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RESEARCH ARTICLE

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Surveying *Orius* species (Hemiptera: Anthocoridae) in the South African sugarcane agro-ecosystem as potential biological control agents for *Fulmekiola serrata* Kobus (Thysanoptera: Thripidae) and other sap sucking pests

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Natural enemy surveys, especially for indigenous anthocorid predators of sugarcane thrips *Fulmekiola serrata* Kobus, were completed between 2008 and 2013 in and around sugarcane fields in the Mpumalanga and KwaZulu-Natal provinces of South Africa. Four Orius species were recorded during the surveys. First records for South Africa of *Orius tantillus* (Motchulsky) and *Orius naivashae* (Poppius) were made, and the presence of *Orius thripoborus* (Hesse) and *Orius brunnescens* (Poppius) in the country was confirmed. For each species, habitat and climate preferences are described. *Orius thripoborus* was the only anthocorid natural enemy which was observed preying on the sugarcane thrips in the field.

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INTRODUCTION

The sugarcane crop (*Saccharum* spp. Hybrid) is attacked by a wide range of insect pests all through its plant stages, though the majority of these are minor pests. A few major pests exist and are categorised based on their nature of damage: leaf feeders, sap feeders, stalk feeders and root feeders (Goebel and Nikpay 2017). In South Africa, the stalk borer, *Eldana saccharina* Walker (Lepidoptera: Pyralidae), is undoubtedly the industry's most serious pest. However, certain sap-sucking insects can also be serious pests if not managed: the yellow sugarcane aphid, *Sipha flava* (Forbes) (Homoptera: Aphididae), and the sugarcane thrips, *Fulmekiola serrata* Kobus (Thysanoptera: Thripidae) (Singels et al. 2019).

Fulmekiola serrata is native to Asia and has spread to Africa (Madagascar, Mauritius, Réunion and South Africa), North America (Barbados, Cuba, Florida, Guadeloupe, Trinidad) and South America (Venezuela and Guyana) (CABI 2020). It was possibly introduced into South Africa with planting material, or it came naturally from Mauritius (Way et al. 2006b; Sallam 2009). Since its first record in December 2004, *F. serrata* has spread rapidly throughout South Africa's sugarcane fields (Leslie and Donaldson 2005; Way et al. 2006a; Way 2008). The species causes damage in young sugarcane, inhabiting rolled leaf spindles and curled margins of leaves, where it oviposits and feeds on the leaf epidermis and chlorophyll, thus reducing the plant's photosynthetic ability (Sallam 2009). Due to their cryptic lifestyle, thrips, including *F. serratta*, are notably difficult to control. Therefore, the availability of an effective indigenous natural enemy of *F. serrata*, living in the same cryptic habitat, could provide local growers with an alternative management strategy against this invasive pest. Such natural enemies may be even more valuable for biological control programmes if they also attack other sugarcane pests such as aphids (Hemiptera: Aphididae), and thrips pests in other South African agricultural systems.

By examining more than 50,000 spindles of 3- to 4-month-old sugarcane from 2005 to 2007 in South Africa, Way (2008) found anthocorids (Heteroptera: Anthocoridae) to be amongst the most abundant predators inhabiting the same ecological niche as *F. serrata*. These insects, also called flower bugs or minute pirate bugs, are common in many agricultural habitats and are typically amongst the most abundant predators in field-cropping systems (Hernández and Stonedahl 1999). Only 14 anthocorid species have been recorded from southern Africa to date, but the museums possess many unidentified specimens, and it is highly likely that many more species (most of them are probably yet to be described) occur in South Africa (Jacobs, pers. comm.). According to Carayon (1961), the most common South African anthocorids belong to the Oriini tribe and most of them fall into the genus *Orius*. However, Hernández and Stonedahl (1999) suggested that only about two-thirds of the actual African *Orius* fauna is identified.

