83i1.5

Blackflies (Diptera: Simuliidae) are pests in the livestock and labour-intensive farming systems along the major rivers in South Africa. Since 1995, blackflies have been controlled in the Orange River with the larvicide *Bacillus thuringienses* var. *israelensis* (*Bti*). During 2006–2007, the views of livestock farmers concerning blackfly annoyance were determined by means of questionnaires. The results of the questionnaires were substantiated by seasonal abundance surveys of the sub-adult stages of blackflies, conducted in 2007 at 13 sites in the Orange River and 11 sites in the Vaal River. More than half (52%) of the 39 participating farmers along the Orange River and 79% of the 52 participating farmers along the Vaal River stated that they experienced severe blackfly problems. The majority of farmers were unaware of the availability of products that could be used to protect their animals against blackfly attacks and were willing to be involved in blackfly research. High numbers of blackfly sub-adult stages found in both rivers supported the high annoyance levels reported by the respondents. *Simulium chutteri*, *Simulium damnosum* s.l., *Simulium hargreavesi*, *Simulium adersi* and *Simulium alcocki* were identified at Christiana and Delportshoop on the Vaal River, whilst *S. chutteri*, *S. damnosum* s.l., *S. adersi*, *S. alcocki* and *Simulium gariepense* were identified at Marksdrift and Ses Bridge on the Orange River. Despite the extensive control of blackflies, farmers still experience problems and this contention is supported by surveys conducted along the rivers.

Introduction

Owing to their blood feeding habits and huge numbers, blackflies (Diptera: Simuliidae) are considered to be major pests in the livestock and labour-intensive farming systems in South Africa.[1,2] The construction of dams, canals, irrigation schemes or hydro-electrical plants along rivers in South Africa increases the areas suitable for the breeding of blackflies and has escalated the problem along the rivers to pest status.[3] The Orange, Vaal, Great Fish, Sundays, Olifants, Berg, Eerste and Gamtoos Rivers and their surroundings in South Africa are known for problems with blackflies.[1,4]

Industries and organisations affected by blackflies in South Africa are livestock farming, labour-intensive farming (e.g. orchards and vineyards), irrigation farming, the Department of Water Affairs, wildlife, tourism and recreation, as well as diamond mining.[1] Along the Orange River, *Simulium chutteri* Lewis is one of the most important pest species.[1] Irritation by blackflies also causes sheep to huddle together and stop grazing, with consequent economic losses.

Several surveys have been conducted by various workers along the Orange River to determine the extent of the blackfly problem: in 1979 [5], 1982 [6], 1983 [7], 1997 [1] and 1997–2002 [8], the latter survey having been extended to include the Vaal River. Serious blackfly outbreaks in 2000 and 2001 were attributed to higher than normal river levels and an alleged larval resistance to temephos (Abate®; BASF, Johannesburg, South Africa).[9]

Despite the present Orange River Blackfly Control Programme, administrated by the Department of Agriculture, Forestry and Fisheries (formerly the National Department of Agriculture), whereby *Bacillus thuringienses* var. *israelensis* (*Bti*) is used to control the problem, blackfly annoyance levels still seem to be high. This may indicate shortcomings in the present control programme and has led to this assessment of blackfly abundance along the Vaal and Orange Rivers by means of questionnaires and surveys conducted during 2006–2007.

Similar to a previous survey,[7] the aim of the present questionnaire survey was to establish the farmers' views regarding the problem and to reveal possible pronounced general trends. To substantiate the results obtained from the questionnaire survey, subsequent seasonal surveys

of blackfly abundance were conducted at some of the focal blackfly breeding sites along the rivers. Tributaries of the Vaal River, namely the Riet and Harts Rivers, were also monitored to establish their contribution to the blackfly population in the Vaal River. Blackfly species were identified at four sites to confirm important pest species along the Vaal and Orange Rivers.

