

**SPIDER ECOLOGY IN THE ERFENIS
DAM NATURE RESERVE, FREE STATE
PROVINCE (ARACHNIDA: ARANEAE)**

by

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I declare that the dissertation hereby handed in for the qualification Master Scientiae at the University of the Free State, is my own independent work and that I have not previously submitted the same work for a qualification at/in another University/faculty.

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ABSTRACT

Few spider studies have been done in the Grassland Biome of South Africa, even though it dominates the central part of South Africa. In September 2005, a study was initiated in Erfenis Dam Nature Reserve, Free State Province, to determine the impact of controlled burning on various faunal groups. Thus, the aim of this study was to determine the effect of controlled burning on ground-dwelling spider communities in the reserve. Pitfall traps were set out in six different sites in the reserve, with three sites located in the burned area and the other three sites in the unburned area. The traps were replaced every 30 days for one year between 21 September 2005 (day following burning) and 30 September 2006. During this period, a total of 5222 spiders representing 33 families and 121 species were collected. In the burned sites Gnaphosidae, Lycosidae, Caponiidae and Salticidae, were dominant in abundance, while Gnaphosidae, Lycosidae, Amaurobiidae and Corinnidae were dominant in the unburned sites. Monthly spider abundance and species richness were consistently lower in the burned grassland, suggesting that succession and colonisation processes are slow. Gnaphosidae and Lycosidae were present throughout the year in all six sites, indicating that they are either fire tolerant or fast colonisers.

The potential was recognised to expand the study to the sampling of grass- and foliage-dwelling spiders as well. This study was conducted from November 2005 until August 2007, with sampling done in the last week of every third month. Foliage spiders were collected from three different tree species (*Acacia karroo*, *Rhus lancea* and *Rhus ciliata*) by beating. During the period of two years a total of 496 foliage spiders were collected that represented 17 families and 54 species. Sweeps were done in four different grasslands (uniform *Themeda triandra*, mixed, weedy and woodland grasslands). During the period of two years a total of 1649 spiders were collected that represented 15 families and 84 species. The families that dominate the Grassland biome in abundance are the Araneidae, Philodromidae, Salticidae and Thomisidae, due mainly because of the vegetation structure and complexity. More spider species as well as individuals were collected from the grasslands than from the tree layers, but the tree layers had a greater diversity of spider families.

As part of the ground-dwelling spider study, the influence of termite activity on the activity of *Ammoxenus amphalodes* Dippenaar & Meyer (Ammoxenidae) was determined. *A. amphalodes* activity were concentrated in the two sites that had the greatest termite activity, especially that of *Hodotermes mossambicus* Hagen. Both *A. amphalodes* and *H. mossambicus* abundance were significantly influenced by soil type, which affects nest construction in *H. mossambicus* and foraging behaviour in *A. amphalodes*.

While sorting the traps for the study on ground-dwelling spiders, a species of *Calommata* (Atypidae) known as the African purse-web spider was found. In South Africa the genus was last collected in the 1920's, when specimens were collected from several localities in Gauteng and the Soutpansberg. Subsequently, no material was collected until the recent discovery of a species in Groenkloof Nature Reserve in Gauteng in 2001, a male in the Blouberg Nature Reserve (Limpopo Province) and eight males found in pitfall traps in Erfenis Dam Nature Reserve. All of the material had previously been regarded as *Calommata simoni* Pocock, but examination of all available material indicated that at least six species occurred in the Afrotropical Region, four of which are described as new. *Calommata transvaalica* Hewitt is removed from synonymy with *C. simoni* and revalidated. *C. meridionalis* sp. n. showed a preference for soils with relative high clay content. Males of this species also showed most activity from October to November.

Key words: Grassland Biome, burning, tree species, grasslands, *Ammoxenus amphalodes*, *Calommata* spp., taxonomy.

UITTREKSEL

Min studies oor spinnekoppe is al gedoen in die Grasland Bioom van Suid-Afrika, al domineer dit die sentrale gedeelte. In September 2005 is 'n studie begin te Erfenis Dam Natuur Reservaat, Vrystaat Provinsie, om die invloed van beheerde brande op verskeie fauna groepe te bepaal. Die doel van hierdie studie was om die effek van beheerde brande op grondlewende spinnekop gemeenskappe te bepaal in die reservaat. Pitvalle is uitgesit in ses verskillende lokaliteite in die reservaat, met drie lokaliteite wat geplaas was in die gebrande area en die ander drie in die ongebrande area. Die valle is elke 30 dae vervang vir een jaar tussen 21 September 2005 (dag na brand) en 30 September 2006. Gedurende hierdie tydperk is 'n totaal van 5222 spinnekoppe, wat 33 families en 121 spesies verteenwoordig, versamel. In die gebrande areas was Gnaphosidae, Lycosidae, Caponiidae en Salticidae dominant, terwyl Gnaphosidae, Lycosidae, Amaurobiidae en Corinnidae dominant was in die ongebrande areas. Maandlikse spinnekop getalle en spesie rykheid was voortdurend laer in die gebrande grasland, wat voorstel dat suksessie en kolonisasie prosesse stadig is. Gnaphosidae en Lycosidae was regdeur die jaar teenwoordig in al ses lokaliteite, wat aandui dat hulle, of vuur tolerant, of vinnige koloniseerders is.

Potensiaal is raakgesien om die studie te verbreed deur gras- en plantlewende spinnekoppe ook te versamel. Dié studie is gedoen vanaf November 2005 tot Augustus 2007, met opnames wat gedoen is in die laaste week van elke derde maand. Plantlewende spinnekoppe is versamel vanaf drie verskillende boom spesies (*Acacia karroo*, *Rhus lancea* en *Rhus ciliata*). In die tydperk is 'n totaal van 496 plantlewende spinnekoppe, wat 17 families en 54 spesies verteenwoordig, versamel. Veenetversameling is uitgevoer in vier verskillende grasvelde (eenvormige *Themeda triandra*, gemengde, onkruid en woudland graslande). 'n Totaal van 1649 spinnekoppe, wat 15 families en 84 spesies verteenwoordig, is versamel. Die tipe plant strukture en kompleksiteit het die families; Araneidae, Philodromidae, Salticidae en Thomisidae, wat die Grasland bioom gedomineer het bepaal. Meer spinnekop spesies sowel as individue

is versamel vanuit die graslande as van bome, maar die bome het 'n groter diversiteit van spinnekop families gehad.

As 'n deel van die grondlewende spinnekop studie, is bepaal die invloed van termiet aktiwiteit is op die aktiwiteit van *Ammodramus ampalodes* Dippenaar & Meyer (Ammodramidae). *A. ampalodes* aktiwiteit is gekonsentreer in die twee areas met die grootste termiet aktiwiteit, veral dié van *Hodotermes mossambicus* Hagen. Beide *A. ampalodes* en *H. mossambicus* volopheid is grootliks beïnvloed deur grondtipe, wat nes konstruksie affekteer in *H. mossambicus* en voedings gedrag in *A. ampalodes*.

Met die pitval sortering vir die grondlewende spinnekop studie, is 'n spesie van *Calommata* (Atypidae), ook bekend as die Afrika beurs-web spinnekop, gevind. In Suid-Afrika is die genus laas versamel in die 1920's, toe eksemplare in verskeie lokaliteite in Gauteng en die Soutpansberge versamel was. Sedertdien is geen materiaal weer versamel nie tot die onlangse ontdekking van 'n spesie in die Groenkloof Natuur Reservaat in Gauteng in 2001, 'n mannetjie in die Blouberg Natuur Reservaat (Limpopo Provinsie) en die agt mannetjies wat versamel is in die pitvalle te Erfenis Dam Natuur Reservaat. Alle vorige materiaal was voorheen bekend as *Calommata simoni* Pocock, totdat alle beskikbare materiaal van nader ondersoek is en dit gevind is dat daar ten minste ses spesies in die Afrotropiese Streek voorkom. Vier hiervan word hier as nuwe spesies beskryf. *Calommata transvaalica* Hewitt is verwyder van sinonimie met *C. simoni* en word weer herken. *C. meridionalis* sp. n. het 'n voorkeur vir grond met relatiewe hoë klei inhoud en mannetjies van hierdie spesie was meestal aktief vanaf Oktober tot November.

Sleutel woorde: Grasland Bioom, brande, boom spesies, graslande, *Ammodramus ampalodes*, *Calommata* spp., taksonomie.

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"It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change" - Charles Darwin

CHAPTER 1

**Studies of spider (Arachnida: Araneae)
ecology in the different biomes of South
Africa**

1.1. Abstract

Spiders have been poorly studied in southern Africa because of the focus that has been placed on the larger taxa of animals. South Africa has a rich spider fauna represented by 69 families, 469 genera and about 2000 species that occur in all of the eco-regions of South Africa. Not many studies were done before the launch of SANSA (South African National Survey of Arachnida), but since its initiation in 1997 studies and projects have increased significantly in the different biomes. Of all the biomes present in South Africa, the Savanna biome is the best studied.

Key words: South Africa, spider fauna, SANSA, biomes, Savanna biome.

1.2. Introduction

In the past, studies in biodiversity and conservation have concentrated on the larger taxa, namely mammals, birds and reptiles, but recent research has paid more and more attention to collect information to incorporate into invertebrate studies (Oxbrough *et al.* 2005). South Africa has a rich spider fauna that is represented by 69 families, 469 genera and about 2000 species that occur in all the eco-regions of South Africa, but currently the country also has a lack of taxonomic expertise, which makes it impossible to identify some spider families to species and sometimes even generic levels. This leads to the underestimation of the actual species pool and undermines meaningful conservation (Dippenaar-Schoeman *et al.* 2008).

Knowledge of spiders in southern Africa is largely limited to descriptions of species, while the ecological and diversity aspect has remained relatively unexplored until recently, even though spiders constitute of an abundant and successful group of the invertebrates (Haddad & Dippenaar-Schoeman 2002). This does not seem to be a problem that is only limited to South Africa (Churchill 1997; Cardoso *et al.* 2004). However, spiders are today being used more and more in ecological studies as indicators of environmental quality and as biological control agents in agricultural ecosystems (Green 1996). In invertebrate communities, spiders are the dominant predatory complex that can influence these communities, and because of this dominance they have been

promoted to being a priority group for research (Churchill 1997). Spiders are the ideal group to study because they fulfill the four criteria to be used as indicators: 1) they are diverse and commonly found, 2) are easy to collect, 3) are functional in ecosystems as predators and are also prey for other predators, and 4) they are in interaction with their abiotic and biotic environment in such a way that they can indicate ecological changes (Churchill 1997). Spiders are abundant in most terrestrial ecosystems and are primarily affected by the changes in vegetation structure, which has led to their use in studies of habitat and the effects of disturbance. Spiders also have the advantage of being efficiently and easily sampled, and are also relatively easily identified compared to other invertebrate groups (Oxbrough *et al.* 2005).

The role of spiders as an important component of arthropod communities has recently received more attention, and there is an increasing interest in the analysis of spider predation in natural ecosystems (Turner 1979; Lockley & Young 1987; Romero & Vasconcellos-Neto 2003, 2004). Knowledge of the feeding behaviour of a specific spider species is necessary to be correctly calculating the impact of spider predation on the arthropod communities. The overall success of spiders as predators is due to the various ways in which they exploit insect populations (Borror *et al.* 1989).

1.3. The South African National Survey of Arachnida (SANSA)

Before the initiation of the South African National Survey of Arachnida (SANSA) in 1997, few projects had been done to study the diversity of spiders in southern Africa (with most studies focused in the savanna biome).

South Africa was recognised in terrestrial terms to be a country that is very rich in biodiversity (Myers 1990). Our country has been developing strategic plans for the conservation and sustainable use of biodiversity, with one of the national efforts being the goal to discover, describe and to compile an inventory of the different arachnid species of South Africa (Foord *et al.* 2002; Dippenaar-Schoeman *et al.* 2008). This is in an effort to be able to meet the obligations of Agenda 21 of the Earth Summit in Rio de Janeiro (1992) and the Convention on Biological Diversity in 1995. It can be reasoned that

meaningful conservation cannot take place if the species involved are not known (Foord *et al.* 2002). A result of this was the initiation of SANSA in 1997 with the main aim of inventorying the arachnid fauna of South Africa (Dippenaar-Schoeman & Craemer 2000). Since then, various projects were started and are still in progress to determine the biodiversity of the arachnid fauna and the species that are protected in existing conservation areas. During the first phase of this project a database was developed from which all the data collected in the SANSA surveys can be accessed. This includes 20 completed projects in South Africa in which more than 40 000 specimens have been collected. SANSA then progressed into a four-year inventory and conservation programme that was launched on the 4th September 2006 at the Botanical Gardens in Pretoria with the aim of carrying out a Red Data assessment on the South African arachnid fauna (Dippenaar-Schoeman & Haddad 2007).

The South African National Biodiversity Institute (SANBI) is providing some of the core funding as well as logistical support during this second phase of SANSA. This is the first major invertebrate project that has been undertaken by SANBI since its transformation from the former National Botanical Institute (NBI). SANBI falls under the Department of Environmental Affairs and Tourism with the main function of monitoring and reporting on the status of biodiversity in South Africa. The Agricultural Research Council (ARC) will continue to coordinate the second phase of SANSA, where most work is undertaken at the Spider Research Centre in Pretoria (Biosystematics Division, ARC-Plant Protection Research Institute). The project consists of many initiatives that address aspects such as accessing the existing data, gap analysis, surveys, identification of existing data, awareness, capacity building, and compiling products such as books and the red data list (Dippenaar-Schoeman & Haddad 2007).

Since the launch of SANSA, many surveys and studies have been done all over South Africa (see under 1.4.). One of SANSA's projects is to determine the arachnids protected in conserved areas (Dippenaar-Schoeman & Haddad 2007). Recently surveys have been initiated in National Botanical Gardens to determine the arachnid diversity to compliment the other surveys. SANSA will also be contributing information from their databases to

the Grasslands Programme, which was launched on 20 May 2008 (Dippenaar-Schoeman & Haddad 2008).

1.4. Spider ecology studies done in South Africa

Even though the order Araneae constitutes an abundant and very successful group of invertebrates, little is known about their diversity, phenology and ecology in contrast with spiders in the more temperate regions (Lotz *et al.* 1991; Dippenaar-Schoeman & Jocqué 1997; Foord *et al.* 2002).

1.4.1. Spider studies done in the biomes

Ecosystems consist of various biological units. When organisms are in interaction with each other in a given area they form communities. Thus, ecosystems are the biotic communities in interaction with their abiotic environment (Price 1975). Various types of ecosystems have developed over time due to the interaction of climate with parent rock material and the availability of flora and fauna in that environment. In turn, these ecosystems are broadly classified as terrestrial and aquatic. The terrestrial ecosystems are further divided into biomes (Dash 1993).

A biome can by definition be considered as a broad ecological unit and it represents a large, relatively homogenic natural environment. A characteristic of a biome is the presence of the same types of animals and plants that occur in an area that can be associated with a certain type of climate (Van Rooyen 2006). According to Dash (1993) the same type of biome is found within the same general latitudes, but in mountains the division lines of biomes are elevational instead of latitudinal.

Southern Africa has seven biomes that are based on the dominant plant types, namely fynbos, succulent Karoo, Nama Karoo, forest, grassland, savanna and desert biomes, with some literature designating an eighth biome, the thicket biome (Van Rooyen 2006).

Spiders are polyphagous predators, which mean they mostly interact with the vegetation indirectly, but can also be directly influenced, for example, web-builders that are directly

influenced by vegetation structure (Gunnarsson 1990). It can thus be said that the number of individuals of a spider family that will be collected depends on the activity patterns of the family and the type of vegetation (Lotz *et al.* 1991).