Most known anthocorid species are polyphagous predators (Péricart 1972) that feed on different life stages of a wide range of small arthropods, including springtails (Collembola), leaf hoppers (Cicadellidae), psyllids (Psylloidea), fly larvae (Diptera), scale insects (Coccidae), grain beetles (Coleoptera), caterpillars (Lepidoptera), leaf-roller larvae (Tortricidae), psocids (Psocoptera), aphids, thrips (Carayon 1972; Kelton 1978; Hernández and Stonedahl 1999), and different mite (Acari) species, such as oribatids, phytoseiids, and tetranychids (Askari and Stern 1972; Tawfik and Ata 1973; Lattin 1999). Anthocorids are also known to be omnivores, feeding on pollen and other plant materials besides arthropod prey (Coll 1998; Lattin 1999; Coll and Guershon 2002; Horton 2008).

Within the Anthocoridae family, species of the genus *Orius* Wolff are economically important predators of agricultural pests such as thrips, aphids, mites, whiteflies (Aleyrodidae) and the eggs of Lepidoptera, both in greenhouses and field crops (Riudavets 1995; Schuh and Slater 1995). However, they appear to show a preference for attacking larval and adult thrips over other available prey (Kakimoto et al. 2006; Arnò et al. 2008; Xu and Enkegaard 2009). Consequently, *Orius* species have been used successfully in biological control programmes in greenhouse and open-field cropping systems against various thrips pests worldwide (van den Meiracker and Ramakers 1991; Cranshaw et al. 1996; van Lenteren et al. 1997; Ohta 2001).

This paper presents the results from surveys conducted in 2008, 2009 and 2013 in South African sugarcane fields and their surroundings, to find anthocorid natural enemies of sugarcane thrips. Most observations were made in the provinces of Mpumalanga and KwaZulu-Natal, where sugarcane is a predominant crop. In 2013, surveys were also done in the Western Cape province where other crops were monitored for the presence of anthocorids.

MATERIALS AND METHODS

Specimens of *Orius* spp. and other anthocorids were collected from sugarcane flowers and several pollen-producing neighbouring (weedy) plants (Maes 2009; Cottenie 2010; Vangansbeke 2010). In 2008 and 2009, the focus was on the sugarcane fields in Mpumalanga and KwaZulu-Natal, representing the epicentre of the South African sugarcane production. In 2013, besides sugarcane, other crops including maize (*Zea mays* L.) were inspected for the presence of anthocorid thrips predators. That year, the survey area was expanded to the non-sugarcane producing Western Cape province, where anthocorids were monitored in a vineyard (*Vitis* sp.), an orange (*Citrus sinensis* (L.) Osbeck) plantation and in naturally occurring fynbos. A list of the sampling sites in each province, including information on the geography and climate is given in Table 1. All sampling locations are situated in the warm temperate climate zone (Kottek et al. 2006).

Insects were collected by placing a resealable plastic zipper storage bag (24 × 35 cm) over flowers or inflorescences and vigorously shaking the bag. Dislodged anthocorids were sucked up with an aspirator and placed in circular plastic vials (8 cm high, 2.5 cm diameter) with gauze lids for ventilation for transporting to the South African Sugarcane Research Institute (SASRI). The material was preserved in 70% ethanol. *Orius* specimens were identified using the keys developed by Carayon (1961) and Hernández and Stonedahl (1999), based on examination of male and female genitalia. Live adults of the two most abundant species, obtained from subsequent field collections, were used to initiate laboratory colonies (Bonte et al. 2012a). Based on laboratory experiments on individuals of these colonies, their biology and biocontrol potential are being investigated (see Bonte et al. 2012a, b, 2015, 2016a, b).

For the statistical comparison of total numbers of males and females collected for each *Orius* species, the statistical program R3.4.4 (R Core Team, 2018) was used to perform a Test of Equal or Given Proportions (‘prop.test’) ($p > 0.05$; R Stats Package, version 3.6.1). Based on a binomial distribution, the null hypothesis states that the proportion of males = proportion of females = 0.5.