Materials and methods

Farmers' questionnaires

Contact details of farmers disposed to participate in such a survey were obtained from Farmers' Unions (North West, Northern Cape and Free State Provinces). Subsequently, 51 livestock farmers were contacted along the Orange River from the Van der Kloof Dam to Vioolsdrift, a distance of approximately 920 km, and 62 along the Vaal River from the Bloemhof Dam to Barkly West, a distance of approximately 218 km (Figure 1).

Farmers were asked if they experience blackfly problems, to rate the extent of the problem on a 10-point scale,[7] viz.: 1–3 = light, 4–6 = average, 7–8 = above average and 9–10 = severe, and to indicate seasonal trends in abundance. Using data provided by the farmers, the farms were classified into four categories according to distance from the river, namely 0 km – 20 km, 21 km – 40 km, 41 km – 60 km and 61 km – 80 km. Participants were asked to indicate what livestock they farmed and if livestock were kept in pens, in feedlots or on pasture. Furthermore, farmers were asked if they were aware of any products that could be used to protect animals against blackfly attack, if they had any experience with these products and whether they were satisfied with these products or not. Lastly, the farmers were asked if they would be willing to become involved in blackfly research aimed at controlling the problem.

Survey of blackfly abundance

Seasonal surveys of blackfly abundance were conducted during 2006–2007 at 13 sites along the Orange River and 11 sites along the Vaal River (Figure 1; Table 1). The populations of immature stages were monitored using the 10-point visual ranking system for flat and cylindrical surfaces developed by Palmer[1]. Larvae and pupae were collected and counted from six randomly selected attachment sites; that is, three flat (stones) and three cylindrical (vegetation) surfaces at each collection site.

Pupae were identified to species level at six of these collection sites, two sites on the Vaal River (Christiana and Delportshoop), two on the Orange River (Marksdrift and Ses Bridge) and one in each of the Riet and Harts tributaries.

Statistical analyses

Blackfly abundance data were analysed using Gen Stat for Windows v. 7.0 statistical software (VSN International, Hemel Hempstead, UK) to determine whether blackfly numbers differed between sites and seasons. Repeated measures ANOVA ($p < 0.05$ was considered as statistically significant) were applied to all the data. Where the data passed the normality test, standard (parametric) methods were used and the Tukey test was applied. Where data did not pass the normality test, non-parametric methods were used and the Friedman test was applied. The Vaal River and its tributaries, the Riet, Modder and Harts Rivers were analysed as a single unit, as was the Orange River.