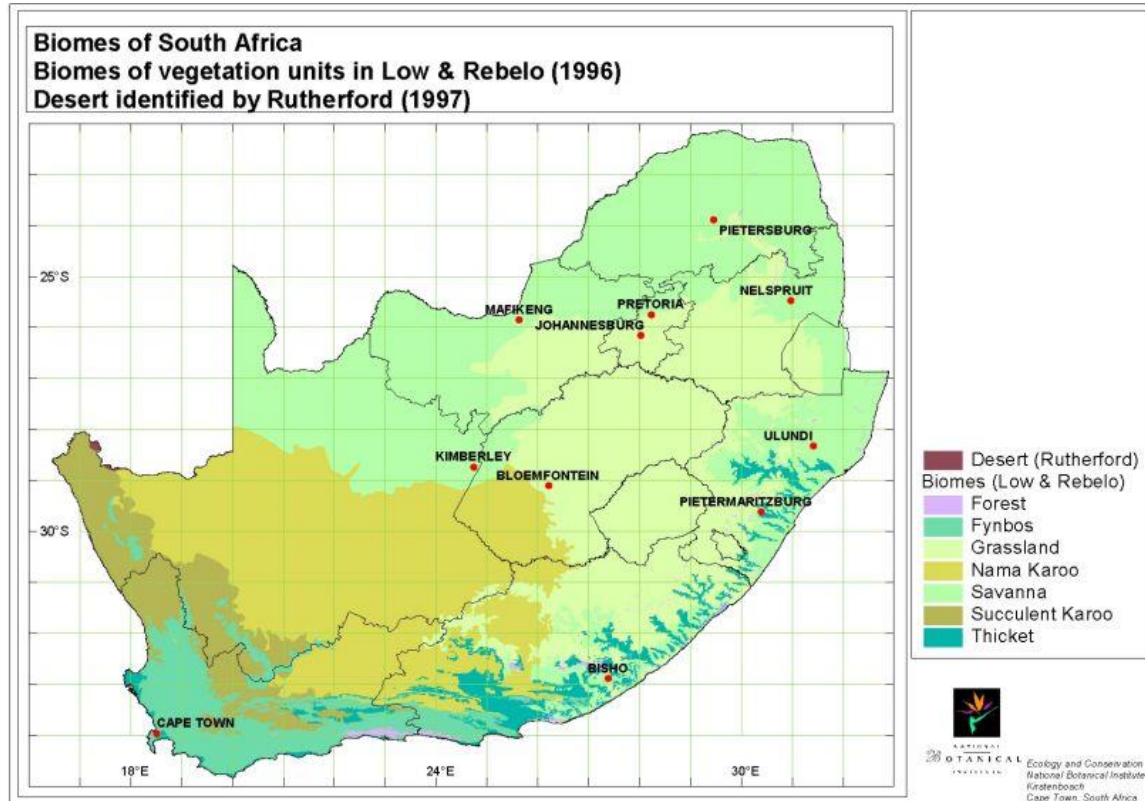


Fig. 1. The distribution of the eight biomes of South Africa based on the dominant plant types, which are associated with a particular type of climate (From the National Botanical Institute, Kirstenbosch 2009).

1.4.1.1. Fynbos: The fynbos biome is a small but diverse vegetation type occurring in the south-western and southern parts of South Africa (Fig. 1) and is one of the world's richest areas of plant species diversity (Visser *et al.* 1999; Goldblatt & Manning 2002). It experiences a mediterranean type of climate that consists of dry summers and wet winters. Vegetation ranges from sclerophyllous to microphyllous, with a large number of species belonging to Asteraceae, Fabaceae, Iridaceae, Aizoaceae, Ericaceae, Proteaceae and Restionaceae (Goldblatt & Manning 2002). Grasses are not prominent in this region and fire plays an important role in maintaining the plant species composition (Van Rooyen 2006). This biome is known for its high species richness as well as the occurrence of many endemic species (about 65 % of the 8650 vascular plant species are

endemic); thus the conservation of this biome is given high priority (Goldblatt 1997; Visser *et al.* 1999). Arthropods associated with this type of flora play an important ecological role and may deserve conservation priority in their own right (Visser *et al.* 1999). According to Giliomee (2003), fynbos has poor insect diversity in comparison to the flora present in the biome, and this is related to the sclerophylly and chemical defenses against herbivory in the plants. Picker & Samways (1996) did an assessment of the Cape Peninsula in the Western Cape Province and found it rich in invertebrate endemics. Procheş & Cowling (2006) found that even though insect diversity does not match plant diversity completely, the fynbos is not as insect-poor as previously thought.

Although insects have been well studied in the fynbos biome (Coetzee *et al.* 1990), not much work has been done on the diversity of arachnids (Haddad & Dippenaar-Schoeman 2009). Coetzee *et al.* (1990) collected 837 spider specimens representing 35 genera and 15 families from proteaceous plants. The most abundant families were Salticidae, Clubionidae, Theridiidae, Araneidae and Philodromidae. From inflorescences, 61 species were collected. Visser *et al.* (1999) studied arachnids associated with *Protea nitida* Mill (Proteaceae) in three study areas in the Western Cape over a one year period, collecting five arachnid orders of which the Araneae was the dominant order. A total of 653 individuals were collected, representing 18 families and 32 species. Of these, five families and eight genera (eight species) were recorded for the first time on the Proteaceae.

Haddad & Dippenaar-Schoeman (2009) reported on the diversity of arachnids (excluding the Acari) in the De Hoop Nature Reserve in the Western Cape Province, which consists of large areas of pristine fynbos and protected marine habitats. Intensive sampling had been undertaken during five visits to the reserve in five habitats. A total of 274 species of arachnids were collected that represented five orders, 65 families and 191 determined genera. Of these, the order Araneae was the most species rich, comprising 252 species in 54 families. This included a published record of a species that was not collected in the De Hoop survey, *Nephila fenestrata* Thorell (Nephilidae) (Fromhage *et al.* 2007). The reserve has the highest recorded spider family diversity, equaling the Soutpansberg in Limpopo Province (Foord *et al.* 2008) and exceeding Ndumo Game

Reserve in KwaZulu-Natal (Haddad *et al.* 2006). The remaining arachnid orders were not as well represented, the most species rich being the Pseudoscorpiones (nine species, five families), followed by Opiliones (eight species, three families), Scorpiones (four species, three families) and Solifugae (one species, one family). The Salticidae was the most species rich, followed by Thomisidae and Gnaphosidae. The majority of the arachnid species that were collected were wanderers (73.0 %), while web-builders comprised 27.0 % (Haddad & Dippenaar-Schoeman 2009).

According to Sharratt *et al.* (2000), 85 cavernicolous invertebrate species across six phyla are supported in the temperate sandstone caves of the Cape Peninsula. Six of these species were previously unknown, including one species of insects (Dermaptera) and one species of spiders (Araneae: Hahniidae). Of the Araneae collected, three species were considered troglobites (obligate cave-dwelling species), five species were considered troglophiles (species collected from caves more than once) and one species was a troglaxene (species that accidentally enter caves, i.e. usually spiders that accidentally wander into caves and are found only in and around cave entrances) (Sharratt *et al.* 2000; Dippenaar-Schoeman & Myburgh 2009). Of the Opiliones collected, two species were troglobites and one species a troglophile. According to Dippenaar-Schoeman & Jocqué (1997) a review of African spiders showed that species of 19 families have been recorded from caves in the Afrotropical Region.

1.4.1.2. Succulent Karoo: This biome extends from southern Namibia, southwards along the western side of the South African escarpment to the eastern border of the Western Cape Province (Fig. 1) and is home to the world's richest succulent flora (Lombard *et al.* 1999). This biome is dominated by a low winter rainfall and extreme dryness in the summer. The vegetation consists of mostly small, succulent shrubs, with grasses being almost absent (except in sandy soils that are sheltered). The plant species diversity is quite high for such a large dry region, and it includes quite a high proportion of rare and endemic species. Unfortunately, most of this region has been disturbed by farming and is overgrazed (Van Rooyen 2006).

Sporadic spider collecting was undertaken in the Swartberg Nature Reserve from 1991-2002. In that ten year period, 45 spider families representing 136 genera and 186 species were collected, with 20 of the families represented by a single species. During the survey, the family Filistatidae (mostly known from Namibia and other parts of the Afrotropical Region) was collected for the first time from South Africa. All 186 species were new distribution records for the reserve (Dippenaar-Schoeman *et al.* 2005).

1.4.1.3. Nama Karoo: This biome covers almost all of the central part of the Northern Cape Province (Fig. 1) and is characterized by a low (100–300 mm) and variable annual rainfall (Beukes *et al.* 2002; Van Rooyen 2006). The vegetation is categorized as dwarf open shrub land, while succulent vegetation and trees are mostly absent (Palmer & Hoffman 1997). Fires do not really occur in this biome because of the scarcity of flammable material (Van Rooyen 2006).

Spiders living on ground covers and tree canopies, as well as epigeic spiders, were surveyed in pistachio orchards near Prieska as part of a large arthropod study (Haddad *et al.* 2004; Haddad *et al.* 2005; Haddad & Dippenaar-Schoeman 2006). In total, 1760 spiders that represented 55 species were collected in three different ground covers. Mainly two species, the lynx spider *Peucetia viridis* (Blackwell) and the jumping spider *Heliophanus pistaciae* Wesolowska (considered as a pistachio agrobiont species), dominated the spider fauna (Haddad *et al.* 2004; Haddad & Louw 2006). A total of 5843 spiders, representing 18 families and 88 species, were collected in the tree canopies. Three spider species dominated the canopies: *Heliophanus pistaciae*, *Cheiracanthium furculatum* Karsch and *Neoscona subfusca* (C.L. Koch). It was also found that there were more spiders in the older orchards than in the younger orchard that was sampled (Haddad *et al.* 2005; Haddad & Louw 2006). A total of 2337 epigeic spiders that represented 81 species from 22 families were collected with pitfall trapping and active searching. Of these, 1692 spiders (16 families, 49 species) were collected by pitfall trapping alone, indicating the effectiveness of this method in determining abundance and phenology. Active searching yielded 645 spiders, representing 16 families and 63 species, indicating that this method was effective for sampling greater diversity. Four families (Linyphiidae,

Gnaphosidae, Lycosidae and Salticidae) dominated in the epigeic fauna, with *Ostearius melanopygius* (O. P.-Cambridge) from the Linyphiidae dominating the spider fauna in all orchards. This species is considered a pistachio agrobiont (Haddad & Dippenaar-Schoeman 2006).

As an additional study, epigeic spider populations were studied in a natural undisturbed Nama Karoo grassland site. A total of 2814 spiders, representing 25 families and 80 species were collected. The grassland site supported a significantly greater abundance and diversity of spiders than the three pistachio orchards, with five families (Agelenidae, Ammoxenidae, Cyrtaucheniidae, Gnaphosidae and Philodromidae) that dominated the epigeic fauna of the grassland. The orchard stands were dominated by Linyphiidae, Lycosidae and Salticidae (Haddad & Dippenaar-Schoeman 2005; Haddad *et al.* 2008).

Dippenaar-Schoeman *et al.* (1999a) sampled spiders over a period of ten years in the Karoo National Park in the Western Cape Province. In this time 38 families were collected, which represented 101 genera and 116 species. Ninety-four of these species were new records for the region. Seventy-seven of the species that were collected was noted as wanderers and 39 were web-builders (Dippenaar-Schoeman *et al.* 1999a). Dippenaar-Schoeman (2006) presented additional records of 43 spider species from the Mountain Zebra National Park in the Eastern Cape Province. Previously, only 32 species from 16 families were known from this park (Dippenaar-Schoeman 1988). The park also represented new range extensions for all 43 species that were newly recorded. Fourteen of the 34 spider families were web-builders (representing 35 species), while the other 20 families (representing 41 species) were wanderers (Dippenaar-Schoeman 2006).

1.4.1.4. Forest: Indigenous forests occupy less than 1 % of the land surface of South Africa. Forests occur from sea level to the mountains and can be divided into coastal forests, afro-montane forests and sand forests in the eastern and southern parts of South Africa, with the northern-most forest located in the Soutpansberg (Fig. 1) (Von Maltitz 2002; Van Rooyen 2006). Because the forests of South Africa are so fragmented, it is considered as one of the most vulnerable vegetation types. As there is quite a variation in

climate, altitude, latitude and topography across southern Africa, it has resulted in the formation of a diversity of forest types (Von Maltitz 2002).

A one year survey was conducted in the Ngome State Forest (in afro-montane forest and pine plantations) on the ground-living spiders where a total of 9360 spiders, representing 33 families and 136 species, were collected in pitfall traps. Grass showed the highest species richness (89 species) of the five habitats that were sampled, while the pine habitat had the lowest species richness (Van der Merwe *et al.* 1996).

Between 1996 and 1997 ground-dwelling spiders were sampled from three different stands of coastal dune forest at Richards Bay, KwaZulu-Natal Province. Twenty-five families, representing 39 genera and 48 species were collected. Lycosidae was the most abundant family, followed by Ctenidae and Thomisidae. The most abundant species was an undescribed lycosid species, followed by *Ctenus gulosus* Arts (Ctenidae). Lycosidae was also the most species rich family that was recorded, followed by Corinnidae. These species were all new distribution records for Richards Bay (Dippenaar-Schoeman & Wassenaar 2002). Dippenaar-Schoeman & Wassenaar (2006) sampled spiders on the herbaceous layer of coastal dune forest. A total of 2955 spiders, representing 23 families, 72 genera and 96 species were collected. Wandering spiders were represented by 52 species, compared to the 44 species of web-builders. Salticidae was the most abundant family, followed by Thomisidae and then Oxyopidae. The most abundant orb-web spider species were *Caerostris sexcupidata* Fabricius and *Pararaneus cyrtoscapus* Pocock. Of the sheet-web spiders, *Charminus atomarius* Lawrence and *C. ambiguus* Lessert were the most abundant species. The most abundant wandering spider species was *Thyene aurantianca* Simon, followed by *Oxyopes longispinosus* Lawrence.

1.4.1.5. Thicket: The different types of thicket that can be found in South Africa include the dune thicket along the coast and the valley thicket and succulent thicket of the river valleys of KwaZulu-Natal and the East Cape Provinces (Fig. 1). Thicket vegetation can be described as closed-off shrubs or low growing woody vegetation that mostly has thorns, and occurs in regions with a low annual rainfall (Van Rooyen 2006). Thicket

vegetation types contain few endemics, most of which are succulents of Karoo origin (Lubke 1996). No literature on thicket spiders has been published until date.

1.4.1.6. Savanna: The Savanna biome is one of the world's major biomes and covers about one third of South Africa (Rutherford & Westfall 1986). It is especially well developed in the Kalahari, parts of Limpopo and KwaZulu-Natal, Mpumalanga and the Eastern Cape Provinces (Fig. 1). The savanna occurs in the more tropical, summer rainfall region (Van Rooyen 2006). Savanna is typically characterized by having a continuous, well-developed grass layer and an open, discontinuous layer of shrubs or trees (Knoop & Walker 1985). Insufficient rainfall, fires and grazing pressure maintain the vegetation structure (Van Rooyen 2006). African savannas are prone to fires but almost all the vegetation is adapted to survive these fires (Govender *et al.* 2006). Fires are also important for determining the composition and structures of these types of ecosystems (Bond & Van Wilgen 1996).

Most diversity studies have been done in this biome. Reports on the spiders of the Savanna biome include mostly inventories in the conserved areas. By 2007, a total of 53 families represented by 282 genera and 605 species had been recorded in this biome (Dippenaar-Schoeman & Haddad 2007). A list of studies conducted in the biome has been summarised in Table 1.

1.4.1.6.1. Patterns in the conservation areas of the Savanna biome: In a study to determine the responses of spiders to alien plant invasions in Hluhluwe-Imfolozi Park, the most species rich families were the Araneidae, Salticidae, Thomisidae, Lycosidae and Gnaphosidae, and the most abundant families the Lycosidae, Salticidae, Thomisidae, Gnaphosidae and Araneidae. Of these, a total of 22 species were web builders and 138 species were wanderers. Changes were determined in spider richness, abundance and composition with the invasion of alien plants (Mgobozi *et al.* 2008).

In Polokwane Nature Reserve, 191 species were wandering spiders and the remaining 84 species were web-builders. Nine mygalomorphae spiders were collected out of the 14 species that occur in the province (Dippenaar-Schoeman 2002; Dippenaar *et al.* 2008).

One hundred and three species were new records for the Kruger National Park. Fifteen families were represented by only one species. Ninety-one species were wandering spiders while the other 61 species were web-builders (Dippenaar-Schoeman & Leroy 2003). In the Makalali Private Game Reserve, 38 families were sampled with only two families (Oxyopidae and Salticidae) found at all the sites, three families were found in 98 % of the sites and eight families were found in only one site. The occurrence *Sipalolasma humicola* (Benoit) from the family Barychelidae was also a new distribution record in South Africa (Whitmore *et al.* 2001; 2002).

Foord *et al.* (2008) collected 334 species in the Western Soutpansberg, of which 81 species were wandering spiders and 49 species were web-builders. Of the 106 genera collected, 96 were represented by a single species. Foord *et al.* (2008) found that the endemic taxa were associated with tall forest and to a lesser extent to the woodland in the habitats that were sampled. The woodland had the highest species diversity.

In Roodeplaat Dam Nature Reserve, the dominant families were Tetragnathidae, Araneidae and Salticidae. Wandering spiders represented 38.0 % of the total spiders, while 34,5 % were web builders, 22.0 % were ambushers and 2,7 % were burrowing spiders. One kleptoparasite, *Argyrodes* sp., and one web invader, *Mimetus* sp., were also collected (Dippenaar-Schoeman *et al.* 1989). In the Nylsvley Nature Reserve, 125 species (representing 24 families) were wandering spiders and the other 50 species (representing 13 families) were web-building spiders. A total of 158 species were new records for the reserve. *Oxyopes tuberculatus* Lessert, 1915 was a new record for South Africa and six species could be new to science (Dippenaar-Schoeman *et al.* 2009).

