The role of flowering plant species in the survival of blackflies (Diptera: Simuliidae) along the lower Orange River, South Africa

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This study is an investigation of the role that plants play in the survival of adult blackflies by providing shelter and carbohydrate food. A detailed phenological study of the 29 most abundant plant species in the Augrabies Falls National Park showed that throughout the year the percentage of plant species flowering was remarkably constant. It is therefore unlikely that the availability of carbohydrates would limit adult *Simulium* survival at any time of the year. Blackflies were recorded feeding on the flowers of *Pappea capensis*, *Acacia karroo*, *A. mellifera*, *Tamarix usneoides*, *Ziziphus mucronata*, *Schotia afra* and *Sisyndite spartea*. An additional survey showed that another 64 plant species flowered throughout the year, and these can be regarded as potential carbohydrate sources. Blackflies were observed sheltering in dense shrubs and trees that provide protection against predation and harsh environmental conditions. This study suggests that vegetated drainage lines are the means by which adult blackflies survive dispersal away from the river. It is concluded that carbohydrate scarcity cannot be considered a limiting factor to adult blackfly survival along the lower Orange River.

Key words: *Simulium chutteri*, phenology, carbohydrate, survival, shelter.

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Introduction

Much of the research on blackflies (Simuliidae) in South Africa focused on the aquatic stages and control of the larvae (Car 1983; De Moor & Car 1986; Palmer 1994; Palmer *et al.* 1995a, 1995b; Palmer & Palmer 1995; Palmer *et al.* 1996). This meant that many questions regarding the adult blackflies were left unanswered, for example the influence of various factors on adult survival, host preferences, activity patterns, and so forth, are unknown. The ARC-Onderstepoort Veterinary Institute recently initiated a project to investigate the first of the above-mentioned aspects. This paper is the first in a series on factors believed to influence adult blackfly survival and deals specifically with the role that flowering plants along the Orange River play in this regard.

Carbohydrates play an important role in blackfly ecology. Male and female blackflies need it for flight energy and increased longevity (Hocking 1953; Davies *et al.* 1962; Hunter 1977; Sutcliffe 1986). Females of some species require carbohydrates for ovarian development (Cupp & Collins 1979) and in some other species it permits autogeny (Corbet 1964; Hunter 1977). Carbohydrates are obtained from nectar (Lewis & Domoney 1966; Hunter 1977; Brenner & Cupp 1980; Cupp 1981; Wenk 1981; Crosskey 1990), other plant juices (e.g. phloem sap) (Crosskey 1990) or homopteran honeydew (Burgin & Hunter 1997a, 1997b, 1997c). Since carbohydrates are primarily obtained from floral or extrafloral nectaries (Crosskey 1990), blackfly seasons are, in general, associated with the season of nectar production (Hocking 1953; Burgin & Hunter 1997a).

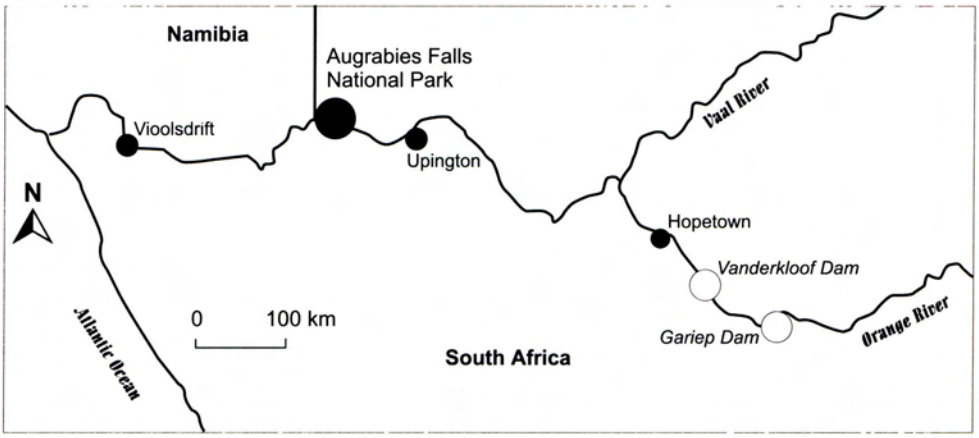

Fig. 1. Location of the Augrabies Falls National Park in relation to the Orange River and neighbouring towns.