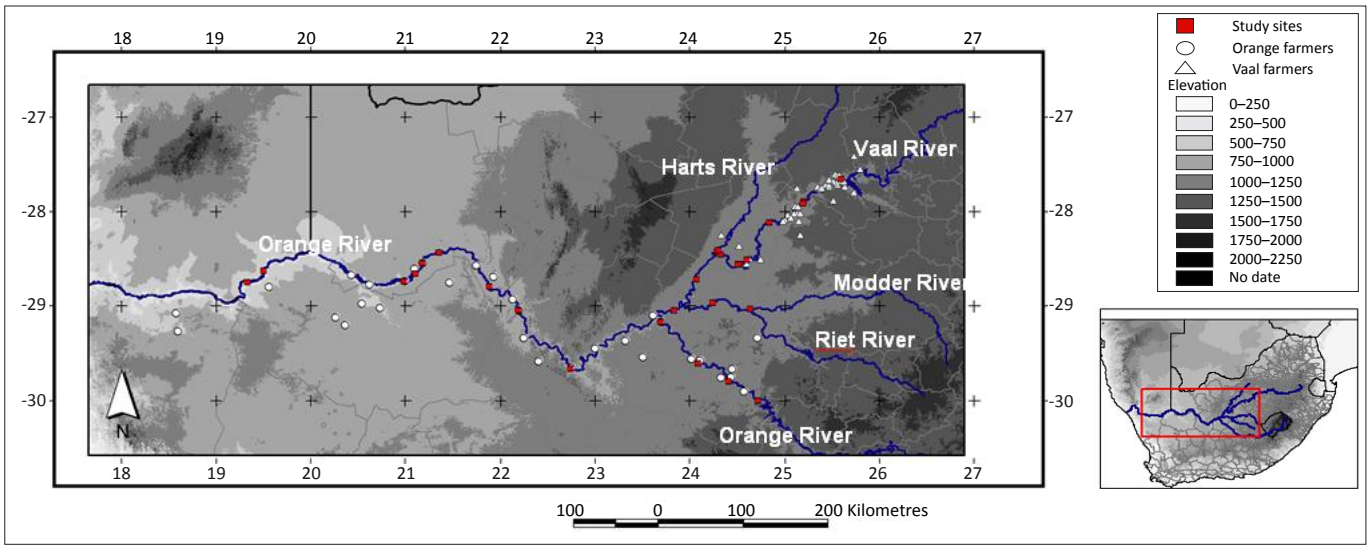
Results

Farmers' responses

Of the 51 livestock farmers contacted along the Orange River, 39 (76%) responded to the questionnaire, whilst 52 (80%) of the 62 farmers contacted along the Vaal River participated.

Distance from river

Along the Orange River, 72% of the participating farmers were closer than 20 km to the river, 19% were in the 21 km – 40 km zone, whilst only 6% and 3% were in the 41 km –



Source: Map produced by Guy Hendrickx, Avia GIS, 2007

FIGURE 1: Study sites on the Orange, Vaal, Riet, Modder and Harts Rivers, as well as the locations of the livestock farmers that were contacted through questionnaires.

60 km and 61 km – 80 km zones, respectively. Along the Vaal River, 84% of the participating farmers were within 20 km of the river, 9% were within 21 km – 40 km, 7% within 41 km – 60 km and none were further than 61 km from the river. The results from the questionnaires therefore mostly represent the situation closer than 20 km from the river, but farmers up to 80 km from the river were also represented.

Livestock and farming practices

According to the questionnaires, the most commonly farmed animals along the Orange River were sheep (71%) and cattle (58%). However, there were also farmers who kept goats (10%), horses (2%) and game (2%), all of which are hosts to blackflies. Most of these animals (68%) were kept in open pastures most of the time. Some farmers (23%) kept the animals on pasture and moved them to feedlots when needed. Only 9% of farmers kept their animals permanently in feedlots.

Similarly, the most commonly farmed animals along the Vaal River were cattle (67%) and sheep (34%). Some of the farmers kept horses (10%), pigs (5%), ostriches (2%), game animals (2%) and goats (1%). The majority of these animals (58%) were kept in the open most of the time, whilst 17% of farmers kept their animals permanently in feedlots.

Extent of blackfly problem

More than half (52%) of the 39 participating farmers along the Orange River experienced severe blackfly problems (9–10 rating) (Figure 2). None of the farmers allocated a non-severe rating (1–3). Along the Vaal River, 79% of the 52 participating farmers experienced a blackfly problem. Only 24% of the farmers rated the problem as severe (rating 9–10), 12% allocated a non-severe (1–3 rating) (Figure 2), whilst blackflies were not seen as a problem by 21% of the respondents.

The fact that none of the 39 respondents along the Orange River rate the problem as non-severe may indicate that the problem can extend up to 80 km from the river. Taking into account the uneven distribution of the number of respondents in each distance class, with only 3% and 6% residing 40 km and 61 km from the river, respectively, the association between distance and extent of the blackfly problem was not further analysed.

Farmers along both rivers indicated that the blackfly problem increased significantly after the first summer rains (October), was more severe in summer (October–February) and reached its peak towards the end of the summer months (November–February) (Figure 3). After February, the problem gradually decreased and was least severe in winter (May–August) (Figure 3).

Products used against blackfly attacks

Less than half (43%) of the participating farmers along the Orange River were aware of products that could be used

TABLE 1: Sites along the Orange and Vaal Rivers at which seasonal surveys of blackfly abundance were conducted during 2006–2007.