From Ndumo Game Reserve, a total of 457 species of arachnids were collected, representing six orders, 59 families and 240 determined genera. The most diverse order was the Araneae (431 species), followed by the Pseudoscorpiones, Scorpiones, Opiliones, Solifugae and Amblypygi. As is usually typical for savanna, the most diverse families all belonged to the Araneae: Salticidae, Thomisidae and Araneidae. The spider family diversity in this reserve was the second highest recorded from any protected area in South Africa, exceeded only by De Hoop Nature Reserve (Haddad & Dippenaar-Schoeman

2009), while the species diversity is the highest and represents approximately 22.0 % of the country's spider fauna. Concerning the family Salticidae in Ndumo Game Reserve, a total of 72 species of 38 genera were found, where one new genus (*Aenigma*) was described as well as 14 new species (Wesolowska & Haddad 2009). Near Ndumo Game Reserve lies Tembe Elephant Park, where elephant impacts on spider assemblages were studied to assess the potential use of spiders as indicators of habitat change. The spider communities were determined over two weeks by five sampling methods. In total, 2808 specimens, representing 38 families, 144 genera and 251 species were sampled (Haddad *et al.* in press).

Twelve of the collected families in Sovenga Hill were web-builders, while the other seventeen families were wanderers. Thomisidae was the most abundant family (167), followed by the Gnaphosidae (101) and the Lycosidae (77). The most abundant species was a thomisid *Tmarus comellini* Garcia-Neto (82), followed by a clubionid *Clubiona godfreyi* Lessert (66). The Thomisidae was the most species rich family (12) species, followed by the Gnaphosidae (11) species and the Araneidae (10) (Modiba *et al.* 2005).

1.4.1.6.2. Patterns in agroecosystems in the Savanna biome in Mpumalanga: In avocado orchards in the Mpumalanga lowveld the most abundant families were represented by Salticidae, followed by Thomisidae and Tetragnathidae. The most diverse families were Araneidae, Salticidae and Thomisidae. The most abundant species was the thomisid, *Oxytate argenteooculata* (Simon) which represented 22.2 % of all the spiders that were collected, followed by two salticids, *Thyene coccineovittata* (Simon) (11.5 %) and *T. natalii* Peckham & Peckham (11.0 %), and the tetragnathid, *Tetragnatha subsquamata* Okuma with 8.4 % (Dippenaar-Schoeman *et al.* 2005).

Near Marble Hall in Mpumalanga, Lycosidae represented 62.5 % of all spiders collected in the pitfall traps in cotton fields, followed by the Theridiidae with 20.0 % and Linyphiidae with 9.1 %. *Steatoda erigoniformis* (O. P.-Cambridge) (Theridiidae) was the most abundant species, representing 19.7 % of the spiders collected, followed by *Pardosa clavipalpis* Purcell (Lycosidae) with 16.5 %, an undetermined *Trabea* sp. (Lycosidae)

with 15.7 %, and *Pardosa crassipalpis* Purcell (Lycosidae) with 14.4 %. Neither Bt-cotton nor endosulfan application had had a marked or persistent negative impact on ground- or plant-dwelling spiders in the field (Mellet *et al.* 2006). When the effect of two pesticides were tested in cotton fields, it was found that Lycosidae was numerically the most dominant family and *Pardosa crassipalpis* the most dominant family (Van den Berg *et al.* 1990). In a study of alphamethrin and endosulfan sprays on red spider mite predators on cotton, 76,5 % in endosulfan-treated plots and 73,6 % in untreated control plots, were spiders (Van den Berg & Dippenaar-Schoeman 1991). The Thomisidae were the richest in species (21) followed by the Araneidae (18) and Theridiidae (11). The most abundant spider species were *Pardosa crassipalpis* Purcell (Lycosidae), *Enoplognatha* sp. (Theridiidae), *Eperigone fradeorum* (Berland) (Linyphiidae) and *Misumenops rubrodecorata* Millot (Thomisidae). Wandering spiders constituted 61.5 % and web-builders 38.5 % of all spiders collected (Dippenaar-Schoeman *et al.* 1999b).

Salticidae (72.7 %) was the most abundant family of all the spiders collected in macadamia orchards in the Mpumalanga Lowveld. Sparassidae (6.9 %), Hersiliidae (3.9 %) and Araneidae (3.3 %) followed in abundance. The most species rich families were the Salticidae (17), followed by the Araneidae (16) and the Thomisidae (11). Wandering spiders dominated the fauna, representing 95.8 % of the total number of specimens collected, while 4.2 % of the total was web-builders (Dippenaar-Schoeman *et al.* 2001).

In a pine plantation near Sabie, 38.5 % of the 1484 spiders collected belonged to Clubionidae, 13.0 % to Lycosidae, 10.0 % to Tetragnathidae, 8.0 % to Salticidae and 7.0 % to Linyphiidae (Van den Berg & Dippenaar-Schoeman 1988). Of the 5059 spiders collected in strawberry beds at the Horticultural Research Institute at Roodeplaat, 70.0 % belonged to Lycosidae. Argiopidae (moved to Araneidae), Thomisidae, Clubionidae,

Table 1. A list of studies done in conserved areas and agroecosystems (marked *) in the Savanna biome.

Locality	Duration of study	Species	Genera	Families	Total individuals	Literature
Hluhluwe-iMfolozi Park	One year	106	-	30	825	Mgobozi <i>et al.</i> 2008
Polokwane Nature Reserve	One year	275	156	39	13821	Dippenaar <i>et al.</i> 2008
Kruger National Park	1985 - 2001	152	116	40	-	Dippenaar-Schoeman & Leroy 2003
Makalali Private Game Reserve	-	268	147	38	4 832	Whitmore <i>et al.</i> 2001, 2002
Ndumo Game Reserve	2000-2006	457	240	54	-	Haddad <i>et al.</i> 2006
Nylsvley Nature Reserve	30 years	175	131	37	-	Dippenaar-Schoeman <i>et al.</i> 2009
Roodeplaat Dam Nature Reserve	Four years	-	82	27	10270	Dippenaar-Schoeman <i>et al.</i> 1989
Sovenga Hill	Two months	76	62	29	793	Modiba <i>et al.</i> 2005
Soutpansberg Mountains	1996-2000	127	109	46	-	Foord <i>et al.</i> 2002
Soutpansberg Mountains	-	297	156	49	9985	Foord <i>et al.</i> 2008
Tembe Elephant Park	Two weeks	251	144	38	2808	Haddad <i>et al.</i> in press
Avocado orchards *	July 1997- July 1998	90	68	26	3715	Dippenaar <i>et al.</i> 2005
Cotton *	2001/2002; 2002/2003	54	-	21	9420	Mellet <i>et al.</i> 2006
Cotton *	Four months	76	61	18	2388	Van den Berg <i>et al.</i> 1990
Cotton *	1987/1988	-	-	-	-	Van den Berg & Dippenaar-Schoeman 1991
Cotton *	1979-1997	127	92	31	-	Dippenaar-Schoeman <i>et al.</i> 1999b
Macadamia orchards *	1997-1998	80	57	21	2778	Dippenaar-Schoeman <i>et al.</i> 2001
Pine plantation *	June 1984	-	-	23	1484	Van den Berg & Dippenaar-Schoeman 1988
Strawberry beds *	1972-73	33	-	14	-	Dippenaar-Schoeman 1979

Salticidae and Linyphiidae represented 28.0 % of the total spiders collected. The most abundant species was *Pardosa crassipalpis* Purcell which accounted for over 80.0 % of all lycosids that were recorded. In the study, an average of 3.8 % spiders/m² were recorded which represented a spider community that was periodically disturbed (Dippenaar-Schoeman 1979).

1.4.1.7. Grassland: Grasslands seem to flourish in temperate regions (Dash 1993). The Grassland biome dominates the central region of South Africa (Rutherford & Westfall 1986). It includes large parts of the Gauteng, Mpumalanga and Free State Provinces, parts of the North West Province, and the inland regions of the KwaZulu-Natal and Eastern Cape Provinces (Fig. 1). The main topography is flat and rolling, but it includes the escarpment itself (Bredenkamp *et al.* 1996). This biome is dominated by a single layer of grass and an absence of trees, except in a few localized areas where a few trees are present (Rutherford & Westfall 1986). The amount of grass cover depends on rainfall and the degree of animal grazing. Frosts, fire and grazing all maintain the grass dominance and usually prevent the establishment of trees (Bredenkamp *et al.* 1996). There is little natural grassland left in South Africa that does not show signs of decay from overgrazing, disturbance and cultivation (Van Rooyen 2006).

Lotz *et al.* (1991) did the first study in the Grassland biome on surface active spiders, where 4922 specimens were collected representing 31 families. However, most studies that have been done in this biome have focused on the association of spiders with termites (Haddad & Dippenaar-Schoeman 2002, 2006). Haddad (2005) also studied the ecology of spiders inhabiting *Themeda triandra* Forskål grassland. There are many ongoing projects to determine the diversity of spiders in grassland, with about 910 sites that have been sampled in this biome so far (Dippenaar-Schoeman & Haddad 2007). This includes eight sites (Florisbad Research Station, Deelhoek, Bloemfontein, Erfenis Dam Nature Reserve, Golden Gate National Park, Qwa-Qwa Park, Drakensberg, Spitskoppen) where long-term surveys (one to five years in duration) have been conducted (Dippenaar-Schoeman & Haddad 2007).

At the Rietondale Research Station, 1854 specimens were collected representing 21 families, 41 genera and 55 species. The dominant families were the Gnaphosidae, Ammoxenidae, Salticidae, Lycosidae and the Theridiidae. Family dominance also varied between the years of study. Gnaphosidae was the most abundant family. Six spider species were also observed feeding on other spiders (Van den Berg & Dippenaar-Schoeman 1991).

1.4.1.8. Desert: The desert biome is represented almost exclusively by the Namib Desert in southern Africa. In South Africa, the biome compromises the most arid portions of the Succulent Karoo biome and the Nama Karoo biome. In these parts of the biome, there are rapid changes in vegetation over short distances due to steep ecological gradients (Rutherford & Westfall 1986; Jürgens *et al.* 1997). No literature on desert spiders has been published to date.

1.4.2. Aims of study

This study aims to determine the spider ecology in Erfenis Dam Nature Reserve in the Free State Province. Foliage-, grass-dwelling and ground-dwelling spiders were studied in their grass habitat, with further focus on the biology of termite-eating spiders (Ammoxenidae) and purse-web spiders (Atypidae). To provide a basis for the latter study, the genus *Calommata* Lucas, 1837 in the Afrotropical Region was revised and included the descriptions of new species including one from Erfenis Dam Nature Reserve. This locality is the second southernmost record of the genus in Africa (Botanical Garden at Bloemfontein is the southernmost record). This was a four year project that forms part of SANSA and will also contribute to the Grasslands Programme.

1.5. Conclusion

Projects such as SANSA, as well as other studies, have increased the amount of ecological studies done in South Africa. SANSA has various projects in progress, such as inventories of spider fauna in the different floral biomes to determine the number of species already protected in existing conservation areas (Dippenaar-Schoeman & Haddad 2007).

To be able to use or apply spiders more effectively in practice (as predators of pests or ecological indicators), the ecology of spiders needs to be understood better, together with knowledge of their distribution and taxonomy. In this regard the SANSA project will help greatly to supplement studies previously done by exposing new species to study as well as expanding known distribution ranges of some arachnids. It will also show where more studies need to be carried out in South Africa.

1.6. References

BEUKES, P.C., COWLING, R.M. & HIGGINS, S.I. 2002. An ecological economic simulation model of a non-selective grazing system in the Nama Karoo, South Africa. *Ecological Economics* **42**: 221-242.

BOND, W.J. & VAN WILGEN, B.W. 1996. *Fire and plants*. Chapman and Hall, London. 263pp.

BORROR, D.J., TRIPLEHORN, C.A. & JOHNSON, N.F. 1989. *An introduction to the Study of Insects*. 6th edition. Brooks/Cole, USA. 875pp.

BREDENKAMP, G., GRANGER, J.E. & VAN ROOYEN, N. 1996. Moist Sandy Highveld Grassland. In: Low, A.B. & Robelo, A.G. (eds.) *Vegetation of South Africa, Lesotho and Swaziland*. Department of Environmental Affairs and Tourism, Pretoria. 870pp.

CARDOSO, P., SILVA, I., DE OLIVEIRA, N.G. & SERRANO, A.R.M. 2004. Indicator taxa of spider (Araneae) diversity and their efficiency in conservation. *Biological Conservation* **120**: 517-524.

CHURCHILL, T.B. 1997. Spiders as ecological indicators: an overview for Australia. *Memoirs of the Museum of Victoria* **56**: 331-337.

COETZEE, J.H., DIPPENAAR-SCHOEMAN, A.S. & VAN DEN BERG, A. 1990. Spider assemblages on five species of proteaceous plants in the fynbos biome in South Africa. *Phytophylactica* **22**: 443-447.

DASH, M.C. 1993. *Fundamentals of ecology*. Tata McGraw-Hill Publishing Company Limited, New Delhi. 210pp.

DIPPENAAR, S.M., DIPPENAAR-SCHOEMAN, A.S., MODIBA, M.A. & KHOZA, T.T. 2008. A checklist of the spiders (Arachnida, Araneae) of the Polokwane Nature Reserve, Limpopo Province, South Africa. *Koedoe* **50**: 10-17.

DIPPENAAR-SCHOEMAN, A.S. 1979. Spider communities in strawberry beds: seasonal changes in numbers and species composition. *Phytophylactica* **11**: 1-14.

DIPPENAAR-SCHOEMAN, A.S. 1988. Annotated check list of the spiders (Araneae) of the Mountain Zebra National Park. *Koedoe* **31**: 151-160

DIPPENAAR-SCHOEMAN, A.S. 2002. *Baboon and trapdoor spiders of southern Africa: an identification manual*. Plant Protection Research Institute Handbook No. 13. Agricultural Research Council, Pretoria. 128pp.

DIPPENAAR-SCHOEMAN, A.S. 2006. New records of 43 spider species from the Mountain Zebra National Park, South Africa (Arachnida: Araneae). *Koedoe* **49**: 23-28.

DIPPENAAR-SCHOEMAN, A.S. & CRAEMER, C. 2000. The South African National Survey of Arachnida. *Plant Protection News* **56**: 11-12.

DIPPENAAR-SCHOEMAN, A.S. & HADDAD, C.R. (eds.) 2007. *Survey of botanical gardens*. SANSA newsletter no. 3. Agriculture Research Council, Pretoria. 17pp.

DIPPENAAR-SCHOEMAN, A.S. & HADDAD, C.R. (eds.) 2008. *Launch of Grasslands Programme*. SANSA newsletter no. 6. Agriculture Research Council, Pretoria. 13pp.

DIPPENAAR-SCHOEMAN, A.S. & JOCQUÉ, R. 1997. *African spiders, an identification manual*. Plant Protection Research Institute Handbook no. 9, Agricultural Research Institute, Pretoria. 392pp.

DIPPENAAR-SCHOEMAN, A.S. & LEROY, A. 2003. A check list of the spiders of the Kruger National Park, South Africa (Arachnida: Araneae). *Koedoe* **46**: 91-100.

DIPPENAAR-SCHOEMAN, A.S., LEROY, A., DE JAGER, M. & VAN DEN BERG, A. 1999a. A check list of the spider fauna of the Karoo National Park, South Africa (Arachnida: Araneae). *Koedoe* **42**: 31-42.

DIPPENAAR-SCHOEMAN, A.S. & MYBURGH, J.G. 2009. A review of the cave spiders (Arachnida: Araneae) from South Africa. *Transactions of the Royal Society of South Africa* **64**: 53-61.

DIPPENAAR-SCHOEMAN, A.S., VAN DEN BERG, A. & PRENDINI, L. 2009. Spiders and scorpions (Arachnida: Araneae, Scorpiones) of the Nylsvley Nature Reserve, South Africa. *Koedoe* **51**: 1-9.

DIPPENAAR-SCHOEMAN, A.S., VAN DEN BERG, A.M. & VAN DEN BERG, A. 1989. Species composition and relative seasonal abundance of spiders from the field and tree layers of the Roodeplaat Dam Nature Reserve. *Koedoe* **32**: 25-38.

DIPPENAAR-SCHOEMAN, A.S., VAN DEN BERG, A.M. & VAN DEN BERG, A. 1999b. Spiders in South African cotton fields: species diversity and abundance (Arachnida: Araneae). *African Plant Protection* **5**: 93-103.

DIPPENAAR-SCHOEMAN, A.S., VAN DEN BERG, M.A. & VAN DEN BERG, A.M. 2001. Spiders in macadamia orchards in the Mpumalanga Lowveld of South Africa: species diversity and abundance (Arachnida: Araneae). *African Plant Protection* **7**: 36-46.

DIPPENAAR-SCHOEMAN, A.S., VAN DEN BERG, A.M., VAN DEN BERG, M.A. & FOORD, S.H. 2005. Spiders in avocado orchards in the Mpumalanga Lowveld of South

Africa: species diversity and abundance (Arachnida: Araneae). *African Plant Protection* **11**: 8–16.