Table 1. List of the different sampling sites per province, including information on geography and climate

Province	Location	Coordinates[a]	Altitude (m)[a]	Köppen-Geiger climate classification[b]	Annual mean min/max temperature (°C)[c]	Annual rainfall (mm/y)[c]
KwaZulu-Natal	Durban	29°47′15.1″ S 30°57′51.2″ E	96	cfa	16.6 / 26.4	1040
KwaZulu-Natal	Eston	29°51′59.0″ S 30°32′04.7″ E	516	cfa	13.2 / 27.9	863
KwaZulu-Natal	Ginginhlovu	29°01′03.0″ S 31°35′01.3″ E	74	cfa	17.8 / 24.7	1212
KwaZulu-Natal	Mt Edgecombe	29°42′19.3″ S 31°02′34.2″ E	90	cfa	17.6 / 25.0	925
KwaZulu-Natal	Pongola	27°23′36.0″ S 31°37′34.1″ E	509	cfa	15.4 / 28.1	678
KwaZulu-Natal	Stanger	29°22′40.8″ S 31°17′47.4″ E	43	cfa	16.6 / 26.4	1040
KwaZulu-Natal	Umfolozi	28°19′26.3″ S 32°14′17.0″ E	74	cfa	17.8 / 24.7	1212
KwaZulu-Natal	Umzimkulu	30°15′37.1″ S 29°55′27.1″ E	763	cfb	13.2 / 27.9	863
Mpumalanga	Malalane	25°28′50.2″ S 31°32′38.8″ E	345	cwa	19.0 / 28.5	644
Western Cape	Citrusdal	32°35′34.9″ S 19°01′49.0″ E	170	csb	10.8 / 25.2	120
Western Cape	Stellenbosch	33°55′58.3″ S 18°52′28.6″ E	129	csb	12.0 / 27.2	802

[a] Source: Google Earth (2015)
[b] c = warm temperate climate; s = dry summer; w = dry winter; f = fully humid; a = hot summer; b = warm summer (Kottek et al. 2006)
[c] Source: World Weather Online (2015)

RESULTS AND DISCUSSION

These surveys extended the previously known distribution of *Orius naivashae* (Poppius) and *Orius tantillus* (Motchulsky) southwards into South Africa (Tables 2 and 3). *Orius naivashae* is only known from Kenya, where it has been recorded in cotton, preying on *Helicoverpa armigera* (Hübner) (Hernández and Stonedahl 1999). *Orius tantillus* has a very wide distribution, from Oceania (Australia (Ghauri 1972; Woodward and Postle 1986), Solomon Islands, Guam (Ghauri 1972) and Micronesia (Herring 1967)) to Asia (Malaysia, Thailand (Manley 1976; Yasunaga and Miyamoto 1993), South China (Zheng 1982), Sri Lanka, India, and Pakistan (Distant 1906; Ghauri 1972)) and Africa (Kenya, Tanzania and Nigeria (Hernández and Stonedahl 1999)). *Orius tantillus* has been observed in association with *H. armigera* in sunflower and cotton in Kenya and on flowers of *Pennisetum typhoides* (Burm.) in Tanzania (Hernández and Stonedahl 1999). *Orius thripoborus* (Hesse) (Table 4) is present in Kenya (van Denberg and Cock 1995), St. Helena (Carayon 1976) and South Africa (Hesse 1940). It had been recorded previously in South Africa, feeding on *H. armigera* eggs in cotton fields (Van Hamburg and Guest 1997), and as a natural enemy of the thrips species *S. aurantii*, *H. haemorrhoidalis* and *S. rubrocinctus* (Hesse 1940; Steyn et al. 1993). Dennil (1992) proposed that *O. thripoborus* could be considered as a potential biological agent to control the thrips pests mentioned previously in cotton in Mpumalanga (formerly Eastern Transvaal province), South Africa. In Kenya, *O. thripoborus* is recorded feeding on *H. armigera* eggs in sunflower and cotton (van Denberg and Cock 1995; van Denberg et al. 1997).

Table 2. Records of *O. naivashae* from different locations and host plants in South Africa, from 2008 to 2013. Records are clustered by plant category. Apart from the record in Citrusdal (with citrus as the adjacent crop), sugarcane was adjacent in all these records.