Rivers	Sites	Coordinates	
		South	East
Orange River	Van der Kloof	29°59′33″	24°43′26″
	Fluitjieskraal Bridge	29°47′25″	24°24′131″
	Hope Town	29°36′01″	24°05′17″
	Marksdrift	29°09′45″	23°41′39″
	Prieska	29°39′26″	22°44′39″
	Buchuberg	29°02′36″	22°11′53″
	Sishen Bridge	28°47′14″	21°52′45″
	Strausbury	28°25′52″	21°21′17″
	Ses Bridge	28°32′37″	21°10′39″
	Kanoneiland	28°38′53″	21°06′08″
	Keimoes	28°43′40″	20°59′07″
	Raap en Skraap	28°37′37″	19°30′17″
	Onseepkans	28°44′33″	19°20′04″
Vaal River	Bloemhof	27°39′15″	25°35′44″
	Nkolo Spa	27°53′11″	25°12′29″
	Christiana	27°54′21″	25°11′40″
	Warrenton	28°06′21″	24°50′35″
	River Mead	28°29′58″	24°36′16″
	Rietgat (Barkly West)	28°32′54″	24°31′43″
	Rekaofela Resort	28°33′15″	24°30′25″
	Delportshoop	28°25′02″	24°17′25″
	Sydney on Vaal	28°27′01″	24°19′33″
	Schmidtsdrif	28°42′44″	24°04′21″
	Douglas	29°02′40″	23°50′09″

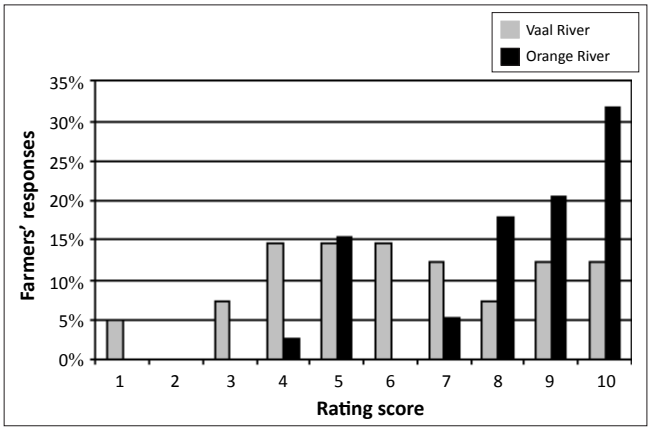


FIGURE 2: Percentage of farmers experiencing blackfly annoyance levels (scaled on a rating of 1–10 for increasing severity) along the Orange and Vaal Rivers.

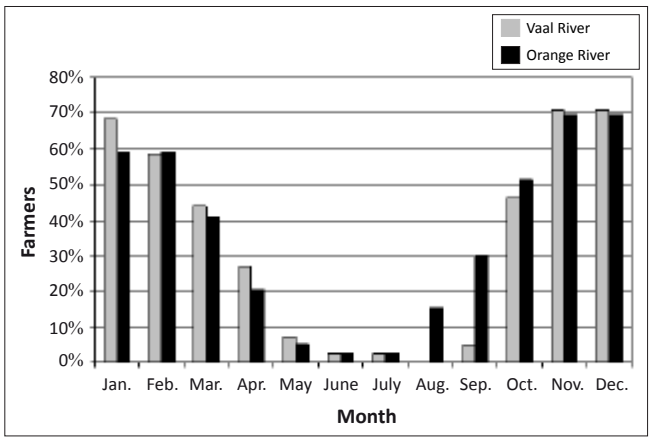


FIGURE 3: Percentage of farmers who indicated highest blackfly annoyance for a specific month along the Orange and Vaal Rivers.

to protect livestock against blackfly attacks. Of these, only 40% actually made use of the available products. Diazinon 30% (Dazzel®; Bayer AH, Johannesburg, South Africa) and Alphamethrin 7% (Paracide®; Pfizer AH, Johannesburg, South Africa) were the most frequently used products; 53% of farmers used the former and 20% the latter product, regularly. Only 27% of the farmers were satisfied with the results obtained from the use of the available products, whilst 73% were dissatisfied, stating that the available products were too expensive and effective only for relatively short periods. They regarded the application of the products as labour-intensive, the animals having to be collected for treatment, and all agreed that it was insufficient to treat the animals only and that blackfly control should be targeted in the river itself.