This may prove to be an important consideration in the survival of adult blackflies as the arid conditions along the Orange River suggests that nectar availability may be severely limited during certain periods (Palmer 1997). Furthermore, plants in arid and semi-arid summer rainfall regions have characteristic short flowering seasons. The non-flowering period for most plant species also occurs during the hot and dry summer months (Struck 1994).

However, plants are not only a source of carbohydrates, but also give blackflies protection against harsh environmental factors and predation and, furthermore, they provide resting sites (Lewis & Domoney 1966; Brenner & Cupp 1980; Crosskey 1990; McCreadie *et al.* 1994; Reyes-Villanueva & Rodriquez-Perez 1994). Service (1977) stressed the importance of having knowledge on the resting behaviour of insect vectors as this is important in developing protocols to study host preferences, species composition and age structure. Considering this, it is surprising that as recently as 1994 information on the natural resting sites of blackflies existed only as general accounts (Reyes-Villanueva & Rodriquez-Perez 1994).

The present study was undertaken to investigate carbohydrate availability to blackflies, their feeding preferences and resting or sheltering behaviour in plants. The information obtained will be related to adult survival.

Study area

The study was conducted in the southern section (4500 ha) of the Augrabies Falls National Park (AFNP) in the Northern Cape Province, South Africa. The park is located approximately 120 km west of Upington between 28°25'–28°38'S and 20°15'– 20°20'E (Fig. 1). The AFNP has a history of blackfly attacks, and the Augrabies gorge is considered one of the main breeding sites for blackfly along the Orange River (Palmer 1997).

The temperature in the AFNP varies from –2.9 °C in winter to 42.9 °C in summer (Land Type Survey Staff 1986). The park falls in the summer rainfall area and averages 211 mm per annum, but it has been shown to vary between less than 40 mm to 391 mm per annum (Weather Bureau 1996). Rainfall and temperature figures during this study were obtained from the Weather Bureau's data collected in the park.

During the present study (January–December 2000) the rainfall total for the year in the AFNP was 200 mm, 5 % below the average annual rainfall. Most of the precipitation was recorded from January to April, with the maximum monthly rainfall (95 mm) in March. Light rainfall was also recorded from June to September. Average temperatures were highest from November to February and lowest from May to August (Fig. 2).

The vegetation in the park is typical of the Orange River Nama Karoo Type found within the drainage basin of the Orange River. This vegetation is found in a band (approximately 10–75 km wide) along the Orange River and extends from Vioolsdrift in the west to Hopetown in the east (Hoffman 1996). The AFNP is the largest conservation area within the Orange River Nama Karoo biome and contains six major plant communities. These include *Aloe dichotoma* Sparse Woodland, *Schotia afra* Open Woodland, *Ceraria namaquensis* Open Shrubland, *Acacia mellifera* Open Shrubland, *Stipagrostis hochstetteriana* Open Grassland and *Ziziphus mucronata* Closed Woodland (Bezuidenhout 1996).

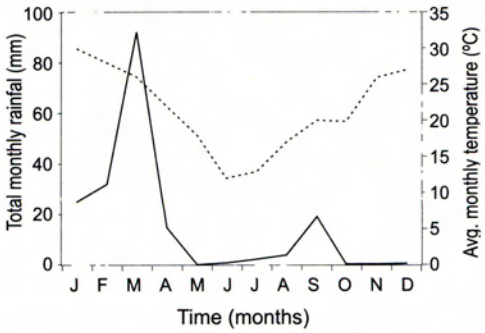

Fig. 2. Total monthly rainfall (solid line) and average monthly temperature (broken line) recorded in the Augrabies Falls National Park from January to December 2000.

