

MALARIA VECTOR SURVEILLANCE IN SOUTH AFRICA DURING THE PERIOD JANUARY 2014 TO JULY 2015

Riann Christian^{1,2}, Lizette Koekemoer^{1,2}, Eunice Agubuzo^{1,2}, Givemore Munhenga^{1,2}, Allison Gilbert^{1,2}, Leanne Lobb^{1,2}, Erica Erlank^{1,2}, Leonard Dandalo^{1,2}, Oliver Wood^{1,2}, Maria Kaiser^{1,2}, Leyya Essop^{1,2}, Craig Davies^{1,2}, Nelius Venter^{1,2}, Power Tshikae^{1,2}, Ashley Burke^{1,2}, Frans Mbokazi³, Goodness Nkosi³, Jabulani Zikhali², Sfisun Ngxongo⁴, Maureen Coetzee^{1,2}, Basil Brooke^{1,2}

¹Vector Control Reference Laboratory, Centre for Opportunistic, Tropical & Hospital Infections, NICD

²Wits Research Institute for Malaria, Faculty of Health Sciences, University of the Witwatersrand

³Malaria Elimination Programme, Mpumalanga Department of Health, Ehlanzeni District

⁴Department of Health-KwaZulu-Natal, KwaZulu-Natal Provincial Government, Jozini

Introduction

South Africa's malaria affected areas include the low altitude border regions of Limpopo, Mpumalanga and KwaZulu-Natal Provinces.¹ These regions experience active malaria transmission, especially during the peak malaria season which spans the Summer months (November to April). Each of these provinces have developed well-coordinated malaria control operations including routine vector control which is primarily based on the application of indoor residual insecticide spraying (IRS).²

Although IRS has proven efficacy spanning many decades³, low-level residual malaria transmission continues and is likely caused by outdoor feeding and resting *Anopheles* vector mosquitoes that are unaffected by indoor applications of insecticide. In addition, populations of the major malaria vector species *Anopheles funestus* and *An. arabiensis* have developed resistance to insecticides, especially in northern KwaZulu-Natal.^{2,4} The pyrethroid-carbamate resistance profile in *An. funestus*⁵ has proved to be highly significant epidemiologically and was at least partly causative of the malaria epidemic experienced in South Africa during the period 1996 to 2000.^{3,6}

Residual malaria transmission and burgeoning insecticide resistance in malaria vector populations within South

Africa's borders necessitate ongoing vector surveillance. This is especially pertinent in terms of South Africa's malaria elimination agenda⁷ which includes the following key objectives:

- To strengthen passive and active surveillance and monitoring and evaluation systems so that 100% of districts report promptly and routinely on key malaria indicators by 2015
- To ensure that all levels of the malaria programme have sufficient capacity to coordinate and implement malaria interventions by 2016
- To ensure 100% of the population has adequate knowledge, attitudes and practices on malaria by 2018 through appropriate IEC, social mobilization and advocacy
- To effectively prevent malaria infections and eliminate all parasite reservoirs in South Africa by 2018

Malaria vector surveillance forms an integral part of these objectives. Surveillance is routinely conducted by the entomology teams of Limpopo, Mpumalanga and KwaZulu-Natal with operational field and laboratory support from the Vector Control Reference Laboratory (VCRL) of the Centre for Opportunistic, Tropical and Hospital Infections (CO THI), NICD, and Wits Research Institute for Malaria (WRIM).

In general, the VCRL provides a service for the identification of medically important arthropods for entomologists, medical practitioners, health inspectors and health authorities. In terms of malaria vector surveillance, the VCRL conducts mosquito species identification and vector incrimination using surveillance specimens referred to the VCRL by the provincial malaria control programmes. This report summarises malaria vector surveillance in South Africa during the period January 2014 – July 2015 based on specimens referred to the VCRL.