Host plant	Location	Date	Numbers[a]		
			Male	Female	Nymph
Grassland weedy forbs					
Amaranthus hybridus L.	Mt Edgecombe	Aug 2009	0	1	1
Ageratum conyzoides L.	Eston	July 2008	/	/	/
Ageratum conyzoides L.	Mt Edgecombe	Aug 2009	3	14	17
Ageratum conyzoides L.	Mt Edgecombe	Sept 2009	8	38	46
Ageratum conyzoides L.	Stanger	Sept 2009	1	0	1
Ageratum conyzoides L.	Mt Edgecombe	Oct 2013	2	9	4
Ageratum conyzoides L.	Pongola	Oct 2013	0	3	0
Ageratum conyzoides L.	Mt Edgecombe	Dec 2013	0	1	0
Athanasia trifurcata L.	Citrusdal	Oct 2013	0	1	0
Bidens pilosa L.	Mt Edgecombe	July 2009	1	8	9
Bidens pilosa L.	Umfolozi	July 2009	0	4	4
Bidens pilosa L.	Mt Edgecombe	Aug 2009	3	19	22
Bidens pilosa L.	Mt Edgecombe	Sept 2009	1	2	3
Bidens pilosa L.	Pongola	Oct 2013	0	4	0
Conyza bonariensis (L.)	Pongola	Oct 2013	0	1	0
Conyza sp.	Pongola	Oct 2013	0	3	0
Senecio madagascariensis Poir.	Eston	July 2008	/	/	/
Senecio madagascariensis Poir.	Umfolozi	July 2009	0	1	1
Senecio madagascariensis Poir.	Mt Edgecombe	Aug 2009	6	16	22
Senecio madagascariensis Poir.	Mt Edgecombe	Sept 2009	35	82	117
Senecio madagascariensis Poir.	Stanger	Sept 2009	0	1	1
Senecio madagascariensis Poir.	Pongola	Oct 2013	0	3	0
Senecio madagascariensis Poir.	Mt Edgecombe	Oct 2013	1	6	3
Senecio sp.	Pongola	Oct 2013	1	7	0
Tall grasses					
Pennisetum purpureum Schumach.	Stanger	Sept 2009	0	1	1
Saccharum spp. Hybrid	Ginginhlovu	July 2008	/	/	/
Saccharum spp. Hybrid	Mt Edgecombe	Aug 2009	0	1	1
Wetland tall grass reeds					
Phragmites australis (Cav.) Trin. Ex Steud.	Mt Edgecombe	Aug 2009	0	1	1
Trees					
Erythrina lyistemon Hutch.	Umfolozi	July 2009	0	2	2
Totals collected[b]:			62	229	256

[a] Numbers of collected adults and nymphs were not registered when marked with '/'
[b] only for the years 2009 and 2013; the total proportion of males collected was significantly different from that of females (prop.test, $p < 0.001$).

Table 3. Records of *O. tantillus* from different locations and host plants in South Africa, from 2008 to 2013. Records are clustered by plant category. Sugarcane was adjacent in all these records.

Host plant	Location	Date	Numbers[a]		
			Male	Female	Nymph
Grassland weedy forbs					
Amaranthus spinosa L.	Stanger	Sept 2009	0	1	1
Bidens pilosa L.	Malalane	Aug 2008	/	/	/
Bidens pilosa L.	Stanger	Sept 2009	0	1	1
Conyza sp.	Pongola	Oct 2013	0	1	0
Flaveria bidentis L.	Malalane	July 2009	0	1	1
Senecio madagascariensis Poir.	Eston	July 2008	/	/	/
Tall grasses					
Pennisetum purpureum Schumach.	Pongola	Aug 2008	/	/	/
Pennisetum purpureum Schumach.	Stanger	Aug 2009	13	44	57
Pennisetum purpureum Schumach.	Stanger	Sept 2009	32	24	56
Saccharum spp. Hybrid	Pongola	Aug 2008	/	/	/
Saccharum spp. Hybrid.	Malalane	Aug 2008	/	/	/
Saccharum spp. Hybrid (flower-10/11 months)	Pongola	Oct 2013	1	16	2
Sorghum sudanense Stapf.	Pongola	Sept 2008	/	/	/
Zea mays L.	Pongola	Aug 2008	/	/	/
Zea mays L.	Malalane	July 2009	4	21	25
Zea mays L.	Pongola	Oct 2013	2	13	0
Wetland tall grass reeds					
Cyperus fastigiatus Robbt.	Pongola	Aug 2008	/	/	/
Trees					
Acacia nigrescens Oliver	Malalane	Aug 2008	/	/	/
Erythrina lysistemon Hutch.	Malalane	Aug 2008	/	/	/
Melia azedarach L.	Pongola	Aug 2008	/	/	/
Shrubs					
Bougainvillea sp.	Mt Edgecombe	Oct 2013	1	0	0
Ochna atropurpurea (Hochst.) Walp.	Mt Edgecombe	Sept 2008	/	/	/
Totals collected[b]:			53	122	143