Methods

Vegetation studies

Plant phenophases influence the availability and palatability of food to browsers, especially in arid areas (Fabricius & Van den Berg 1993). Using this principle, and applying it to flowering times, 10 individuals of each of the 29 most abundant plant species in the AFNP (Bezuidenhout 1996) were selected and permanently marked. These 290 plants were individually studied for one year (January–December 2000) at 28-day intervals for the presence or absence of leaf growth, shoot growth, flower buds, flowers, immature seeds, mature seeds, leaf yellowing and leaf abscission. A species was considered to be in a new phenophase if two or more individuals manifested the phase (Hoffman 1989).

Although blackflies appear to be discriminate nectar feeders, they will feed on almost any available carbohydrate source when their preferred source is not available (Hunter 1977; Crosskey 1990). We consequently also recorded flowering times of additional plant species in the AFNP for one year (January–December 2000). This was done by two observers who drove a fixed 26-km route during each visit and recorded all plant species that were flowering at the time. All flowering species that could be seen from the vehicle were recorded. The objective of this survey was not to note any feeding activity, but only to record potential carbohydrate sources.

Blackfly activity

During each visit, the 290 plants were each examined for evidence of blackfly activity on flowers, and this was presumed to be feeding activity. These plants were also examined for any blackflies that could be seen resting or taking shelter. Only the presence of blackflies was recorded and not their sex or species.

Results

Vegetation studies

The 29 plant species studied (Table 1) showed a growth peak from January to March. A second peak was recorded from September to December, although it was not as pronounced as the first. The percentage of plant species flowering throughout the year stayed remarkably consant, although small peaks were observed from January to March

Table 1

Alphabetic list of the 29 most abundant plant species in the Augrabies Falls National Park and the presence of blackfly feeding or sheltering activity on these plants (indicated with a "yes")

Plant species	Feeding activity	Shelter
Acacia karroo Hayne (Fabaceae)	Yes	Yes
Acacia mellifera (Vahl) Benth. subsp. *detinens* (Burch.) Brenan (Fabaceae)	Yes	Yes
Adenolobus garipensis (E.Mey.) Torre & Hillc. (Fabaceae)		Yes
Boscia albitrunca (Burch.) Gilg. & Ben. var. *albitrunca* (Capparaceae)		
Boscia foetida Schinz subsp. *foetida* (Capparaceae)		
Cenchrus ciliaris L. (Poaceae)		
Ceraria namaquensis (Sond.) Pearson & Stephens (Portulacaceae)		
Codon schenckii Schinz. (Hydrophyllaceae)		
Commiphora gracilifrondosa Dinter ex J.J.A. V.D. Walt (Burseraceae)		
Diospyros lycioides Desf. subsp. *lycioides* (Ebenaceae)		Yes
Dyerophytum africanum (Lam.) Kuntze (Plumbaginaceae)		
Enneapogon scaber Lehm. (Poaceae)		
Euclea pseudebenus E.Mey. ex A. DC. (Ebenaceae)		
Euphorbia gregaria Marioth (Euphorbiaceae)		
Ficus cordata Thunb. subsp. *cordata* (Moraceae)		Yes
Hibiscus elliottiae Harv. (Malvaceae)		
Hibiscus engleri K. Schum. (Malvaceae)		
Monechma spartioides (T. Anders) C.B. Cl. (Acanthaceae)		
Pappea capensis Eckl. & Zeyh. (Sapindaceae)	Yes	Yes
Phragmites australis (Cav.) Steud (Poaceae)		Yes
Rhus pendulina Jacq (Anacardiaceae)		Yes
Rhus populifolia E.Mey. ex Sond. (Anacardiaceae)		
Sarcostemma viminale (L.) R. Br. (Asclepiadaceae)		
Schotia afra (L.) Thunb. var. *angustifolia* (E.Mey.) Harv. (Fabaceae)	Yes	Yes
Sisyndite spartea E.Mey ex Sond. (Zygophyllaceae)	Yes	Yes
Stipagrostis hochstetteriana (Beck. Ex Hack.) De Winter var. *secalina* (Henr.) De Winter (Poaceae)		
Stipagrostis uniplumis (Licht.) De Winter var. *uniplumis* (Poaceae)		
Tamarix usneoides E.Mey. ex Bunge (Tamaricaceae)	Yes	Yes
Ziziphus mucronata Willd. subsp. *mucronata*. (Rubiaceae)	Yes	Yes

and during May, October and December. The percentage of plant species that carried seeds steadily decreased from a high during January to a low during July. From August onwards the percentage of plant species with seeds started to increase again. Leaf abscission was highest during February and from June to August. During September leaf abscission decreased and increased again during October. Most plant species carried their fruit during January and February. Thereafter fruiting steadily decreased to a minimum between July and October, followed by a small peak during December (Fig.3).