DIPPENAAR-SCHOEMAN, A.S., VAN DER WALT, A.E., DE JAGER, M., LE ROUX, E. & VAN DEN BERG, A. 2005. The spiders of the Swartberg Nature Reserve in South Africa (Arachnida: Araneae). *Koedoe* **48**: 77–86.

DIPPENAAR-SCHOEMAN, A.S. & WASSENAAR, T.D. 2002. A checklist of the ground-dwelling spiders of coastal dune forests at Richards Bay, South Africa (Arachnida: Araneae). *Bulletin of the British Arachnological Society* **12**: 275-279.

DIPPENAAR-SCHOEMAN, A.S. & WASSENAAR, T.D. 2006. A checklist of spiders from the herbaceous layer of a coastal dune forest ecosystem at Richards Bay, KwaZulu-Natal, South Africa (Arachnida: Araneae). *African Invertebrates* **47**: 63-70.

FOORD, S.H., DIPPENAAR-SCHOEMAN, A.S. & VAN DER MERWE, M. 2002. A check list of the spider fauna of the Western Soutpansberg, South Africa (Arachnida: Araneae). *Koedoe* **45**: 35-43.

FOORD, S.H., MAFADZA, M.M., DIPPENAAR-SCHOEMAN, A.S. & VAN RENSBURG, B.J. 2008. Micro-scale heterogeneity of spiders (Arachnida: Araneae) in the Soutpansberg, South Africa: a comparative survey and inventory in representative habitats. *African Zoology* **43**: 156-174.

FROMHAGE, L., JACOBS, K. & SCHNEIDER, J.M. 2007. Monogynous mating behaviour and its ecological basis in the golden orb spider, *Nephila fenestrata*. *Ethology* **113**: 813–820.

GILIOME, J.H. 2003. Insect diversity in the Cape Floristic Region. *African Journal of Ecology* **41**: 237-244.

GOLDBLATT, P. 1997. Floristic diversity in the Cape flora of South Africa. *Biodiversity and Conservation* **6**: 359-377.

GOLDBLATT, P. & MANNING, J.C. 2002. Plant diversity of the Cape region of southern Africa. *Annals of Missouri Botanical Garden* **89**: 281-302.

GOVENDER, N., TROLLOPE, W.S.W & VAN WILGEN, B.W. 2006. The effect of fire season, fire frequency, rainfall and management on fire intensity in savanna vegetation in South Africa. *Journal of Applied Ecology* **43**: 748-758.

GREEN, J. 1996. Spiders in biological control—an Australia perspective. *Revue Suisse de Zoologie* hors série 245-253.

GUNNARSSON, B. 1990. Vegetation structure and the abundance and size distribution of spruce-living spiders. *Journal of Animal Ecology* **59**: 743-752

HADDAD, C.R. 2005. Ecology of spiders (Arachnida: Araneae) inhabiting *Themeda triandra* Forskål grassland in semi-arid South Africa. *Navorsinge van die Nasionale Museum, Bloemfontein* **21**: 25-36.

HADDAD, C.R. & DIPPENAAR-SCHOEMAN, A.S. 2002. The influence of mound structure on the diversity of spiders (Araneae) inhabiting the abandoned mounds of the snouted harvester termite *Trinervitermes trinervoides* (Sjöstedt). *Journal of Arachnology* **30**: 403-408.

HADDAD, C.R. & DIPPENAAR-SCHOEMAN, A.S. 2005. Epigeic spiders (Arachnida: Araneae) in Nama Karoo grassland in the Northern Cape Province. *Navorsinge van die Nasionale Museum, Bloemfontein* **21**: 1-10.

HADDAD, C.R. & DIPPENAAR-SCHOEMAN, A.S. 2006. Epigeic spiders (Araneae) in pistachio orchards in South Africa. *African Plant Protection* **12**: 12–22.

HADDAD, C.R. & DIPPENAAR-SCHOEMAN, A.S. 2009. A checklist of the non-acarine arachnids (Chelicerata: Arachnida) of the De Hoop Nature Reserve, Western Cape Province, South Africa. *Koedoe* **51**: 1-9.

HADDAD, C.R., DIPPENAAR-SCHOEMAN, A.S. & PEKÁR, S. 2005. Arboreal spiders (Arachnida: Araneae) in pistachio orchards in South Africa. *African Plant Protection* **11**: 32–41.

HADDAD, C.R., DIPPENAAR-SCHOEMAN, A.S. & WESOŁOWSKA W. 2006. A checklist of the non-acarine arachnids (Chelicerata: Arachnida) of the Ndumo Game Reserve, Maputaland, South Africa. *Koedoe* **49**: 1–22.

HADDAD, C.R., HONIBALL, A.S., DIPPENAAR-SCHOEMAN, A.S., SLOTOW, R. & VAN RENSBURG, B.J. In press. Spiders as potential indicators of elephant-induced habitat changes in endemic sand forest, Maputaland, South Africa. *African Journal of Ecology*: 1-15.

HADDAD, C.R. & LOUW, S.VDM. 2006. Phenology, ethology and fecundity of *Heliophanus pistaciae* Wesolowska (Araneae: Salticidae), an agrobiont jumping spider in South African pistachio orchards. *African Plant Protection* **12**: 1–11.

HADDAD, C.R., LOUW, S.VDM. & DIPPENAAR-SCHOEMAN, A.S. 2004. Spiders (Araneae) in ground covers of pistachio orchards in South Africa. *African Plant Protection* **10**: 97–107.

HADDAD, C.R., LOUW, S.VDM. & PEKÁR, S. 2008. Commercial pistachio orchards in the Northern Cape Province, South Africa, maintain a lower abundance and diversity of epigeic spiders than undisturbed Nama Karoo grassland (Arachnida: Araneae). *African Plant Protection* **14**: 24–36.

JÜRGENS, N., BURKE, A., SEELY, M.K. & JACOBSEN, K.M. 1997. Desert. Pp. 189-214. In: Cowling, R.M., Richardson, D.M. & Pierce, S.M. (eds.) *Vegetation of southern Africa*. Cambridge University Press, Cambridge.

KNOOP, W.T. & WALKER, B.H. 1985. Interactions of woody and herbaceous vegetation in a southern African savanna. *Journal of Ecology* **73**: 235-253.

LOCKLEY, T.C. & YOUNG, O.P. Prey of the striped lynx spider *Oxyopes salticus* (Araneae: Oxyopidae) on cotton in the delta area of Mississippi. *Journal of Arachnology* **14**:395-397.

LOMBARD, A.T., HILTON-TAYLOR, C., REBELO, A.G., PRESSEY, R.L. & COWLING, R.M. 1999. Reserve selection in the Succulent Karoo, South Africa: coping with high compositional turnover. *Plant Ecology* **142**: 35-55.

LOTZ, L.N., SEAMAN, M.T. & KOK, D.J. 1991. Surface active spiders (Araneae) of a site in semi-arid central South Africa. *Navorsinge van die Nasionale Museum, Bloemfontein* **7**: 529-540.

LUBKE, R. 1996. Thicket biome. In: Low, A.B. & Robelo, A.G. (eds) *Vegetation of South Africa, Lesotho and Swaziland*. Department of Environmental Affairs and Tourism, Pretoria. 807pp.

MELLET, M.A., SCHOEMAN, A.S. & DIPPENAAR-SCHOEMAN, A.S. 2006. Effect of Bt-cotton cultivation on spider (Arachnida: Araneae) populations near Marble Hall, Mpumalanga, South Africa. *African Plant Protection* **12**: 40–50.

MGOBOZI, M.P., SOMERS, M.J. & DIPPENAAR-SCHOEMAN, A.S. 2008. Spider responses to alien plant invasion: the effect of short- and long-term *Chromolaena odorata* invasion and management. *Journal of Applied Ecology* **45**: 1189-1197.

MODIBA, M.A., DIPPENAAR, S.M. & DIPPENAAR-SCHOEMAN, A.S. 2005. A checklist of spiders from Sovenga Hill, an inselberg in a Savanna biome, Limpopo Province, South Africa (Arachnida: Araneae). *Koedoe* **48**: 109-115.

MYERS, N. 1990. The biodiversity challenge: expanded hot-spots analysis. *The Environmentalist* **10**: 243-256.

OXBROUGH, A.G., GITTINGS, T., O'HALLORAN, J., GILLER, P.S. & SMITH, G.F. 2005. Structural indicators of spider communities across the forest plantation cycle. *Forest Ecology and Management* **213**: 171-183.

PALMER, A.R. & HOFFMAN, M.T. 1997. Nama Karoo. Pp. 167-186. In: Cowling, R.M., Richardson, D.M. & Pierce, S.M. (eds.) *Vegetation of southern Africa*. Cambridge University Press, Cape Town.

PICKER, M.D. & SAMWAYS, M.J. 1996. Faunal diversity and endemism of the Cape Peninsula, South Africa—a first assessment. *Biodiversity and Conservation* **5**: 591-606.

PRICE, P.W. 1975. *Insect ecology*. John Wiley & Sons. Inc. New York. 514pp.

PROCHEŞ, S. & COWLING, R.M. 2006. Insect diversity in Cape fynbos and neighbouring South African vegetation. *Global Ecology and Biogeography* **15**: 445-451.

ROMERO, G.O. & VASCONCELLOS-NETO, J. 2003. Natural history of *Misumenops argenteus* (Thomisidae): seasonality and diet on *Trichogoniopsis adenantha* (Asteraceae). *Journal of Arachnology* **31**: 297-304.

ROMERO, G.O. & VASCONCELLOS-NETO, J. 2004. Foraging by the flower-dwelling spider *Misumenops argenteus* (Thomisidae), at high prey density sites. *Journal of Natural History* **38**: 1287-1296.

RUTHERFORD, M.C. & WESTFALL, R.H. 1986. Biomes of southern Africa: an objective categorization. *Memoirs of the Botanical Survey of South Africa* **54**: 1-98.

SHARRETT, N.J., PICKER, M.D. & SAMWAYS, M.J. 2000. The invertebrate fauna of the sandstone caves of the Cape Peninsula (South Africa): patterns of endemism and conservation priorities. *Biodiversity and Conservation* **9**: 107-143.

- TURNER, M. 1979. Diet and feeding phenology of the green lynx spider, *Peucetia viridans* (Araneae: Oxyopidae). *Journal of Arachnology* **7**:149-154.
- VAN DEN BERG, A. & DIPPENAAR-SCHOEMAN, A.S. 1991. Ground-living spiders from an area where the harvester termite *Hodotermes mossambicus* occurs in South Africa. *Phytophylactica* **23**: 247-253.
- VAN DEN BERG, A.M. & DIPPENAAR-SCHOEMAN, A.S. 1988. Spider communities in a pine plantation at Sabie, eastern Transvaal: a preliminary survey. *Phytophylactica* **20**: 293-296.
- VAN DEN BERG, A.M. & DIPPENAAR-SCHOEMAN, A.S. 1991. Spiders, predacious insects and mites on South African cotton. *Phytophylactica* **23**: 85-86.
- VAN DEN BERG, A.M., DIPPENAAR-SCHOEMAN, A.S. & SCHOONBEE, H.J. 1990. The effect of two pesticides on spiders in South African cotton fields. *Phytophylactica* **22**: 435-441.
- VAN DER MERWE, M., DIPPENAAR-SCHOEMAN, A.S. & SCHOLTZ, C.H. 1996. Diversity of ground-living spiders at Ngome State Forest, KwaZulu-Natal: a comparative survey in indigenous forest and pine plantations. *African Journal of Ecology* **34**: 342-350.
- VAN ROOYEN, N. 2006. *Plantegroei van Suid-Afrika*. Pp. 35-42. In: Bothma, J. Du P. (ed.) Wildsplasbestuur. Van Schaik Uitgewers, Paarl.
- VISSER, D., WRIGHT, M.G., VAN DEN BERG, A. & GILIOMEE, J.H. 1999. Species richness of arachnids associated with *Protea nitida* (Proteaceae) in the Cape fynbos. *African Journal of Zoology* **37**: 334-343.
- VON MALTITZ, G. (project manager). 2002. *Classification system for South African indigenous forests. An objective classification for the Department of Water Affairs and Forestry*. Final draft. CSIR (Environmentek).

WESOŁOWSKA, W. & HADDAD, C.R. 2009. Jumping spiders (Araneae: Salticidae) of the Ndumo Game Reserve, Maputaland, South Africa. *African Invertebrates* **50**: 13-103.

WHITMORE, C., SLOTOW, R., CROUCH, T.E. & DIPPENAAR-SCHOEMAN, A.S. 2001. Checklist of spiders (Araneae) from a savanna ecosystem, Northern Province, South Africa: including a new family record. *Durban Museum Novitates* **26**: 10-19.

WHITMORE, C., SLOTOW, R., CROUCH, T.E. & DIPPENAAR-SCHOEMAN, A.S. 2002. Diversity of spiders (Araneae) in a savanna reserve, Limpopo, South Africa. *Journal of Arachnology* **30**: 344-356.

CHAPTER 2

**Diversity and abundance of spiders
(Arachnida: Araneae) in the field and
tree layers of Erfenis Dam Nature
Reserve, Free State Province.**

2.1. Abstract

The Grassland biome is dominated by a layer of grass and an absence of trees, except in a few localized areas where a few trees are present. From November 2005 to August 2007, foliage- and grass-dwelling spiders (Arachnida: Araneae) were collected at Erfenis Dam Nature Reserve in the Free State Province. The spiders were collected in the last week of every third month to account for seasonal variation. Spiders were collected from three tree species (*Acacia karroo*, *Rhus lancea* and *Rhus ciliata*) and four different types of grasslands (uniform *Themeda triandra*, mixed, weedy and woodland grasslands). During the two-year period a total of 496 tree spiders was collected that represented 17 families and 54 species. From the grass layer, 1649 grass-dwelling spiders were collected, representing 15 families and 84 species. The fewest spiders were caught in both August 2006 and August 2007, because of the effects of winter. The most spiders were caught in November 2005 and February 2007, reflecting the high availability of prey and emergence of immature spiders from egg sacs during summer. A bottom-up effect from rainfall might be a reason why there are more spiders in the summer season. More spider species as well as individuals were collected from the grasslands than from the tree layers, but the tree layers had a greater diversity of spider families. Vegetation complexity and structure appear to be the most important factors determining the dominant families and species.

Key words: Grassland biome, foliage, grass, dominant families, vegetation complexity, spiders, Erfenis Dam.

2.2. Introduction

A biome is considered a broad ecological unit and represents a big, relatively homogenous natural environment. A characteristic of a biome is the presence of the same types of animals and plants that occur in an area that can be associated with a certain type of climate. South Africa has seven biomes that are based on the dominant plant types, namely Grassland, Savanna, Nama Karoo, Succulent Karoo, Fynbos, Desert and Forest biomes, with some literature that considers the Thicket biome as an eighth biome (Van Rooyen 2006).

The Grassland biome dominates the central region of South Africa (Rutherford & Westfall 1986). It includes large parts of Gauteng, Mpumalanga, Free State, parts of the North West, the inland regions of KwaZulu-Natal and Eastern Cape (Fig. 1). The main topography is flat and rolling, but the escarpment itself is included (Rutherford & Westfall 1986; Bredenkamp *et al.* 1996). This biome is dominated by a layer of grass and an absence of trees, except in a few limited small areas where a few trees are present (Dippenaar-Schoeman & Haddad 2007). The amount of grass cover depends on rainfall and the degree of animal grazing. Other factors that maintain the dominance of grass are frosts and fire, which prevent the establishment of trees. The Grassland biome is considered to have an extremely high plant biodiversity that is only second to the Fynbos biome (Bredenkamp *et al.* 1996).

Many arachnids found in the Grassland biome have unique adaptations in their body form, colour, and as well as their web and retreat construction. At the moment the Arachnida is represented by approximately 65 families, 200 genera and 300 species in this biome (Dippenaar-Schoeman & Haddad 2007).



Fig. 1. The location of the Grassland biome in South Africa (From Department of Environmental Affairs and Tourism 1998).

Today spiders are being used more and more in ecological studies as indicators of environmental quality and as biological control agents in agricultural ecosystems (Green 1996). Spiders can be considered as an ideal group to study because they fulfill the four criteria to be used as indicators: 1) they are diverse and commonly found, 2) easy collectable, 3) are functional in ecosystems as predators, but are also

available as prey for other predators, and 4) they are in interaction with their abiotic and biotic environment in such a way that they can indicate ecological changes (Churchill 1997).