Materials & Methods

During the period January 2014 to July 2015, *Anopheles* mosquitoes were collected by the provincial entomology teams and VCRL personnel. Adult specimens were obtained by rearing larvae obtained from routine larval collections and adults were also periodically collected using trapping techniques including exit window traps, clay pots, modified buckets, human landing catches (HLC) and CO₂ baited net traps. One or more of these collection techniques were deployed at sentinel sites in Limpopo, Mpumalanga and KwaZulu-Natal provinces (Figure 1). Collected adult *Anopheles* specimens were preserved on silica and sent to the NICD for identification to species. Identification of all mosquito specimens was based on the use of morphological keys^{8,9} and PCR.^{10,11}

Results & Discussion

A total of 4 746 *Anopheles* mosquitoes was collected from sentinel sites during the period under review (Figure 1). Of these, 992 (20.9%) were collected from KwaZulu-Natal, 2 592 (54.6%) from Mpumalanga, 489 (10.3%) from Limpopo and 672 (14.2%) from the northern region of the Kruger National Park. The vast majority of the anophelines collected were members of the *An. gambiae* species complex (4 557; 96%) while the remaining 4% (189) were members of the *An. funestus* species group. Subsequent PCR analysis

revealed that the *An. gambiae* complex member species included *An. arabiensis*, *An. merus* and *An. quadriannulatus*. Member species of the *An. funestus* group identified included *An. rivulorum*, *An. vaneedeni*, *An. parensis* and *An. leesoni*. A summary of the species collected by relative proportion by province and species group is given in Figure 2.

Anopheles arabiensis was collected in comparatively large numbers in Mpumalanga and KwaZulu-Natal but did not appear in the Limpopo collections although this species has previously been detected there (Figure 2A,C). This species is a major malaria vector with variable feeding and resting behaviours. Outdoor feeding and resting components of South Africa's *An. arabiensis* populations are likely at least partially responsible for ongoing residual malaria transmission. This species has been directly implicated in malaria transmission in southern Mozambique.¹²

Anopheles merus was collected in the greatest relative proportion in Limpopo followed by Mpumalanga with only a small relative proportion collected in KwaZulu-Natal (Figure 2A,C,F). This species is generally listed as a minor or localised malaria vector. Currently, there is no indication of what, if any, contribution this species makes to malaria transmission in South Africa although it has also been implicated in malaria transmission in southern Mozambique.¹² Interestingly, this species is traditionally described as a salt-water coastal breeder but the larval collections from which most of these specimens accrued were found in fresh-water breeding sites. Recent data suggest that this species is increasing its inland range by adapting to breeding in fresh-water habitats (Mbokazi et al. - unpublished data).

Anopheles quadriannulatus is a non-vector member of the *An. gambiae* species complex that is comparatively common in the southern African region including South

Africa. This species was detected in Mpumalanga and Limpopo in comparatively large relative proportions and in a small relative proportion in KwaZulu-Natal (Figure 2A,C,F).

No *An. funestus sensu strictu* were collected during the review period. In the absence of vector control, this species is the predominant malaria vector in the southern African region where it is especially prevalent in Mozambique and Zimbabwe.¹³ Although the eastern Lowveld regions of South Africa form part of the natural range of this species, its absence can be attributed to intensive IRS programmes in KwaZulu-Natal, Mpumalanga and Limpopo. This is because *An. funestus* is highly endophilic (indoor-resting) and is therefore especially susceptible to IRS. Other members of the *An. funestus* species group were only detected in Mpumalanga and KwaZulu-Natal in comparatively low numbers (Figure 2B,D) although member species of this group have previously been collected in Limpopo. *Anopheles leesonii*, *An. vaneedeni* and *An. parensis* are generally considered to be non-vector species while *An. rivulorum* has been implicated as a minor malaria vector in East Africa.^{14,15} The possibility of one or more of these species playing a role in residual malaria transmission in South Africa cannot be ruled out.

The occurrence of *An. arabiensis* and *An. quadriannulatus* in the northern Kruger National Park (Figure 2E) has previously been documented.¹⁶ These species tend to occur in sympatry, especially at the Malahlapanga site. During the review period *An. quadriannulatus* predominated at Malahlapanga but previous surveys have shown a predominance of *An. arabiensis* there.¹⁶ The change in relative densities of these two species at this site is likely linked to fluctuations in environmental conditions and weather patterns.