Along the Vaal River, 43% of the participating farmers indicated that they were aware of products that can be used to protect livestock against blackfly. Of these, 49% indicated that they used these products. Unlike the Orange River respondents, the two most frequently used products were Deltamethrin 1% (Clout®; Cooper [Afrivet], Pretoria, South Africa) and Flumethrin 1% (Drastic Deadline®; Bayer AH, Johannesburg, South Africa), with 20% of the farmers using these regularly. A total of 55% of the farmers were satisfied with the results obtained from the use of the available products, whilst the rest were dissatisfied (20%), only partly satisfied (5%) or could not tell (20%) whether these products were effective against blackfly.

Potential farmers' involvement

In all, 92% of the 39 participating farmers along the Orange River and 90% of the 52 along the Vaal River stated that they would be willing to take part in blackfly control research.

Survey results of blackfly abundance

The numbers of blackflies sampled seasonally at the various sites along the Orange and Vaal Rivers are indicated in Figure 4a and Figure 4b, respectively. In the Orange River, more than 1000 blackfly larvae and pupae were collected at 7 of the 13 sites sampled. The upper part of the Orange River had the highest larval and pupal numbers. No significant differences were found between the numbers of blackfly larvae and pupae collected at the different sites ($p = 0.193$). There were, however, significant differences ($p < 0.001$) in blackfly numbers between seasons, with the highest abundance in spring.

More than 1000 blackfly larvae and pupae were collected at two sites on the Vaal River, namely Rietgat (Barkly West) and Schmidtsdrif. There were, however, no significant differences in blackfly numbers between the different sites ($p = 0.124$) or seasons ($p = 0.986$).

Pupae were identified to species level at Christiana and Delportshoop on the Vaal River, at Marksdrift, and Ses Bridge on the Orange River and at one site on each of the Harts and Riet Rivers. A total of six species were identified. Five species, namely *S. chutteri*, *Simulium damnosum* s.l., *Simulium adersi, Simulium alcocki and Simulium gariepense,* were identified at the two sites in the Orange River. Of all the pupae identified, 95% were *S. chutteri*. *Simulium damnosum* s.l. and *S. gariepense* were collected at Marksdrift only and *S. alcocki* at Ses Bridge only. The largest variety of species was found in spring. Only *S. gariepense* and *S. chutteri* were located on the stones; the rest of the species were found only on the vegetation.