Information on the diversity and phenology of African spiders is relatively poor in contrast with spiders in the temperate regions. It is especially true for the semi-arid areas of southern Africa (Lotz *et al.* 1991). Lotz *et al.* (1991) and Van den Berg & Dippenaar-Schoeman (1991) did the first two studies in the Grassland biome on surface active spiders. Other subsequent studies in this biome include influence on the diversity of spiders in *Trinervitermes trinervoides* Sjöstedt mounds (Haddad & Dippenaar-Schoeman 2002, 2006), and a study on the species composition and seasonality of spiders associated with *Themeda triandra* Forsskål in the central Free State Province (Haddad 2005). Currently, there are several ongoing projects to determine the diversity of spiders in the Free State Province. About 910 sites have been sampled in the Grassland Biome, including eight sites (Florisbad Research Station, Deelhoek, Bloemfontein, Erfenis Dam Nature Reserve, Golden Gate National Park, Qwa- Qwa Park, Drakensberg, Spitskoppen) where long-term surveys have been conducted for between one and five years (Dippenaar-Schoeman & Haddad 2007).

A project was started in September 2005 to determine the arachnofauna of the Erfenis Dam Nature Reserve, located near Theunissen in the Free State Province. Initially, the primary focus of the study was to determine the impact of controlled burning on various faunal groups, which included arachnids, insects and small mammals. While the project was focused on the ground-dwelling fauna, the potential was later recognised to expand the project to sampling of foliage- and grass -dwelling spiders from unburned areas as well. Thus, the aim of this project was to determine the spider communities in three tree species and four contrasting grassland types in the reserve over a two year period. The project is a part of SANSA (South African National Survey of Arachnida), which is a project that involves determining the diversity of arachnids in the different biomes, conservation areas, agro-ecosystems and provinces of South Africa. The material that is collected can be used in revisions, to determine the distribution of individual species, to identify the species that can be of

conservation importance, and provide the basic data foundation for further ecological studies on arachnids (Dippenaar-Schoeman & Haddad 2007).

2.3. Materials and methods

2.3.1. Study area and period: The Erfenis Dam Nature Reserve is located in the central part of the Free State Province, about 18 km south-east of Theunissen on the R708 (Fig. 2). The dam of the same name is part of the Vet River system and extends over 3800 ha when full, with the reserve comprising about 400 ha of grassland (Stuart & Stuart 1997).

The sampling was done in the last week of every third month from November 2005 until August 2007. This is representative of the four seasons of the year. Coordinates were taken at each site. Tree spiders were collected from three different tree species: *Acacia karroo* Hayne (Family Mimosaceae) (28°30.243'S, 26°47.500'E), *Rhus lancea* Barkley (Family Anacardiaceae) (28°29.552'S, 26°47.646'E) and *Rhus ciliata* Licht. ex Schult (Family Anacardiaceae) (28°29.888'S, 26°48.488'E). Grass-dwelling spiders were collected from four contrasting types of grasslands: uniform (*Themeda triandra*) (28°29.803'S, 26°47.476'E), mixed (28°29.859'S, 26°48.528'E), weedy (28°29.722'S, 26°48.439'E) and woodland (28°30.243'S, 26°47.500'E) grasslands.

2.3.1.1. Foliage: *Acacia karroo* is found in a variety of habitats in biomes, from low lying areas to the highveld. This tree species has a rounded crown, branching fairly low down on the trunk. It is variable in shape and size, reaching a maximum height of about 12m where there is good water nearby. The leaves are finely textured and dark green, with flowers that appear in early summer in a mass of yellow pompons (Fig. 3). The thorns are usually paired, with a greyish to white colour and are long and straight (Aubrey & Reynolds 2002). *Rhus lancea* is a small to medium sized evergreen tree that usually grows to a height of 7m and a width of 7m and is found throughout the Free State. It is usually a single-stemmed, low branching tree that has a dense, soft, round canopy with compound leaves, possessing three narrowly lanceolate (lance shaped) leaflets (Fig. 4). The small, inconspicuous flowers are greenish-yellow in colour and are produced from June until September (i.e. winter to

early spring). *Rhus lancea* occurs naturally in *Acacia* woodland and along drainage lines, rivers and streams (Stern 2002). *Rhus ciliata* forms an evergreen, thorny, thin and crooked-stemmed shrub from 2 to 4 m high (Fig. 5). The leaves are also trifoliolate, with minute flowers that are yellow-green in colour and insignificant. The fruits are drupes, and are shiny, light to dark brown in colour. It is widespread in the central drier parts of South Africa (Harris 2003).



Fig. 2. The location of Erfenis Dam Nature Reserve in the Free State Province.



Figs 3-5. Photographs of three tree species from which spiders were collected from November 2005 to August 2007 in Erfenis Dam Nature Reserve, Free State Province: 3) *Acacia karroo*, 4) *Rhus lancea* and 5) *Rhus ciliata*.

2.3.1.2. Grassland: The four grassland sites sampled can be described as follows (plant classification follows Germishuizen *et al.* 2006): The uniform *Themeda* grassland consisted primarily of homogenous *Themeda triandra* Forssk. grassland, with small scattered patches of *Eragrostis* and *Cymbopogon* grasses. The mixed

grassland consisted of various *Eragrostis* species, *Aristida congesta* Roem. & Schult., *Enneapogon cenchroides* (Roem. & Schult.) C.E.Hubb, *Setaria pumila* (Poir.) Roem. et Schult., *Sporobolus fimbriatus* (Trin.) Nees and *Tragus berteronianus* Schult., with very little *Themeda triandra* present. The weedy grassland was structurally the most heterogenous, consisting of *Aristida congesta*, *Cymbopogon pospischilii* (K.Shumm.) C.E.Hubb., *Eragrostis lehmanniana* Nees, *E. tef* (Zucc.) Trotter, *Setaria pumila* and *Sporobolus fimbriatus* grasses, with a variety of weeds, including *Nidorella resedifolia* DC., and *Berkeya* spp. The woodland grassland was dominated by *Themeda triandra* and *Eragrostis* grasses, interspersed with *Acacia karroo*, *Rhus lancea* and *Ziziphus mucronata* Willd. trees.



Figs 6-9. Photographs of four contrasting grasslands from which spiders were collected from November 2005 to August 2007 every third month in Erfenis Dam Nature Reserve, Free State Province: 6) uniform *Themeda triandra*, 7) mixed, 8) weedy and 9) woodland grasslands.

2.3.2. Sampling methods: The tree spiders were collected with the beating method. This is a good method to use to sample sessile and slow-moving species by simply knocking them off the vegetation using a beating stick and tray (Uys & Urban 2006). A total of 100 (50 beats interval) beats were taken from each tree species (usually

from three trees) during each sampling period, and the specimens preserved in 70% ethanol.

The grass spiders were collected with the sweep method using a 35 cm diameter net. Sweep nets dislodge the specimens from vegetation with a sweeping action and this is an effective way of collecting large numbers of specimens with minimum effort (Uys & Urban 2006). A total of 250 sweeps (50 sweeps interval) were done at each site during each sampling period, and the specimens preserved in 70 % ethanol. The spiders were sorted to morphospecies level in the laboratory and then identified to family level and tallied. Morphospecies were identified further to genus and species level (only adult specimens) by Dr. Ansie Dippenaar-Schoeman (ARC-Plant Protection Research Institute, Pretoria), and Charles Haddad (University of the Free State, Bloemfontein).

2.3.3. Statistics: All data were entered into Microsoft Excel 2003 from which graphs were drawn and data analysed. Similarity in species composition of the three trees and four grassland types were calculated with Sørensen's quotient of similarity. The qualitative Sørensen's quotient of similarity, $QS = 2j / (a + b)$, where a and b are the number of species in two habitats and j the number of species common to both samples (Magurran 1988). A high value (closer to 1) indicates a more similar fauna at site A compared to site B, while a lower value indicates a more unique fauna. Species richness was used to compare the species composition in tree species and grassland, and was calculated as the number of species collected at a site divided by the total number of species collected.

Species accumulation curves were drawn from data that were entered into Microsoft Excel 2003. These accumulation curves are possible to extrapolate when the curves represent samples taken in a systematic way and are restricted to areas of reasonably homogenous habitat (Magurran 2004) and species richness can be estimated by the following calculation: $S_{Chao1} = S_{obs} + F_1^2 / 2F_2$. $Chao_1$ is based on the abundance data available, and is a function of the ratio between the singletons and doubletons in the data and reaches an asymptote when each species is represented by at least two individuals. F_1 equals the number of observed species represented by one individual

and F_2 equals the number of observed species represented by two individuals (Magurran 2004).

Differences in species richness and abundance between tree species /grassland types were compared using repeated measures ANOVA and Tukey-Kramer Multiple Comparisons test. A Linear Regression Test was done to see if rainfall had an influence on the numbers of spiders. All calculations were done in GraphPad Instat.

2.4. Results

The guild classification of spiders follows Dippenaar-Schoeman *et al.* (1999) and Foord *et al.* (2002), which is summarised in Table 1.

Table 1. Summary of the guild classification of spider taxa (Dippenaar-Schoeman *et al.* 1999; Foord *et al.* 2002).

	Guilds	Micro-habitats
Wandering spiders (W)	Ground wanderers (GW)	Free-living (FGW)
		Burrow-living (BGW)
	Plant wanderers (PW)	Free-living (FPW)
		Burrow-living (BPW)
Web-builders (WB)		Adapted orb-webs (AOWB)
		Funnel-web (FWB)
		Gumfoot-web (GWB)
		Orb-web (OWB)
		Retreat-web (RWB)
		Sheet-web (SHWB)
		Space-web (SPWB)

2.4.1. Foliage

A total of 496 spiders were collected from foliage-beating representing 17 families and 53 species over two years (Table 2). Differences in species richness and abundance between tree species was very significant ($P=0.0082$, ANOVA). In the Tukey-Kramer Multiple Comparisons test *Acacia karroo* vs. *Rhus lancea* and *Rhus lancea* vs. *Rhus ciliata* was significant ($P<0.05$), and *Acacia karroo* vs. *Rhus ciliata* was considered non significant ($P>0.05$). Species accumulation curves provide clues about the species richness in a habitat (Magurran 2004).

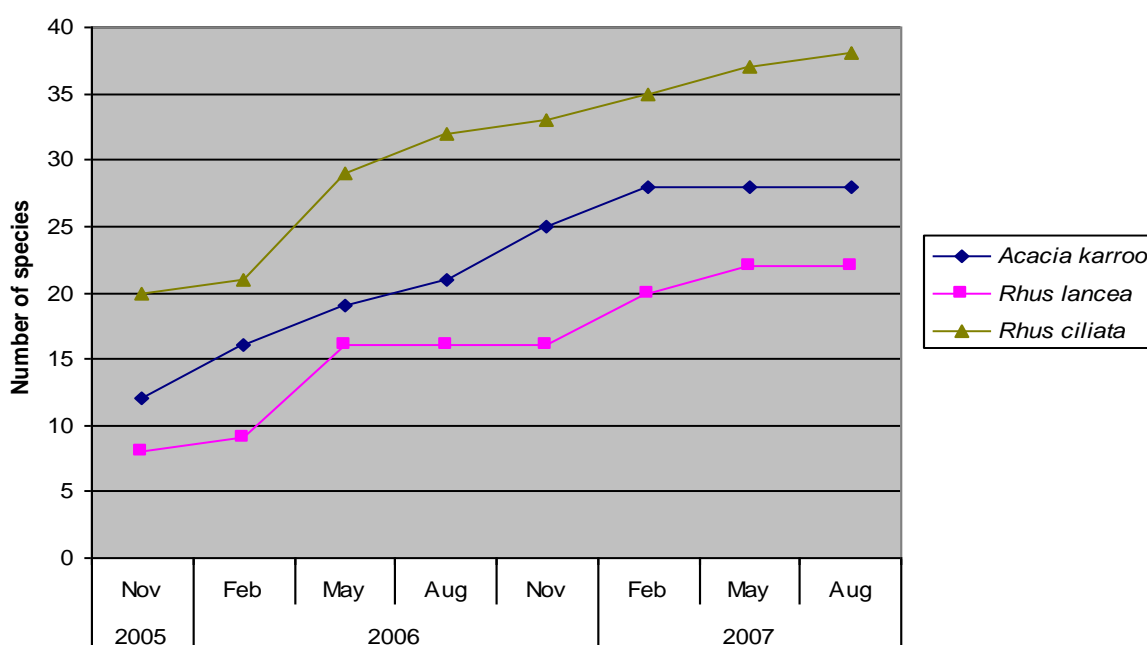


Fig. 10. The species accumulation curve for the spider species that were captured by foliage beating in Erfenis Dam Nature Reserve, Free State Province from November 2005 until August 2007.

New species were sampled almost every time sampling was done. The exception was in *Rhus lancea* where no new species were sampled in both August and November 2006 as well as in *Acacia karroo* no new species were sampled in the last two sampling periods (Fig 10).

Table 2. Species diversity and abundance of spiders collected from three species of trees: *Acacia karroo*, *Rhus lancea* en *Rhus ciliata* in Erfenis Dam Nature Reserve, Free State Province, from November 2005 until August 2007. Abbreviations: *Ac* – *Acacia karroo*, *Rl* – *Rhus lancea* and *Rc* – *Rhus ciliata*, †- new species, ? – Dubious identification.

FAMILY /SPECIES	Guilds	<i>Ac</i>	<i>Rl</i>	<i>Rc</i>	Total	% of total
AGELENIDAE						
<i>Benoitia ocellata</i> (Pocock, 1900)	FWB	0	0	1	1	0.20
ARANEIDAE						
Araneidae sp. 1	OWB	1	0	0	1	0.20
<i>Araneus</i> sp. 1	OWB	0	1	0	1	0.20
<i>Caerostris</i> sp. 1	OWB	0	0	2	2	0.40
<i>Hypsosinga lithyphantoides</i> Caporiacco, 1947	OWB	1	0	0	1	0.20
<i>Lipocrea longissima</i> (Simon, 1881)	OWB	1	1	6	8	1.61
<i>Neoscona blondeli</i> (Simon, 1886)	OWB	9	7	6	22	4.44
<i>Neoscona rapta</i> Thorell, 1899	OWB	0	0	1	1	0.20
<i>Neoscona subfusca</i> (C.L. Koch, 1837)	OWB	12	1	15	28	5.65
<i>Pararaneus</i> sp. 1	OWB	1	3	1	5	1.00
<i>Pararaneus</i> sp. 2?	OWB	0	2	0	2	0.40
CLUBIONIDAE						
<i>Clubiona</i> sp. 1	FPW	0	1	1	2	0.40
CORINNIDAE						
<i>Copa</i> sp. 1	FWG	0	0	1	1	0.20
<i>Thysanina absolve</i> Lyle & Haddad, 2006	FWG	0	0	5	5	1.00
DICTYNIDAE						
<i>Dictyna</i> sp. 1	RWB	0	0	1	1	0.20
GNAPHOSIDAE						
Echeminae sp. 1	FGW	0	0	1	1	0.20
Echeminae sp. 2	FGW	0	0	1	1	0.20
LINYPHIIDAE						
<i>Microlinyphia sterilis</i> (Pavesi, 1883)	SHWB	0	0	1	1	0.20

LYCOSIDAE

<i>Trabea purcelli</i> Roewer, 1951	FGW	0	1	0	1	0.20
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MITURGIDAE

<i>Cheiracanthium furculatum</i> Karsch, 1879	FPW	27	12	10	49	9.88
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MYSMENIDAE

Mysmenidae sp. 1	OWB	0	1	0	1	0.20
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OXYOPIDAE

<i>Oxyopes affinis</i> Lessert, 1915?	FPW	24	0	0	24	4.84
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<i>Oxyopes russoi</i> Caporriacco, 1940	FPW	0	0	2	2	0.40
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<i>Oxyopes</i> sp. 3	FPW	6	0	1	7	1.41
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PHILODROMIDAE

<i>Gephyrota</i> sp. 1	FGW	4	0	0	4	0.81
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<i>Philodromus browningi</i> Lawrence, 1952	FGW	28	18	23	69	13.91
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<i>Philodromus</i> sp. 2	FGW	7	2	1	10	2.02
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<i>Philodromus</i> sp. 3	FGW	12	4	0	16	3.23
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<i>Tibellus minor</i> Lessert, 1919	FGW	0	0	2	2	0.40
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PHOLCIDAE

<i>Smeringopus sambesicus</i> Kraus, 1957	SPWB	0	0	1	1	0.20
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SALTICIDAE

<i>Baryphas ahenus</i> Simon, 1902	FPW	1	0	32	33	6.65
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<i>Evarcha prosimilis</i> Wesolowska & Cumming, 2008	FPW	0	0	6	6	1.21
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<i>Heliophanus nanus</i> Wesolowska, 2003	FPW	2	5	2	9	1.82
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<i>Heliophanus pistaciae</i> Wesolowska, 2003	FPW	4	1	1	6	1.21
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<i>Heliophanus transvaalicus</i> Simon, 1901	FPW	0	0	14	14	2.82
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<i>Pseudicius</i> sp. 1	FPW	1	0	6	7	1.41
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<i>Pseudicius</i> sp. 2	FPW	0	3	0	3	0.61
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<i>Rhene</i> sp. 1†	FPW	1	0	0	1	0.20
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Salticidae sp. 1	FPW	0	1	2	3	0.61
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<i>Thyene</i> sp. 1	FPW	0	1	0	1	0.20
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<i>Tusitala</i> sp. 1	FPW	0	0	1	1	0.20
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SPARASSIDAE

<i>Pseudomicrommata longipes</i> (Bösenberg & Lenz, 1895)	FPW	1	0	0	1	0.20
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TETRAGNATHIDAE

<i>Tetragnatha</i> sp. 1	OWB	16	0	9	25	5.04
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THERIDIIDAE

<i>Achaearanea</i> sp. 1	GWB	3	0	19	22	4.44
<i>Achaearanea</i> sp. 2	GWB	0	0	1	1	0.20
<i>Coleosoma</i> sp. 1	GWB	1	0	0	1	0.202
<i>Theridion</i> sp. 1	GWB	2	0	15	17	3.43
<i>Theridion</i> sp. 2	GWB	2	0	16	18	3.63

THOMISIDAE

<i>Misumenops rubrodecoratus</i> Millot, 1942	FPW	37	1	4	42	8.47
<i>Pherecydes</i> sp. 1	FPW	1	1	0	2	0.40
<i>Synema</i> sp. 1	FPW	0	0	4	4	0.81
<i>Thomisus stenningi</i> Pocock, 1900	FPW	0	0	3	3	0.61
<i>Tmarus cameliformis</i> Millot, 1942	FPW	1	0	2	3	0.61

TOTAL		206	70	220	496	100.00
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Of the three tree species, *Rhus ciliata* have the most unique species (Table 3). *Acacia karroo* and *R. lancea* almost have the same number of unique species. *R. ciliata* also has the highest species richness of the three species, with *R. lancea* with the lowest species richness.