Conclusion

Several known and potential malaria vector species occur in the north-eastern Lowveld regions of South Africa despite well-coordinated IRS programmes that generally achieve high spray coverage rates (80% or more of targeted structures in endemic areas). It is highly likely that one or more of these species are responsible for ongoing residual transmission within South Africa's borders. It is envisaged that the vector surveillance programmes in each of the affected provinces and the scaling up of these activities in collaboration with the VCRL will clarify the role, if any, of each of these species in malaria transmission in South Africa. This information will enable an intensification of vector control activities to include methods designed to target outdoor feeding vector populations. The absence of *An. funestus sensu strictu* within South Africa's borders is indicative of continued high-level effectiveness of the provincial IRS-based vector control programmes.

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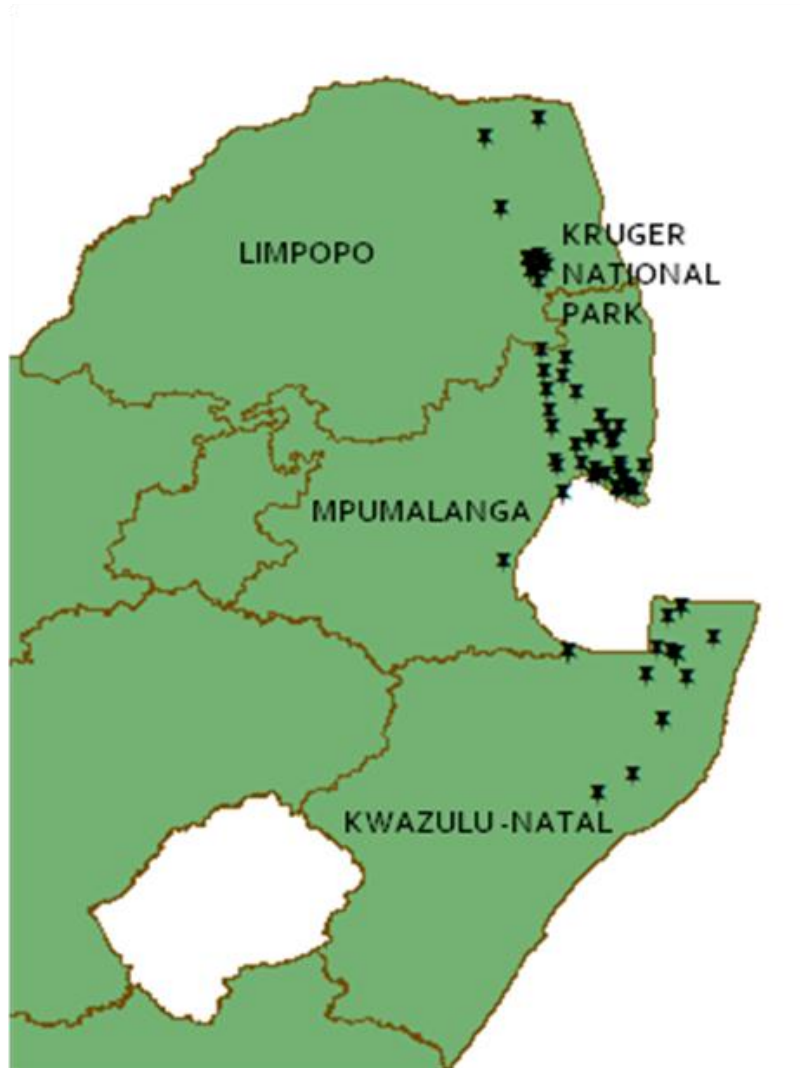


Figure 1: Sentinel sites where malaria vector surveillance was conducted in South Africa during the period January 2014 to July 2015.