[a] Numbers of collected adults and nymphs were not registered when marked with '/'
[b] Only for the years 2009 and 2013; the total proportion of males collected was significantly different from that of females (prop.test, $p < 0.001$).

The single record of *Orius brunnescens* (Poppius) in July 2008 on *Senecio madagascariensis* Poir. in Eston confirms its presence in South Africa. *Orius brunnescens* is widely distributed in Africa (Carayon 1961), from sea level to the alpine meadows at 3 000 m above sea level. However, it is more common in natural mountainous habitats rather than agricultural ecosystems (Carayon 1961). Likewise, the habitat record obtained for this species during this survey in South Africa was also at elevated altitude, i.e. the midlands of KwaZulu-Natal near Eston, at 516 m above sea level, and not at the coastal sugarcane sites sampled.

Both abiotic (e.g., climate) and biotic factors (e.g., presence and abundance of prey and flowering host plants) determine the seasonal occurrence of anthocorid predators in South Africa (Dicke and Jarvis 1962). Regarding the habitat and climate preferences of the *Orius* species recovered in South Africa during these surveys, limited inferences can be made due to the inconsistent monitoring strategy regarding survey years and seasons. However, there were indications that those *Orius* species recovered in sugarcane fields and the surrounds displayed a preference for particular categories of plants, e.g. grassland weedy forbs (see Tables 2 to 4). Almost all the predatory bugs were collected from the pollen-producing flower stamens. Many *O. naivashae* were recovered in pollen-producing grassland weedy forbs, and occasionally from (wetland) tall grasses (Poaceae), including sugarcane (Table 2). *Orius thripoborus* was more prevalent in taller vegetation, i.e. shrubs and trees, and tall grasses, mostly sugarcane, maize, lemon (*Citrus limon* (L.) Burm. f.), mango (*Mangifera indica* L.) and peach (*Prunus persica* (L.) Stokes). This species was recovered in the pollen-free spindle of young sugarcane, with *F. serrata*. *Orius thripoborus* was rarely recovered from flowering weed species (Table 4). *Orius tantillus* was prevalent on flowering tall grasses, including maize and sugarcane. This species was only occasionally found on weeds, wetland tall grass reeds and shrubs and trees (Table 3).

Laboratory studies on the thermal biology of *O. thripoborus* and *O. naivashae* show the former species is adapted to cooler temperatures than the latter (Bonte et al. 2012a). *Orius tantillus* is known from more tropical regions and appears to be more abundant in higher temperatures than *O. naivashae* and *O. thripoborus* (Bonte et al. 2012a; Nakashima and Hirose 1997). The results from the surveys conducted in South Africa during this study only partly reflect the various thermal preferences of these *Orius* species. *Orius naivashae* was common in regions with hot summers and humid conditions throughout the year such as Mount Edgecombe. In these surveys, a single recovery of *O. naivashae* was recorded in citrus at Citrusdal that is characterised by hot and dry summers, although the citrus crop was irrigated which influenced

Table 4. Records of *O. thripoborus* from different locations and host plants in South Africa, from 2008 to 2013. Records are clustered by plant category. Apart from the records in Stellenbosch (with vineyard or fynbos as the adjacent crop), sugarcane was adjacent in all these records.