In addition to the 29 selected plant species, a total of 66 other flowering species were recorded in the AFNP during the study period. Many of these species flowered from January to May. The number of species that were flowering was low for the remainder of the year, although a small peak was recorded during September (Fig. 4).

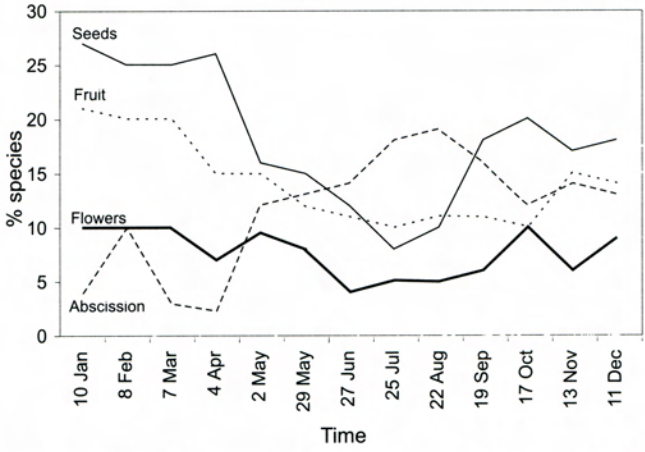

Fig. 3. Combined phenology of the 29 most abundant plant species in the Augrabies Falls National Park from January to December 2000.

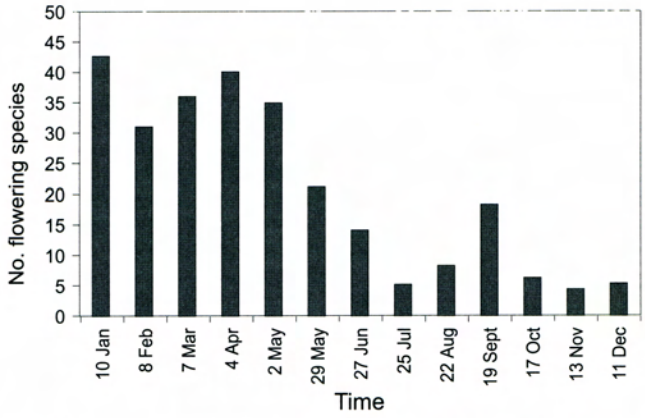

Fig. 4. Number of plant species flowering throughout the year in the Augrabies Falls National Park (excluding the 29 most abundant species).

Blackfly activity

Blackfly activity was recorded on the flowers of *Pappea capensis*, *Acacia karroo*, *Tamarix usneoides*, *Acacia mellifera*, *Ziziphus mucronata*, *Schotia afra* and *Sisyndite spartea* (Table 1). Activity was more common on the first five species and they are therefore likely to be the preferred nectar sources. At least one of these species was flowering at any given time of the year (Fig. 5).

Blackflies did not seem to have specific preferences regarding plant species used as shelters or resting sites, although they were more common on dense shrubs and trees and were never recorded on any grass species, except the reed, *Phragmites* spp. Resting behaviour was recorded on the seven species mentioned above, and on *Adenolobus garipensis*, *Phragmites* spp., *Diospyros lycioides*, *Ficus cordata* and *Rhus pendulina* (Table 1).