Table 3. Species diversity and richness of tree spiders that were collected by foliage beating in Erfenis Dam Nature Reserve, Free State Province.

	Total species	Species richness	Chao est. sp. richness	Unique species
<i>Acacia karroo</i>	27	0.510	47.17	7
<i>Rhus lancea</i>	20	0.378	56.00	6
<i>Rhus ciliata</i>	38	0.717	54.33	18
Total species	53	-	-	-
Total unique species	31	-	-	-

The Sørensen's values for the comparison between *R. lancea* and *R. ciliata* is less than 0.5, indicating that these two trees had a relatively unique spider community with regards to each other (Table 4). *A. karroo* shares a more similar spider community with *R. lancea* and *R. ciliata*. *R. ciliata* and *A. karroo* had the most species in common.

Table 4. Sørensen's Quotient values for combinations of spider diversity collected by foliage beating from three tree species in Erfenis Dam Nature Reserve, Free State Province.

Tree species	<i>Acacia karroo</i>	<i>Rhus lancea</i>	<i>Rhus ciliata</i>
<i>Acacia karroo</i>	-	0.511	0.554
<i>Rhus lancea</i>		-	0.414

The number of spiders that were collected from the three tree species was compared to the rainfall that occurred in the sampling month (including the two months prior).

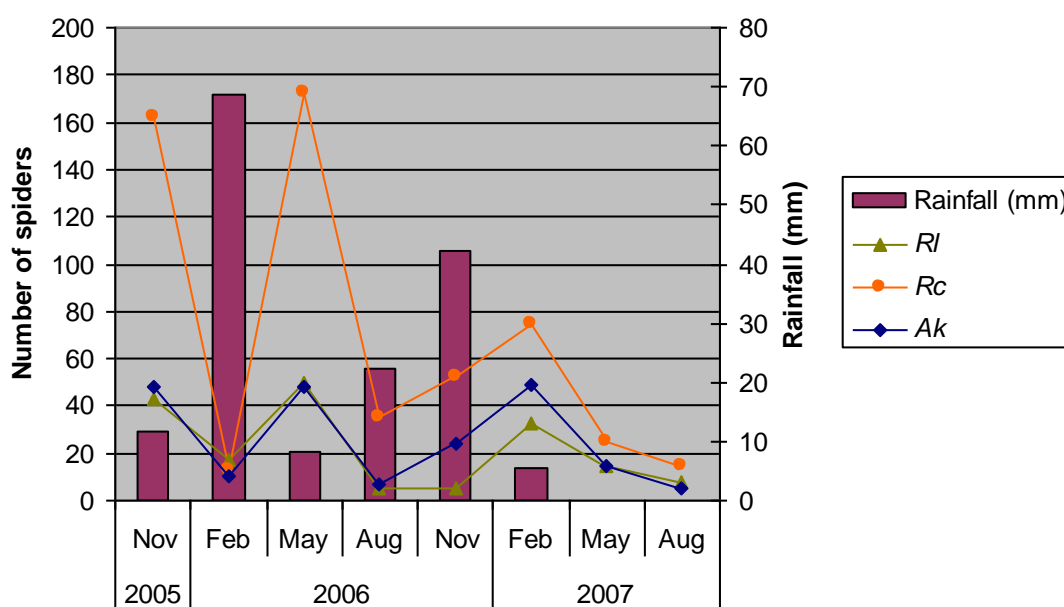


Fig. 11. The number of spiders collected from the three tree species by foliage beating in Erfenis Dam Nature Reserve, Free State Province, compared to monthly rainfall (mm) from November 2005 to August 2007. Abbreviations: Ac – *Acacia karroo*, Rl – *Rhus lancea* and Rc – *Rhus ciliata*.

The highest rainfall occurred in the summer season of 2006, and the lowest rainfall occurred in the winter season of 2007. Not many spiders were sampled during both of the August months. In February 2006, few spiders were collected (Fig. 11). The five most dominant families were determined for each of the sites sampled (Figs 12-14).

Rainfall does not have a significant influence on the numbers of spiders in the tree foliage in the sampling months as well as the two months prior ($P=0.9278$).

The most consistently dominant families that were found in the three tree species were Araneidae, Philodromidae and Thomisidae (Figs 12-14). The other dominant families only occurred on one of the three species, except Salticidae. This family was dominant in both *R. lancea* and *R. ciliata*. In *A. karroo*, Philodromidae was dominant throughout the two years, with Miturgidae only showing real dominance in February 2007. Thomisidae was dominating in both November 2005 and 2006 (Fig. 12). In *R. lancea*, Araneidae was the only dominant family present in August 2006 while Miturgidae was likewise the only dominant family present in November 2006. Thomisidae was absent through most of the two years, being only dominant in May 2007 (Fig. 13). In *R. ciliata*, Salticidae showed the greatest dominance in November 2005 and May 2006. Theridiidae was a dominant family in these shrubs, but was not present on either of the other two tree species. It was also dominant throughout most of the two years. In May 2006, both Philodromidae and Salticidae were very dominant (Fig. 14).

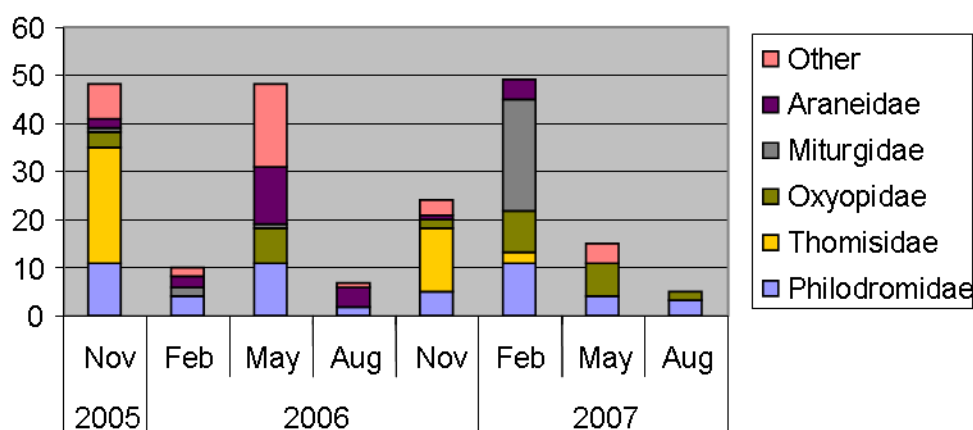


Fig. 12. The five dominant spider families collected from *Acacia karroo* by foliage beating in Erfenis Dam Nature Reserve, Free State Province.

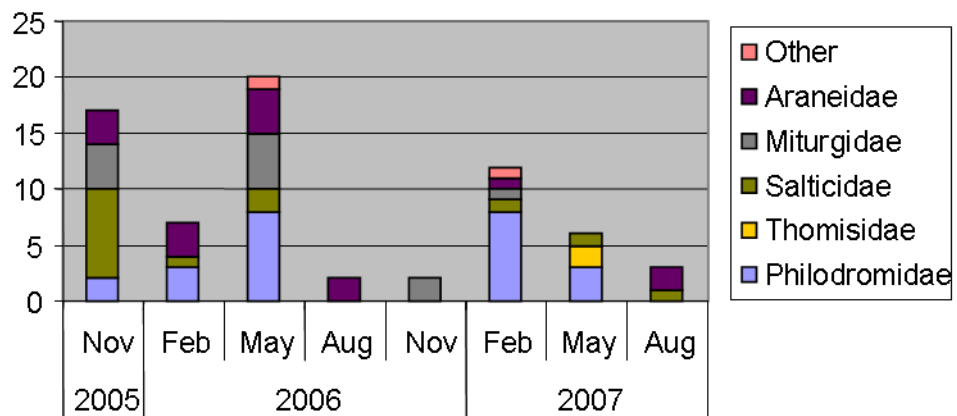


Fig. 13. The five dominant spider families collected on from *Rhus lancea* by foliage beating in Erfenis Dam Nature Reserve, Free State Province.

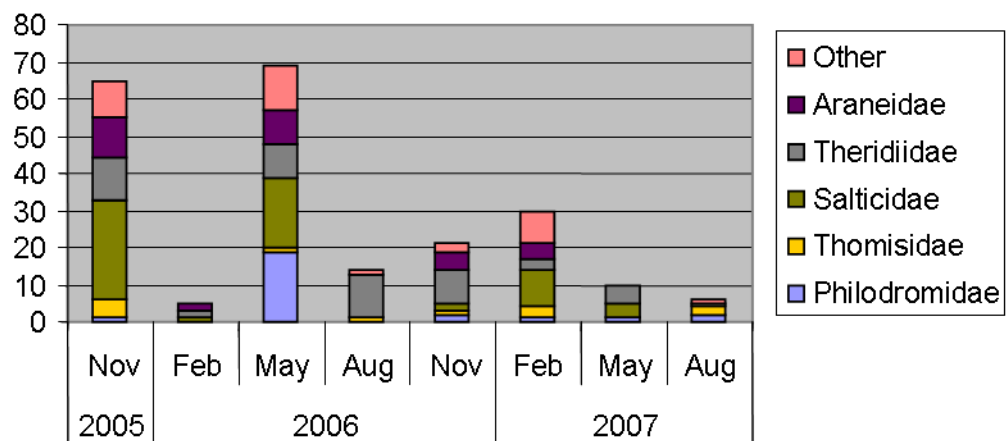


Fig. 14. The five dominant spider families collected on from *Rhus ciliata* by foliage beating in Erfenis Dam Nature Reserve, Free State Province.

The dominance of families differed in each month. The seasonality of the most dominant species collected throughout the two years were also determined (Fig. 15).

The dominant foliage-dwelling species that were the most abundant were *Philodromus browningi* (13.91%), *Cheiracanthium furculatum* (9.88%) and *Misumenops rubrodecoratus* (8.47%) (Fig. 15). These dominant species belong to each of the dominant families, with *P. browningi* and *M. rubrodecoratus* belonging to two of the consistently dominant families (Philodromidae and Thomisidae). Of the dominant foliage-dwellers, four species were active hunters and only one (*Neoscona subfusca*) a web-dweller.

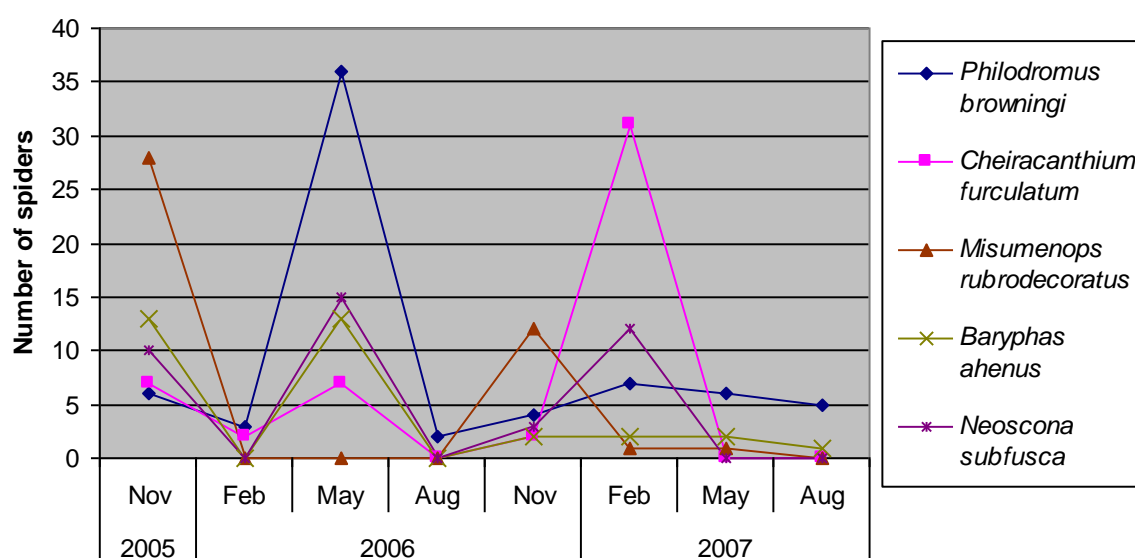


Fig. 15. The seasonality of the dominant spider species collected by foliage beating in Erfenis Dam Nature Reserve, Free State Province (pooled data of three tree species).

2.4.2. Grassland

During the period of two years a total of 1649 spiders were collected from sweep-netting, representing 15 families and 83 species (Table 5). There were more unique species sampled from the trees than from the grassland relative to the total species per

site (Tables 3 & 6). Differences in species richness and abundance between grassland types was not significant ($P=0.5940$, ANOVA).

In almost every sampling period first species records were collected except in the last two sampling periods where the amount of species is constant. The weedy and woodland grasslands have a lower amount of species than the uniform and mixed grasslands. The uniform and mixed grasslands have almost the same amount of species at the end of the last sampling period (Fig. 16).

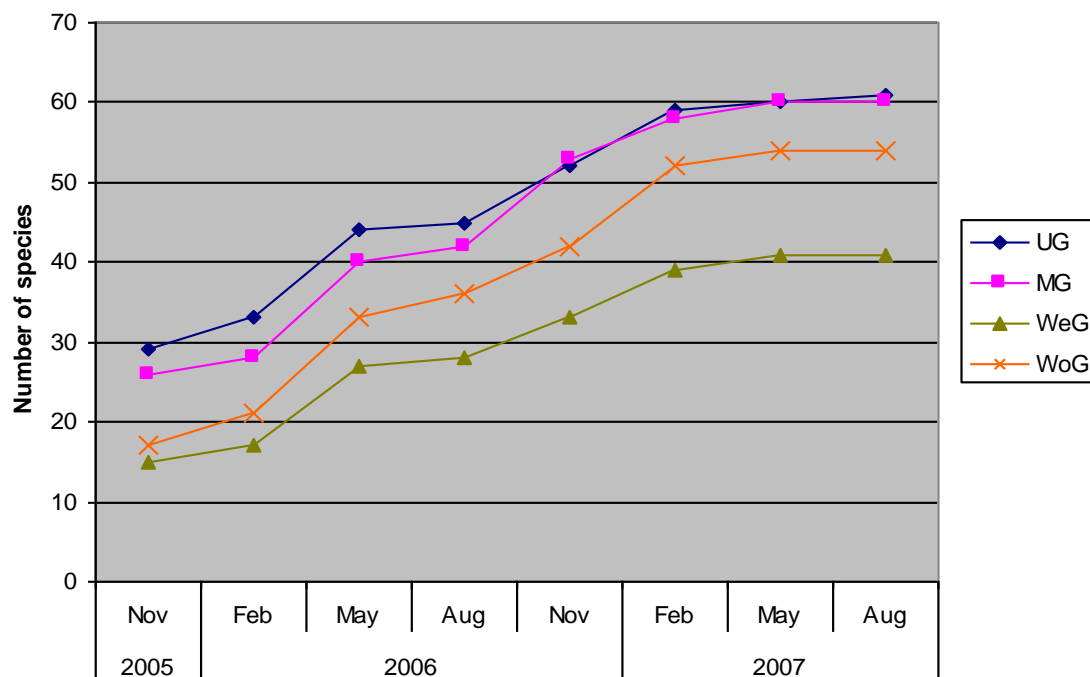


Fig. 16. The species accumulation curve of spider species captured by sweep-netting in Erfenis Dam Nature Reserve, Free State Province from November 2005 to August 2007. Abbreviations : UG - uniform grassland, MG - mixed grassland, WeG - weedy grassland and WoG - woodland grassland.