Host plant	Location	Date	Numbersa		
			Male	Female	Nymph
Grassland weedy forbs					
Ageratum conyzoides L.	Eston	July 2008	/	/	/
Ageratum conyzoides L.	Mt Edgecombe	Sept 2009	2	1	3
Bidens pilosa L.	Umfolozi	July 2009	2	6	8
Bidens pilosa L.	Mt Edgecombe	Sept 2009	0	1	1
Flaveria bidentis L.	Malalane	July 2009	1	1	2
Indigofera sp.	Stellenbosch	Nov 2013	1	0	2
Lantana camara L.	Pongola	Aug 2008	/	/	/
Parthenium hysterophorus L.	Mt Edgecombe	Oct 2013	0	1	0
Senecio madagascariensis Poir.	Eston	July 2008	/	/	/
Senecio madagascariensis Poir.	Mt Edgecombe	Aug 2009	0	1	1
Senecio madagascariensis Poir.	Mt Edgecombe	Sept 2009	0	2	2
Tagetes minuta L.	Eston	July 2008	/	/	/
Tall grasses					
Saccharum spp. Hybrid	Pongola	Aug 2008	/	/	/
Saccharum spp. Hybrid	Mt Edgecombe	July 2009	0	2	2
Saccharum spp. Hybrid	Malalane	July 2009	0	3	3
Saccharum spp. Hybrid (young spindle with *F. serrata*)	Mt Edgecombe	Nov 2013	1	2	0
Sorghum sudanense Stapf.	Pongola	Sept 2008	/	/	/
Zea mays L.	Malalane	Aug 2008	/	/	/
Zea mays L.	Pongola	Sept 2008	/	/	/
Zea mays L.	Malalane	July 2009	5	8	13
Trees					
Vachellia robusta Burch.	Malalane	Aug 2008	/	/	/
Albizia adianthifolia (Schumach.) W.F. Wight	Umzimkulu	Sept 2008	/	/	/
Citrus limon L.	Pongola	Sept 2008	/	/	/
Erythrina lysistemon Hutch.	Umfolozi	July 2009	1	2	3
Erythrina lysistemon Hutch.	Durban	Sept 2009	1	2	3
Eucalyptus cladocalyx F. Muell.	Mt Edgecombe	Oct 2013	7	4	0
Jacaranda acutifolia auct. non-Humb. & Bonpl.	Mt Edgecombe	Oct 2013	0	4	0
Mangifera indica L.	Umzimkulu	Sept 2008	/	/	/
Maytenus oleoides Loes.	Stellenbosch	Nov 2013	2	2	2
Melia azedarach L.	Pongola	Sept 2008	/	/	/
Persea americana Mill.	Umzimkulu	Sept 2008	/	/	/
Shrubs					
Boscia senegalensis (Pers.) Lam. ex Poir.	Malalane	Aug 2008	/	/	/
Brunia sp.	Stellenbosch	Nov 2013	1	3	0
Erica glandulosa Thunb.	Stellenbosch	Nov 2013	4	11	0
Ochna atropurpurea (Hochst.) Walp.	Mt Edgecombe	Sept 2008	/	/	/
Rubus cuneifolius Pursh	Malalane	Aug 2008	/	/	/
Totals collected[b]:			28	56	45

[a] Numbers of collected adults and nymphs were not registered when marked with '/'
[b] Only for the years 2009 and 2013; the total proportion of males collected was significantly different from that of females (prop.test, ***p*** = 0.003).

the conditions that the insects were exposed to. *Orius thripoborus* was recovered in various weather conditions within the widespread warm temperate climate zone. The latter species was located in the Western Cape (Stellenbosch, with warm and dry summers), Mpumalanga (Malalane, with dry winters and hot summers) and KwaZulu-Natal (e.g., Mount Edgecombe, humid all year round, with hot summers; or Umzimkulu, humid all year round, with warm summers). Finally, *O. tantillus* was mainly collected in regions where annual temperatures were overall higher, driven by hot summers, combined with high year-round humidity (e.g., Pongola), or with dry winters (e.g., Malalane). Given the single record of *O. brunnescens*, there is insufficient information to hypothesise about its host plant and climate preferences.