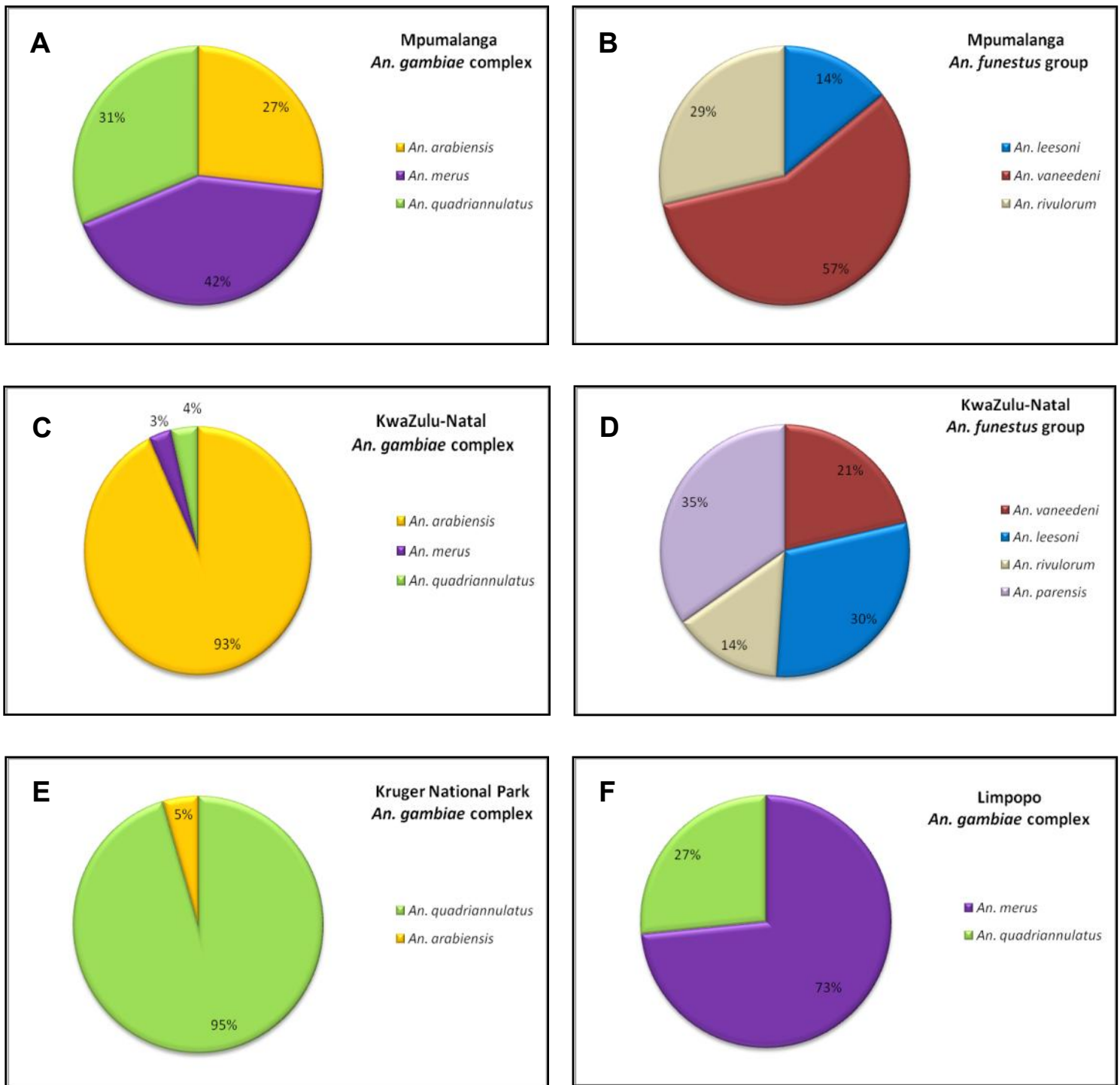


Figure 2: Relative proportions of member species of the *Anopheles gambiae* species complex and *An. funestus* species group by province/locality, South Africa. These proportions are based on *Anopheles* specimens collected during the period January 2014 to July 2015.

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