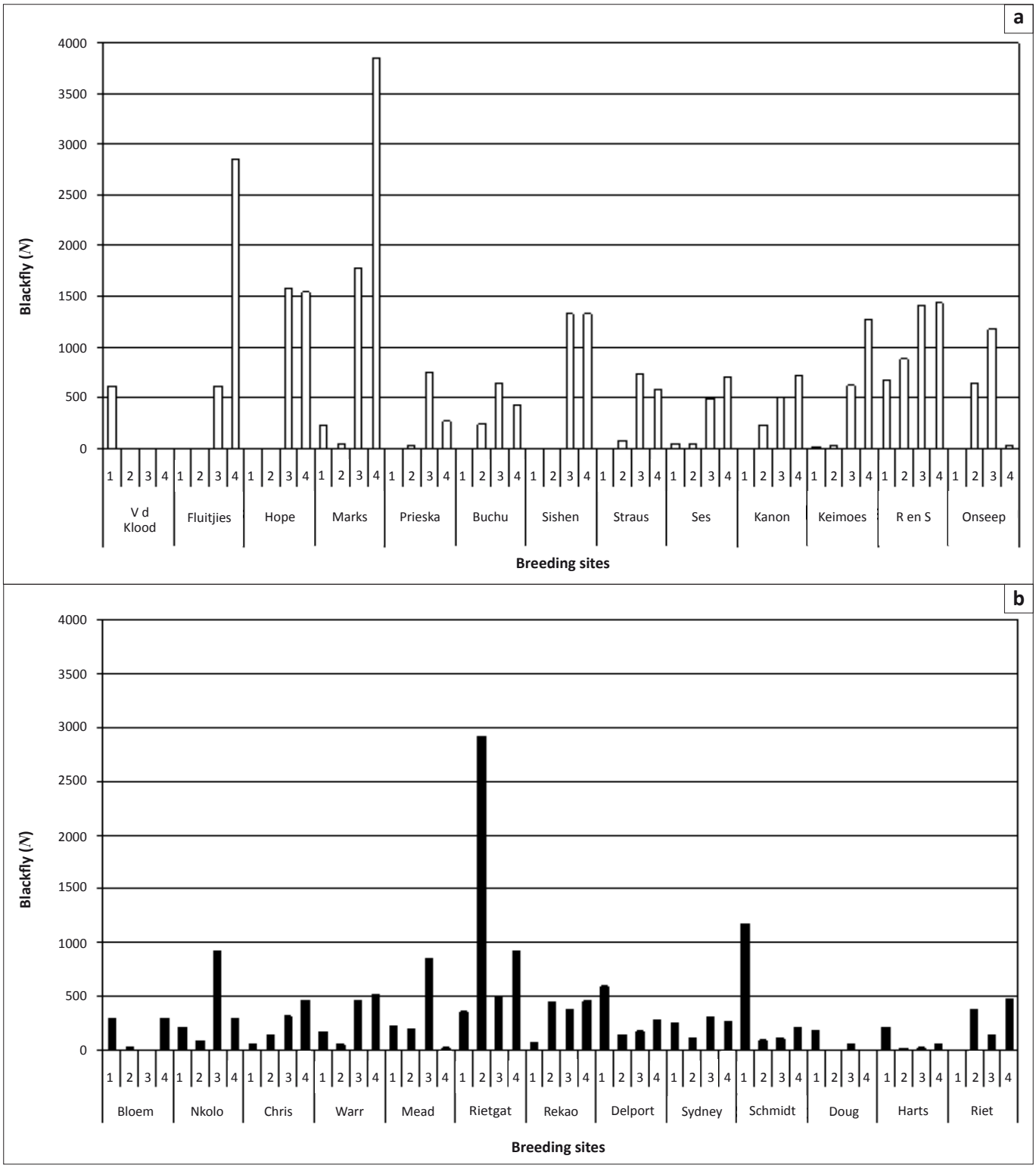
Five species were identified in the Vaal River, namely *S. chutteri*, *S. damnosum* s.l., *Simulium hargreavesi, S. adersi* and *S. alcocki.* Of these, *S. adersi* was the most abundant species collected throughout the seasons. Differences were found in the species composition at the two sites sampled in the Vaal River. *Simulium alcocki* represented 19% of the species collected at Christiana but was not collected at Delportshoop. The opposite was found for *S. hargreavesi*; *S. hargreavesi* (35%) and *S. damnosum* s.l. (39%) were the most abundant species at Delportshoop and Christiana, respectively. The highest species diversity in the Vaal River occurred in winter. Similar to the situation in the Vaal River, *S. adersi* was the most abundant species in the Harts and Riet Rivers. It was the only species to be found along the Harts River and contributed 53% of the blackflies in the Riet River.

Discussion

The aim of the questionnaires was to identify pronounced general trends, similar to the previous survey.[7] Questionnaire data cannot be regarded as definite and care should be taken against over interpretation of explicit numbers or frequencies.