Table 5. Species diversity and abundance of spiders collected in four different grassland types in Erfenis Dam Nature Reserve, Free State Province, by sweep-netting from November 2005 to August 2007. Abbreviations : UG - uniform grassland, MG - mixed grassland, WeG - weedy grassland and WoG - woodland grassland, †- new species, ? – Dubious identification, imm – immature.

FAMILY/SPECIES	Guilds	TG	MG	WeG	WoG	Total	% of total
ARANEIDAE							
<i>Araniella</i> sp. 1	OWB	1	25	0	0	26	1.58
Araneinae sp. 1	OWB	7	21	5	3	36	2.18
Araneinae sp. 2	OWB	0	5	0	4	9	0.55
<i>Cyclosa insulana</i> (Costa, 1834)	OWB	0	0	1	0	1	0.06
<i>Hypsosinga lithyphantoides</i> Caporiacco, 1947	OWB	6	25	32	8	71	4.31
<i>Hypsosinga</i> sp. 2	OWB	24	14	5	4	47	2.85
<i>Hypsosinga</i> sp. 3	OWB	6	0	0	0	6	0.36
<i>Kilima</i> sp. 1†	OWB	41	15	19	7	82	4.97
<i>Kilima</i> sp. 2?	OWB	0	0	0	1	1	0.06
<i>Larinia</i> sp. 1?	OWB	0	0	6	12	18	1.09
<i>Lipocrea longissima</i> (Simon, 1881)	OWB	6	9	4	5	24	1.46
<i>Nemoscolus cotti</i> Lessert, 1933	OWB	0	14	0	2	16	0.97
<i>Neoscona blondeli</i> (Simon, 1886)	OWB	8	1	7	6	22	1.33
CLUBIONIDAE							
<i>Clubiona</i> sp. 1	FPW	0	1	0	0	1	0.06

CORINNIDAE

<i>Poachelas striatus</i> Haddad & Lyle, 2008	FGW	1	2	0	0	3	0.18
<i>Thysanina absolve</i> Lyle & Haddad, 2006	FGW	4	1	0	4	9	0.55

DICTYNIDAE

<i>Archaeodictyna</i> sp. 1	RWB	22	13	0	3	38	2.30
<i>Dictyna</i> sp. 1	RWB	4	9	5	0	18	1.09

GNAPHOSIDAE

Echeminae sp. 1	FGW	0	0	0	1	1	0.06
Echeminae sp. 2	FGW	0	0	0	1	1	0.06
<i>Zelotes</i> sp. 1	FGW	1	4	0	2	7	0.42

LINYPHIIDAE

<i>Microlinyha sterilis</i> (Pavesi, 1883)	SHWB	0	0	2	1	3	0.18
<i>Ostearius melanopygius</i> (O. P.-Cambridge, 1879)	SHWB	0	0	1	0	1	0.06
Linyphiidae sp. 1	SHWB	0	1	0	0	1	0.06
Linyphiidae sp. 2	SHWB	1	2	1	0	4	0.24
Linyphiidae sp. 3	SHWB	0	2	0	1	3	0.18
Linyphiidae sp. 4	SHWB	1	0	0	0	1	0.06
Linyphiidae sp. 5	SHWB	1	0	0	0	1	0.06

LIOCRANIDAE

<i>Rhaeboctesis</i> sp. 1	FGW	1	0	0	0	1	0.06
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LYCOSIDAE

<i>Pardosa</i> sp. 1	FGW	3	2	1	2	8	0.49
<i>Proevippa</i> sp. 1	FGW	9	9	49	15	82	4.97
Lycosidae sp. 1	FGW	1	0	0	0	1	0.06

MITURGIDAE

<i>Cheiramiona florisbadensis</i> Lotz, 2003	FPW	1	1	0	0	2	0.12
<i>Cheiracanthium furculatum</i> Karsch, 1879	FPW	1	2	1	0	4	0.24
Miturgidae sp. 1	FPW	1	4	0	4	9	0.55

OXYOPIDAE

<i>Oxyopes affinis</i> Lessert, 1915?	FPW	21	8	3	9	41	2.49
<i>Oxyopes jacksoni</i> Lessert, 1915	FPW	5	0	0	0	5	0.30
<i>Oxyopes russoi</i> Caporiacco, 1940	FPW	14	6	0	1	21	1.27
<i>Oxyopes</i> sp. 4	FPW	0	2	0	0	2	0.12
<i>Peucetia striata</i> Karsch, 1878?	FPW	13	2	3	1	19	1.15

PHILODROMIDAE

<i>Gephyrota</i> sp. 1	FGW	0	0	0	1	1	0.06
<i>Philodromus</i> sp. 1	FGW	9	1	8	6	24	1.46
<i>Suemus</i> sp. 1	FGW	0	1	0	0	1	0.06
<i>Thanatus dorsilineatus</i> Jézéquel, 1964?	FGW	2	20	4	8	34	2.06
<i>Thanatus vulgaris</i> Simon, 1870	FGW	0	0	0	1	1	0.06
<i>Tibellus hollidayi</i> Lawrence, 1952	FGW	5	23	57	15	100	6.06

<i>Tibellus minor</i> Lessert, 1919	FGW	88	58	19	13	178	10.79
SALTICIDAE							
<i>Heliophanus debilis</i> Simon, 1901	FPW	0	0	0	2	2	0.12
<i>Heliophanus charlesi</i> Wesolowska, 2003?	FPW	1	0	0	0	1	0.06
<i>Heliophanus nanus</i> Wesolowska, 2003	FPW	1	6	2	2	11	0.67
<i>Heliophanus pistaciae</i> Wesolowska, 2003	FPW	8	5	12	12	37	2.24
<i>Heliophanus prozysniskii</i> Wesolowska, 2003	FPW	1	1	12	2	16	0.97
<i>Pellenes bulawayoensis</i> Wesolowska, 1999	FGW	1	0	0	0	1	0.06
<i>Phlegra karoo</i> Wesolowska, 2006	FGW	1	0	0	0	1	0.06
<i>Rhene</i> sp. 1?	FPW	2	5	0	0	7	0.42
Salticidae sp. 1	FPW	0	1	0	0	1	0.06
Salticidae sp. 2	FPW	0	1	0	2	3	0.18
<i>Thyene aperta</i> (Peckham & Peckham, 1903)	FPW	0	0	0	1	1	0.06
<i>Thyene inflata</i> (Gerstäcker, 1873)	FPW	0	0	2	1	3	0.18
<i>Thyene semiargentea</i> (Simon, 1884)	FPW	30	75	24	22	151	9.16
SPARASSIDAE							
<i>Olios correvoni</i> Lessert, 1921?	FGW	0	1	0	0	1	0.06
THERIDIIDAE							
<i>Anelosimus</i> sp. 1?	GWB	0	0	1	1	2	0.12
<i>Latrodectus renivulvatus</i> Dahl, 1902	GWB	1	0	0	0	1	0.06
<i>Phoroncidia</i> sp. 1	GWB	8	12	3	0	23	1.40

<i>Theridion</i> sp. 1	GWB	4	6	12	3	25	1.516
<i>Theridion</i> sp. 2	GWB	0	3	2	1	6	0.36
<i>Theridion</i> sp. 3	GWB	1	0	2	1	4	0.24

THOMISIDAE

<i>Heriaeus</i> sp. 1†	FPW	2	3	1	0	6	0.36
<i>Misumenops rubrodecoratus</i> Millot, 1941	FPW	49	14	21	89	173	10.49
<i>Monaeses gibbus</i> Dippenaar-Schoeman, 1984	FPW	1	2	0	1	4	0.24
<i>Monaeses</i> sp. 2	FPW	1	0	0	0	1	0.06
<i>Runcinia aethiops</i> (Simon, 1901)?	FPW	0	1	0	0	1	0.06
<i>Runcinia affinis</i> Simon, 1897	FPW	15	2	0	0	17	1.03
<i>Runcinia erythrina</i> Jézéquel, 1964?	FPW	1	0	0	1	2	0.12
<i>Runcinia flavida</i> (Simon, 1881)	FPW	13	9	28	52	102	6.19
<i>Runcinia grammica</i> (C.L. Koch, 1837)	FPW	0	1	3	2	6	0.36
<i>Stiphropus affinis</i> Lessert, 1923	FGW	3	2	1	1	7	0.42
Thomisidae sp. 1	FPW	0	1	0	0	1	0.06
Thomisidae sp. 2	FPW	1	0	0	0	1	0.06
<i>Thomisops sulcatus</i> Simon, 1895	FPW	0	1	0	0	1	0.06
<i>Thomisus stenningi</i> Pocock, 1900	FPW	2	1	1	4	8	0.49
<i>Thomisus</i> sp. 2 imm.	FPW	8	8	10	10	36	2.18
<i>Xysticus</i> sp. 1	FGW	0	1	0	0	1	0.06

TOTAL		463	465	370	351	1649	100.00
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Table 6. Species diversity and richness of grass-dwelling spiders collected by sweep-netting in Erfenis Dam Nature Reserve, Free State Province. Abbreviations : UG - uniform grassland, MG - mixed grassland, WeG - weedy grassland and WoG - woodland grassland.

	Total species	Species richness	Chao est. sp. richness	Unique species
UG	54	0.651	114.50	12
MG	56	0.675	70.45	9
WeG	38	0.458	48.13	2
WoG	49	0.590	67.06	7
Total species	83	-	-	-
Total unique species	31	-	-	-

The grass-dwelling spider communities were more similar to each other than the tree-dwelling communities according to the Sørensen's Quotient values (Table 7). The woodland grassland and the mixed grassland had the greatest similarity (0.781), while the uniform grassland and the woodland grassland had the lowest similarity (0.621).

Table 7. Sørensen's Quotient values for combinations of spider species richness collected by sweep-netting in four different grassland types in Erfenis Dam Nature Reserve, Free State Province. Abbreviations : UG - uniform grassland, MG - mixed grassland, WeG - weedy grassland and WoG - woodland grassland.

Grasslands	UG	MG	WeG	WoG
UG	-	0.727	0.652	0.621
MG		-	0.660	0.781
WeG			-	0.713

Similar results to the foliage are found in the grasslands when the rainfall is compared to the number of spiders (Fig. 17). In November 2005, high numbers of grass-dwelling spiders were collected, even though rainfall was low in the previous three months. In the winter months the number of spiders decreased. In February 2006, few spiders were collected, even though it was in a summer month. Rainfall does not have a significant influence on the numbers of spiders in the grasslands in the sampling months as well as the two months prior ($P=0.9415$).

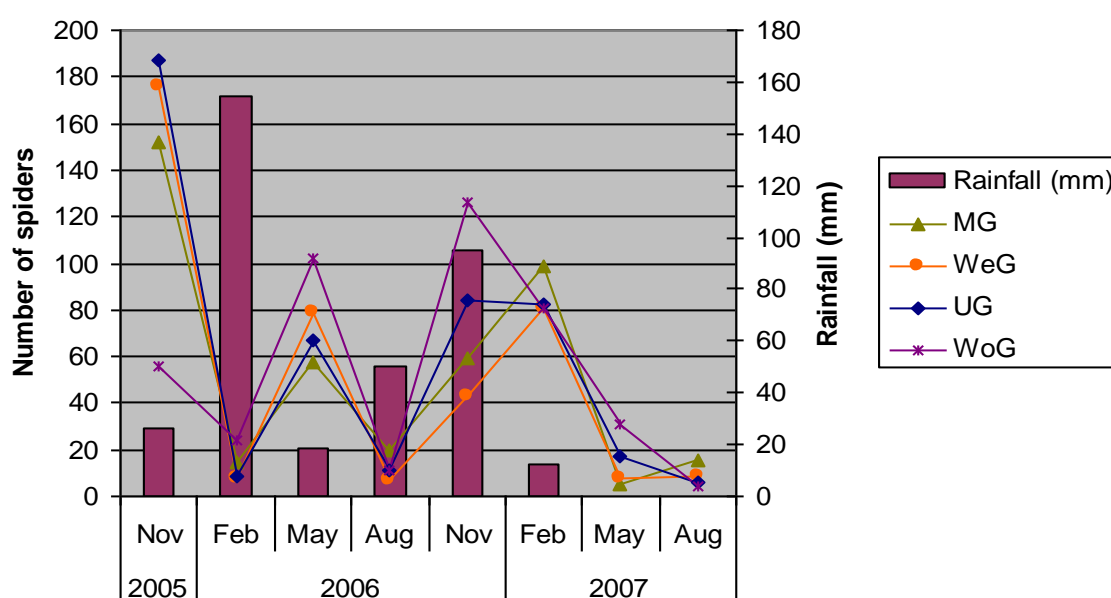


Fig. 17. The number of spiders collected by sweep-netting in the four types of grassland in Erfenis Dam Nature Reserve, Free State Province, compared to monthly rainfall (mm) from November 2005 to August 2007.

The dominant families of the grassland were also similar to the dominant families of the foliage (Figs 18-21). The Araneidae, Philodromidae, Salticidae and Thomisidae were consistently dominant in all four grassland types (Figs 18-21). Other common families were only abundant at one, two or three types of grasslands.

In the *Themeda* grassland, Philodromidae was dominant in November 2005, then remains almost absent till February 2007, and then become absent again. Thomisidae

was greatly dominant in November 2005 and February 2007 with Araneidae being more dominant in both November 2005 and 2006 (Fig. 18). In the mixed grassland, Araneidae was greatly dominant in November 2005; 2006 and February 2007, with Salticidae being greatly dominant in both November 2005; 2006, February 2007 and May 2007. Philodromidae was greatly dominant in both November 2005; 2006, May 2006 and February 2007 (Fig. 19). In the weedy grassland, both Philodromidae and Thomisidae were greatly dominant in November 2005 while Lycosidae was dominant in May 2006. In both February 2006 and 2007 Thomisidae's dominance increased again. Araneidae was dominant in both November 2005 and 2006 (Fig. 20). In the woodland grassland, Thomisidae was dominant through most of the year (except August 2007) with both Araneidae and Lycosidae dominant in May 2006 (Fig. 21).

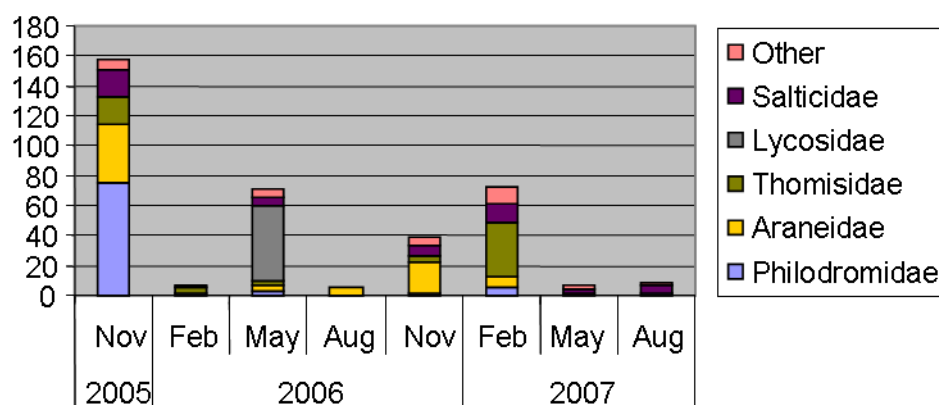


Fig. 18. The five dominant spider families that was collected in the uniform *Themeda triandra* grassland with the sweeping method in Erfenis Dam Nature Reserve, Free State Province.

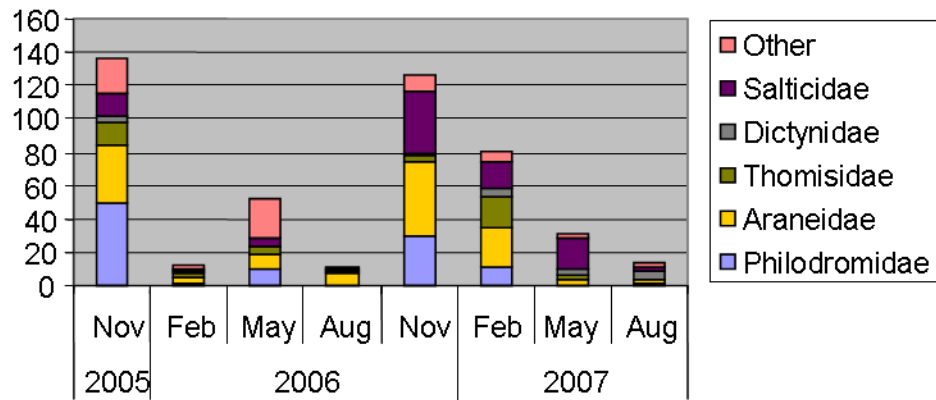


Fig. 19. The five dominant spider families that was collected in the mixed grassland with the sweeping method in Erfenis Dam Nature Reserve, Free State Province.