More female than male *Orius* individuals were observed in both 2009 and 2013 (both $p < 0.001$ for *O. naivashae* and *O. tantillus*; $p = 0.003$ for *O. thripoborus*). For *O. thripoborus*, *O. tantillus* and *O.*

naivashae, 2, 2.3 and 3.7 times more females were recorded in the field, respectively (Tables 2 to 4). In most species, dispersal rates vary between sexes and male and female offspring may disperse from one habitat to another to differing degrees (Julliard 2000). Especially on sunny days, *Orius* females engage less in-flight activity than males do, and invest more time in on-plant foraging and oviposition (Tuda and Shima 2002). As most of the field surveys took place when weather conditions were favourable, the chance of encountering female *Orius* bugs was therefore greater. The difference in observed sex ratio between *O. naivashae* on the one hand, and *O. thripoborus* and *O. tantillus* on the other, is likely due to a naturally occurring female bias in the sampled *O. naivashae* populations. It is hypothesised that endosymbionts might have influenced this sex ratio distortion (Bonte et al. 2012a, b). This warrants further study.

Populations of *Orius* spp. may be supported by pollen-producing wild or cultivated plants in the vicinity of the crop. Habitats with different plant communities and phenologies attract alternative prey and can, whether or not in combination with pollen, support populations of omnivorous predators when target prey becomes scarce (Coll 1998; Lundgren 2009). This knowledge can be incorporated into an Integrated Pest Management (IPM) strategy with *Orius* spp. against pests such as *F. serrata* in sugarcane. The temporal resources provided by the pollen-producing plants can be appropriately synchronised with the predator and pest population build-up in nearby crops. Therefore, regular cutting of weeds for example, may force predators to move into crop fields (Coll 1998). Furthermore, the impact of *Orius* spp. may be broadened to other sugarcane pests, as many of the tall grasses (e.g., sugarcane, *Pennisetum purpureum* Schumach., *Z. mays* and *Sorghum* spp.) and wetland sedges (e.g., *Cyperus* spp.) on which *Orius* spp. were observed, are known hosts for the major sugarcane pest in South African namely, *Eldana saccharina* Walker (Lep. Pyralidae) (Conlong 2001; Keeping et al. 2007). *Eldana saccharina* has a very cryptic biology, ovipositing behind dry leaf sheaths, where small predators such as *Orius* spp. can reach. Neonate *E. saccharina* larvae move up the stalks of sugarcane to "parachute" off the green leaves to surrounding plants which they infest (Conlong et al. 2007). During this dispersal phase it is suggested that they will be prone to predation by *Orius* spp. Augmentation of the correct *Orius* spp. during the period when eggs and neonate larvae are abundant in sugarcane, may thus contribute to the IPM strategy against *E. saccharina*. Moreover, *Orius* spp. may also hold promise for the suppression of the yellow sugarcane aphid, *Sipha flava* (Forbes) (Homoptera: Aphididae), a recent invasion in sugarcane in South Africa (Way et al. 2006b; Conlong and Way 2015).

CONCLUSION

The current and previous studies on South African *Orius* spp. suggest that *O. thripoborus* may be the most suitable native biocontrol agent that can be used against *F. serrata* in South Africa. Bonte et al. (2012a, b; 2015; 2016b) showed that *O. thripoborus* can be mass reared on various factitious foods and has a high predation capacity, which is promising for biological control. *Orius thripoborus* also demonstrated a less restricted climate preference compared with *O. tantillus* and *O. naivashae* during our surveys and was the only anthocorid natural enemy which was observed preying on *F. serrata* in young sugarcane spindles.

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DEDICATION

In memory of Mike Way, an outstanding entomologist and above all a kind-hearted person.

AUTHOR CONTRIBUTIONS

J. Bonte: conceptualisation, formal analysis, investigation, methodology, writing – original draft, writing – review and editing. S. Maes: formal analysis, investigation, methodology. D. Vangansbeke: formal analysis, investigation, methodology. B. Cottenie: formal analysis, investigation, methodology. M. Way: investigation, methodology, writing – original draft. P. De Clercq: conceptualisation, methodology, resources, supervision, writing – original draft. D. Conlong: conceptualisation, methodology, resources, supervision, writing – original draft

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