All participating farmers along the Orange River indicated that they experienced problems with blackflies and more than half rated this as a severe problem. Similar to the previously reported findings,[7] the majority indicated that the blackfly problem increased after the first summer rains and that it is highest in the summer, (November and December) (Figure 3). Apart from the regular treatment of the Orange River with *Bti* for control of the subadult stages, there are not many products registered for the control of adult blackflies and farmers were mostly unaware of any such products. The most popular products used for general fly control, including blackflies, were Dazzel® and Paracide®.

Blackfly problems seem to be less severe in the Vaal River, as only 79% of the respondents regarded this as a problem and only 24% rated it as severe. As along the Orange River, the problems increased after the first summer rains and it was highest in the summer months of November and December (Figure 3). Insecticides for the protection of animals against flies, including blackflies, were used by less than half of the respondents. Because blackfly problems seem to continue, only 55% of the respondents thought that these products were effective against blackflies specifically. Unlike the farmers along the Orange River, these farmers mostly used Clout® and Drastic Deadline®. The reasons for product preferences were not determined and may be the result of availability



1, Summer; 2, Autumn; 3, Winter; 4, Spring.
V d Kloof, Van der Kloof; Fluitjies, Fluitjieskraal Bridge; Hope, Hope Town; Marks, Marksdrift; Buchu, Buchuberg; Sishen, Sishen Bridge; Straus, Strausbury; Ses, Ses Bridge; Kanon, Kanoneiland; R en S, Raap en Skraap; Onseep, Onseepkans.
Bloem, Bloemhof; Nkolo, Nkolo Spa; Chris, Christiana; Warr, Warrenton; Mead, River Mead; Rekao, Rekaofela Resort; Delport, Delportshoop; Sydney, Sydney on Vaal; Doug, Douglas; Harts, Harts River; Riet, Riet River.

FIGURE 4: Blackfly larval and pupal numbers sampled from sites along, (a) the Orange River and (b) the Vaal River and its tributaries.

of products and general consensus amongst farmers. Furthermore, the extent of the problem is highlighted by the fact that more than 90% of the farmers along both rivers indicated that they were willing to participate in any control strategy that will alleviate the blackfly problem.

The severity of problem in summer, as indicated by the questionnaire, was substantiated by the high numbers of immature blackflies in the Orange River, especially in the winter and spring months. This tendency has been reported previously.[1] The numbers were highest in the autumn months

at some sites along the Vaal River, with a similar seasonal build-up from summer to winter also being observed.

The tributaries of the Vaal River, namely the Harts and Riet Rivers, supported relatively small blackfly communities that may contribute to the blackfly numbers in the Vaal River. The Vaal River is the most important tributary of the Orange River and will, therefore, contribute to the fauna and flora of the Orange River. The contribution of the Vaal River is, however, minimised by the presence of the Douglas Dam upstream from the confluence of these two rivers. Water level manipulation downstream from the dam leads to the exposure of rapids for lengths of time that will decrease the numbers of immature stages, as well as the blackfly species composition by exclusion of species that cannot tolerate water level fluctuations.

This study also aimed to identify the pest species along the Orange and Vaal Rivers. It was established that species composition can differ between sites. Four species, *S. chutteri*, *S. damnosum* s.l., *S. adersi* and *S. alcocki* were found to be present in both rivers. *S. hargreavesi* was only collected from sites in the Vaal River and *S. gariepense*, considered to be endemic to southern Africa, only from sites in the Orange River. In 1968, *S. chutteri*, *S. damnosum* s.l., *S. adersi* and *S. gariepense* were found at Warrenton on the Vaal River.[10] In addition to these species, *Simulium nigritarsis* and *Simulium mcmahoni* were also collected, but not *S. alcocki*.[10] Only three of these species, *S. chutteri*, *S. damnosum* s.l. and *S. adersi* were found at Gifkloof on the Orange River.[1] In addition to these species, *Simulium ruficorne*, *S. nigritarsis* and *S. mcmahoni* were found.[1] It is surprising that *S. nigritarsis* and *S. mcmahoni* were not found in the present study at the two sites on both rivers, as these species are common avian pests.[1] Similar to the previous finding,[1] *S. chutteri* was the dominant species found in the Orange River and, as reported before,[10] *S. adersi* was the dominant species in the Vaal River.