Discussion and conclusions

Water is the dominant controlling factor for biological

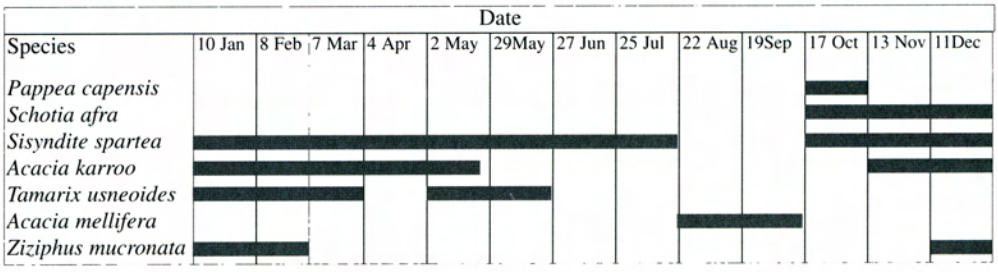

Fig. 5. Flowering times of the seven plant species on which blackfly activity was recorded.

processes in arid and semi-arid areas (Noy-Meir 1973; Milton 1987) and therefore the phenology of plant species in these areas is characterised by a pulse-activity response (Noy-Meir 1973). This was well demonstrated during this study where the combined phenology of the 29 selected plant species showed growth pulses after periods of rainfall. The total number of plant species (excluding the above-mentioned 29 species) flowering throughout the year was also highest after the heavy rainfall experienced early in the year. As blackflies will probably visit any angiosperm in flower (Crosskey 1990), rainfall becomes an important consideration in the survival of adult blackflies in the arid areas along the Orange River. Since more carbohydrate sources are available after periods of rainfall, the adults will not only have a greater variety to choose from, but flowers will also be more abundant.

Begemann (1986) reported visits by *Simulium chutteri* (Lewis 1965) to the following plant species along the Vaal River: *Acacia karroo, A. mellifera, Ziziphus mucronata, Gomphostigma virgatum, Oenothera erythrocephala* and *Senecio burchelli*. Our study correlates well with this study, where the first three species were also identified as food sources. The combined results of these two studies bring the total number of plant species, used as carbohydrate sources by adult blackflies, to ten.

With the exception of *A. mellifera* and *P. capensis*, the distribution of all nectar sources used by blackflies in the AFNP, is largely confined to the drainage lines of the Orange River and its tributaries. These tributaries and drainage lines are generally characterised by a high canopy cover compared to the surroundings (Bezuidenhout 1996). Within these plant communities temperatures will be lower and humidity higher than experienced in adjacent vegetation. These are important considerations in adult blackfly survival, because newly emerged adults seek refugia near their breeding sites where they remain for a few hours to allow sclerotisation of the integument and maturation of organs (Reyes-Villanueva & Rodriguez-Perez 1994). The majority of female blackflies take a sugar meal prior to a blood meal (Walsh & Garms 1980; McCreadie *et al.* 1994) and male blackflies remain close to their breeding sites (Crosskey 1990). Therefore, these plant species within the drainage lines are the ideal nectar sources and shelters for newly-emerged flies. This furthermore suggests that the vegetated drainage lines may be the means by which female blackflies survive dispersal of up to 80 km away from the Orange River, and also perhaps how they survive the return trip to oviposit in the same river, the only available breeding site in the area.

Female blackflies in search of a host or oviposition site can exhaust a sugar meal during prolonged flight (Crosskey 1990). They will therefore need to replenish their sugars on plant species other than those described here. In the open veld, away from drainage lines, there are fewer large bushes that may serve as nectar sources and shelter. The main, if not only species, that falls into this category and which was found in the present study to be favoured by blackfly adults, is *Acacia mellifera*. Its flowering period is restricted to two months, August and September, when adult blackflies usually emerge in high numbers from the river (Palmer 1997). *Acacia mellifera* may contribute significantly to the survival of blackflies, which disperse randomly across open ground, at this time of the year. Clearly other plant species will be used at other times of the year and therefore a similar study should be conducted on plant species in the 5–80 km zone away from the river. The role of cultivated plant species should also be investigated. However, because of the arid nature of this area cultivated plant species will be restricted to irrigated sections along the river.

It is concluded that carbohydrate scarcity is not a limiting factor to the survival of adult blackflies along the lower Orange River, because there is always at least one of the preferred carbohydrate sources flowering at any time of the year. This hypothesis is strengthened by the fact that many other

plants, that can potentially be used, flower throughout the year. The significance of drainage lines and tributaries in the survival of blackflies was shown in this study. They serve as places to rest and shelter and possibly as a means of navigation.

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