Owing to the irrigation needs of farmers, water level fluctuations in the Vaal River are kept to a minimum by dams. This situation is favourable to *S. damnosum* s.l. and can increase the blackfly problem.[10] *Simulium chutteri* exploits temporary stony runs and this biotope is found frequently in the Vaal River where the natural river bed was changed as a result of diamond mining.[10] Regular fluctuations in water level, as present in the Orange River, can lead to an increase in the numbers of *S. chutteri*, considered to be a more mobile species.[10]

Conclusion

Blackflies still present problems along both the Orange and Vaal Rivers, as was indicated by the questionnaires and abundance surveys. The current control strategies need to be re-evaluated and, where possible, be supported by alternative control measures, such as the development of an integrated control strategy that has been recommended.[9] In an integrated control strategy, water flow manipulation can be supplemented by the use of target-specific larvicides, as needed.[9]

Acknowledgements

The Agricultural Research Council – Onderstepoort Veterinary Institute (ARC – OVI) and the Department of Agriculture (Directorate of Land Use and Soil Management) funded this study. We wish to thank the Farmers' Unions (North West, Northern Cape and Free State Provinces) and all the farmers who responded to the questionnaire. We also wish to thank Dr Guy Hendrickx for producing the maps, Mr Boikanyo and Mr Nchabeleng for their excellent technical support and Dr Gert Venter and Arthur Spickett for constructive comments on earlier drafts of this manuscript.

Competing interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this paper.

Authors' contributions

C.J.d.B. (Onderstepoort Veterinary Institute) wrote the manuscript as fulfilment for an MSc degree within the Department of Veterinary Tropical Diseases at the University of Pretoria, for which K.K.G. (University of Pretoria) was the study supervisor.

References

1. Palmer RW. Principles of integrated control of blackflies (Diptera: Simuliidae) in South Africa. Water Research Commission Report No. 650/1/97. Pretoria: Water Research Commission; 1997.
2. Palmer RW, Edwardes M, Nevill EM. Control of pest blackflies (Diptera: Simuliidae) along the Orange River, South Africa 1990–1995. Onderstepoort J Vet Res. 1996;63:289–304. PMid:9173360
3. Nevill EM. The creation of permanent blackfly problems by the construction of dams. Long-term data series relating to South Africa's renewable natural resources. South African National Scientific Programmes Report 1988;157:n.p.
4. Myburgh E, Nevill EM. Review of blackfly (Diptera: Simuliidae) control in South Africa. Onderstepoort J Vet Res. 2003;70:307–317. PMid:14971733
5. Begeman GJ. Vraelys: Riviermuggies. Onderstepoort, Agricultural Research Council – Onderstepoort Veterinary Institute; (Unpublished).
6. Car M. Vraelys: Riviermuggies. Onderstepoort, Agricultural Research Council – Onderstepoort Veterinary Institute; (Unpublished).
7. Jordaan LC, Van Ark H. A survey of annoyance of livestock by *Simulium chutteri* Lewis along the Orange River, South Africa (Diptera: Simuliidae). Onderstepoort J Vet Res. 1990;57:189–195. PMid:2234866
8. Myburgh E. Vraelys: Riviermuggies. Onderstepoort, Agricultural Research Council – Onderstepoort Veterinary Institute; (Unpublished).
9. Palmer RW, Rivers-Moore N, Mullins W, McPherson V, Hattingh L. Guidelines for integrated control of pest blackflies along the Orange River. Water Research Commission Report No. 1558/1/07. Pretoria: Water Research Commission; 2007.
10. Chutter FM. On the ecology of the fauna of stones in the current in a South African river supporting a very large *Simulium* (Diptera) population. J Appl Ecol. 1968;5:531–561. http://dx.doi.org/10.2307/2401631