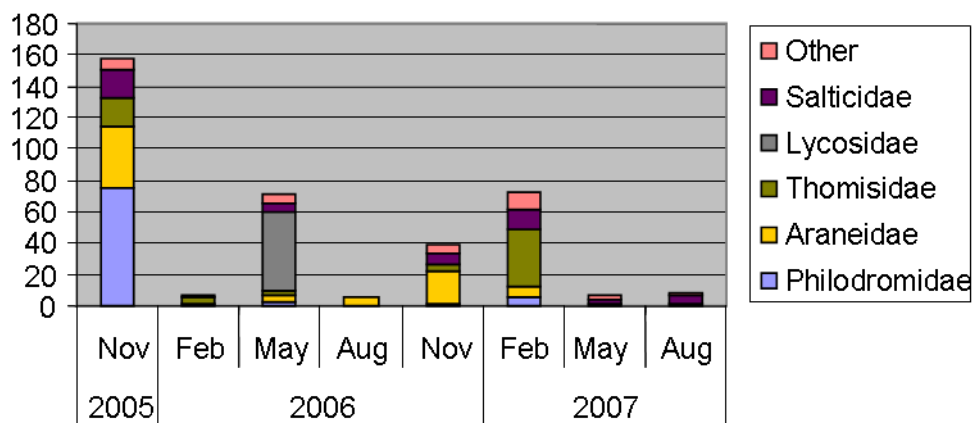


Fig. 20. The five dominant spider families that was collected in the weedy grassland with the sweeping method in Erfenis Dam Nature Reserve, Free State Province.

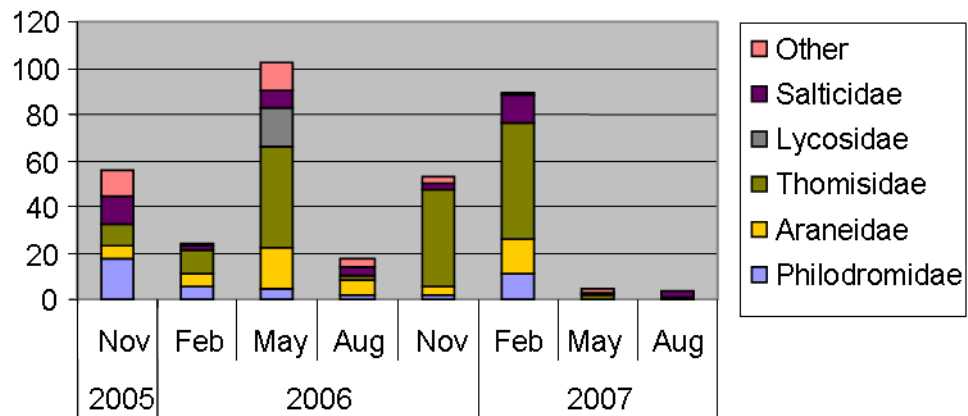


Fig. 21. The five dominant spider families that was collected in the woodland grassland with the sweeping method in Erfenis Dam Nature Reserve, Free State Province.

The numerically dominant species collected were *Tibellus minor* (10.79%), *Misumenops rubrodecoratus* (10.49%) and *Thyene semiargentea* (9.16%) (Fig. 22). These species contributed largely to the dominance of the constant dominant families of Philodromidae, Thomisidae and Salticidae in the survey. It seems that *T. minor* and *T. hollidayi* (not present in summer of 2006) are strongly seasonal, being the most abundant in the summer months. All the dominant species are active hunters.

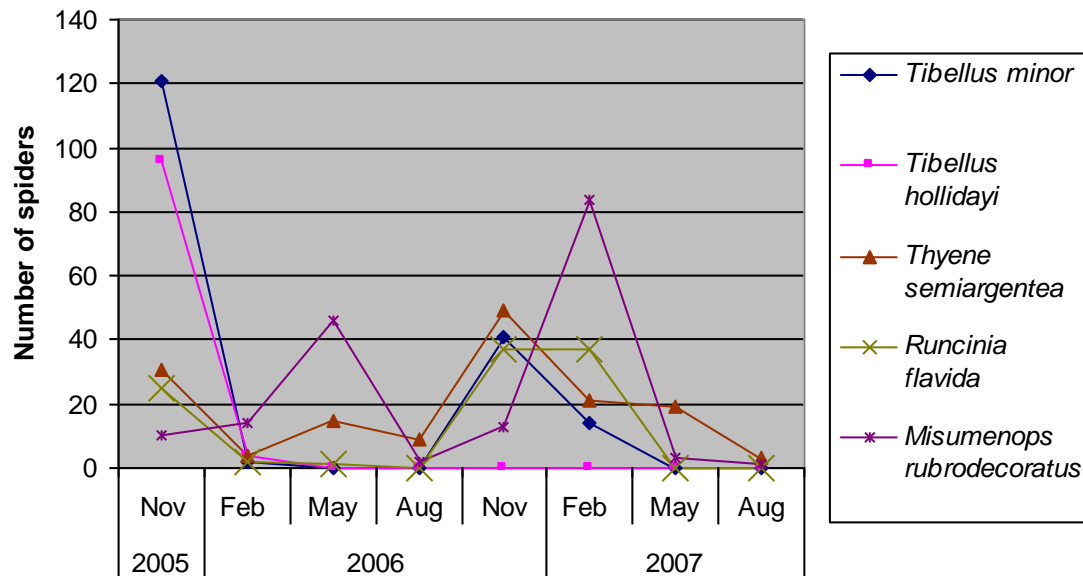


Fig. 22. The seasonality of the dominant spider species collected by sweep-netting in Erfenis Dam Nature Reserve, Free State Province (pooled data of four grassland types).

2.5. Discussion

Ecosystems exist in a continuously changing world. These changes result from different processes in the abiotic or physical environment, from changes that occur in the biotic environment, the living ecosystem community, and by human actions. Disturbance (for example the controlled burning at Erfenis Dam) is defined as any type of influence on an ecosystem that increases the probability of destruction of biomass of the organisms present and can be either biotic or abiotic (Dickinson & Murphy 1998). Populations will exhibit fluctuations in their density because of natality, mortality, immigration (wandering spiders, ballooning technique), emigration, disturbances (fire), the changing environment, and so forth (Dash 1993). In this light most spiders can be viewed to live in a defined environment with limits that are set by physical and biological factors (Foelix 1982 cited in Modiba *et al.* 2005).

2.5.1. Influence of season and rainfall: The Free State Province is known to have summer rainfall, and a dry winter season. The highest number of tree-dwelling spiders was sampled during the first spring (Nov. 2005) and autumn (May 2006) seasons, whereas grass-dwelling spiders reached their peak abundance during the two spring seasons (Nov. 2005 and Nov. 2006) and the second summer season (Feb. 2007). This indicates that spider abundance is greatest after months of good rainfall (Figs 11 & 17). Spiders are extremely efficient and successful predators, which can be attributed to the different ways in which they exploit insect populations (Dippenaar-Schoeman & Jocqué 1997). Spiders are also considered potential bio-indicators, which mean that changes in the spider fauna are likely to reflect ecological impacts at lower levels in the food web. For example, both hunting and web-building spiders are sensitive to changes in habitat structure and rainfall can affect habitat structure in subtle ways (Langlands *et al.* 2006). According to a study of Langlands *et al.* (2006) in the Great Victoria Desert in Australia, sampling years with high spider abundance coincided with years of good rainfall that took place prior to sampling. This was also evident in this study with spider numbers increasing after months with good rainfall and decreasing in months without good rainfall (Figs 11 & 17). A bottom-up effect from rainfall might be responsible for the increases in spider abundance, but the Linear Regression test results showed that rainfall had no significant influence on spider numbers in both the foliage and grasslands when sampling. If an observation is made at a finer temporal scale, rain falling immediately before or during sampling day may also influence spider activity and hence capture rates (Romero & Vasconcellos-Neto 2003). This may explain the low number of spiders captured in February 2006.

The dominance of families varied over the two years and from season to season. According to Langlands *et al.* (2006), some spiders tend to have strong seasonality, so this could also influence the number of spiders present during a year. More spiders were captured in the summer months than in the winter months (Figs 11 & 17), which reflects the high availability of prey and emergence of immature spiders from egg sacs during summer. Lower prey availability in the winter is not problematic to spiders since they are very resistant to starvation, which enables them to survive and maintain normal reproduction in these times (Dippenaar-Schoeman & Jocqué 1997). According to Aitchison (1987) there are winter-active spiders that utilize this season

to have an ecological advantage of little competition from other spiders or other predaceous invertebrates for food. Spiders show two types of overwintering behaviour. The first is winter inactivity, also known as diapause, where there are no moving and no feeding at low temperatures. Spiders have low metabolic rates, whereas in the second type of behaviour the spiders must have elevated metabolic rates. Spiders are able to move and feed at low temperatures, and probably make use of protective microclimates, such as leaf litter or tree bark. A few examples of observed northern hemisphere winter-active spiders are the families Clubionidae, Thomisidae and Tetragnathidae (Aitchison 1987). A top-down effect exerted by higher predators and parasites can also influence spider numbers (Romero & Vasconcellos-Neto 2003). Winter may also be the reason of the decline of species richness in May and August 2007 (Figs 10 & 16).

2.5.2. Influence of vegetation: The number of individuals of a family (or species) that are collected depends on the activities of the family (or species) and the types of vegetation present (Lotz *et al.* 1991). Since spiders are predators they interact with the vegetation indirectly, which means that structural support available for webs, prey availability, as well as a suitable micro-climate is the most important factors in web site selection which will also influence the composition of a spider community (Gunnarsson 1990; Houghton *et al.* 1999; Harwood *et al.* 2001; Dippenaar-Schoeman & Wassenaar 2002, 2006). Spider abundance is correlated with the specific vegetation characteristics, suggesting that the availability of habitats is important for spider colonization and establishment (Jögar *et al.* 2004).

Diversity of spiders can also be attributed to vegetation complexity. Spiders that were collected from the trees are more diverse and unique than the spiders that were collected from the grasslands. The reason for this can be that trees are more complex and have more layers, which leads to more niches that spiders can occupy. The structure of trees is also more stable, so it makes a better habitat than grass, which can be more prone to the environmental effects. An example of this is the grazing of herbivores. Warui *et al.* (2005) found that spider numbers decreased because of the presence of cattle in Kenya. In grasslands and forests, grazing by cattle and wild herbivores has a significant effect on vegetation, with the photosynthetic parts of the plants being reduced more rapidly than the rate of replacement, which will lead the

depletion of spider numbers indirectly due to the attraction of fewer insects (Dash 1993). Thus, the wild herbivore grazers present in Erfenis Dam Nature Reserve may have a significant impact on the abundance of spiders.

Free State grasslands consist of a high diversity of grasses and shrubs that create greater habitat complexity, which means that there are many niches for spiders to live in (Haddad 2005). Yet, grass is also more uniform in structure, which may limit availability of niches in the grasslands. Rainfall was lower in the second year of sampling than in the first year, and because of this, the grass growth was less dense during the second year of sampling. This means that stable grass structures to build webs decreased considerably.

The estimated species richness predicted that *Rhus lancea* would have the most species richness with *Acacia karroo* having the least, but the *R. ciliata* shrubs had more and unique species than the two trees. This could be due to the denser foliage than that of the trees, which means there is more habitat complexity available (more niches). This can also be illustrated by Theridiidae dominance in the shrubs but absence in the other two tree species (Figs 12-14). The two tree species also has thick trunks as well as bark which makes these habitat structures more complex than that of *R. ciliata*. The thorns of *A. karroo* can also be seen as making the habitat structure more complex. The uniqueness of the tree species can be put into relative perspective with the theory of Island Biogeography. According to Meadows (1985) the theory of Island Biogeography is concerned with the number of species inhabiting an 'island' of a given size and of a given distance from the 'mainland'. Because the spiders are isolated from other trees, the species can become relatively unique to a tree species.

Of the grasslands, the mixed, woodland and weedy grasslands all have complex habitat structure. The estimated species richness predicted that the *Themeda* grassland would have the most species richness with the weedy grassland having the lowest. Yet, the mixed grassland was the most diverse habitat (structurally as well as having the most plant species), and had the most species rich spider community. The *Themeda* grassland was uniform in habitat structure, but was very closely the second most species rich grassland. This is probably due to the complex structure of the grass which can have long, thick stems, and the base of such grass patches is a very

complex microhabitat. Also, patches of *Eragrostis* and *Cymbopogon* grasses present in the uniform grassland would have given it greater plant diversity and attracted more insects and spiders. In the woodland grassland the trees probably contributed to the spider diversity by creating a more structurally complex habitat with more niches available for occupation by spiders. The weedy grassland had the lowest spider diversity, despite the structural complexity of the vegetation. It could be that the weeds emitted allomones, which repelled many insects from this habitat. The decrease in food resources for the spiders could have resulted in lower diversity. According to Mgobozi *et al.* (2008), the progressive invasions of the invasive alien weed *Chromolaena odorata* (L.) King & Robinson (Asteraceae) brings with it negative changes in native spider abundance, assemblage patterns, diversity and estimated species richness. The four grasslands seem to have relatively similar spider communities compared to the tree communities. Two explanations can clarify this pattern: 1) this indicates that the grass spider fauna is more flexible in their ecological requirements and can occupy more variable plant communities than the tree fauna. The woodland grassland and mixed grassland had the most similar spider fauna, and this is probably due to high plant diversity in both sites; 2) the tree foliage sampling was inadequate and more sampling may ultimately give higher similarity values; and 3) under sampling.

2.5.3 Family and species dominance: The vegetation structure and rainfall are important factors that determine the domination of families and species in a habitat since most spiders will have a preference to structure (Uetz & Burgess 1979). It is not surprising that the dominant species of the tree layers and grasslands came from Araneidae, Salticidae and Thomisidae as these are some of the most diverse families (Dippenaar-Schoeman & Jocqué 1997). This pattern can also be seen for spiders in agro-ecosystems and nature reserves (Dippenaar-Schoeman *et al.* 2001; Dippenaar-Schoeman & Wassenaar 2002; Foord *et al.* 2002; Dippenaar-Schoeman *et al.* 2005a, b; Haddad *et al.* 2005; Haddad *et al.* 2006; Mellet *et al.* 2006; Dippenaar-Schoeman *et al.* 2009). Araneids is dominant in species abundance probably because of the tree and grass species having structures suitable for web construction by particular species (Mcnett & Rypstra 2000). Thomisids on the other hand, are very adaptable towards their habitats. Romero & Vasconcellos-Neto (2004) found that *Misumenops argenteus* (Mello-Leitao) choose their habitat based on structural attributes like the

morphology of a leaf, for example; *Metepeira spinipes* F.O. Pickard-Cambridge chose Agave plants which provide strong support (Uetz & Burgess 1979). Thus, Erfenis Dam vegetation types may have been structural adequate for spiders needs (e.g. support for their webs). Philodromids are active hunters and are commonly found on plants. Their body form and colour make them cryptic on grass or tree branches; this is particularly evident in *Tibellus* Simon (Van den Berg & Dippenaar-Schoeman 1994).

Different families may prefer different vegetation structures that are present like the Miturgidae which is one of the dominant families in both tree species, but is not a dominant family in *Rhus ciliata*. Like wise, theridiids is a dominant family in *R. ciliata*, but not in the either of the two tree species. Oxyopids are considered plant-dwelling spiders that are commonly found on grass, shrubs and trees (Turner 1979). In this study a distinct preference for foliage was shown. Lycosids was represented in three of the four grasslands, even though they are usually ground-dwellers and scarce on vegetation. According to Lotz *et al.* (1991) lycosids were the second most abundant family at Florisbad Research Station. Jocqué & Alderweireldt (2005) hypothesized that lycosids co-evolved with grasslands and then dispersed with the expansion of this type of habitat. The dictynids are plant-dwellers, but little is known about them. Their abundance in the mixed grassland vegetation may be attributed to the variety of grass species that provide a framework for the construction of their hackle webs, particularly in the florescences (Haddad 2005).

The fluctuations in species abundance are due to seasonality. This is also illustrated by the seasonal dominance of species like Thomisidae and Lycosidae (Figs 12-14; 18-21). The dominant species were most abundant in the rainy season. *Misumenops rubrodecoratus* was dominant in the trees and grassland, indicating that this species is very flexible in its ecological requirements (as mentioned above). It seems that *Tibellus minor* is seasonal, with its numbers peaking in the summer months, but declining in the winter months. This also seems to be true for *Thyene semiargentea* and *Runcinia flavida*. This could be because of favourable temperatures and high rainfall in summer. Seasonal abundance of tree spiders differs from grass-dwelling spiders (Dippenaar-Schoeman *et al.* 1989). Most studies show peaks in temporal

patterns of spider numbers and species during early to mid summers (Hatley & Macmahon 1980; Niemelä *et al.* 1994).

2.6. Conclusion

More spiders are found during the Free State summer months when the temperature and rainfall are higher than in the winter months. This can be attributed to the increase in food resources in the summer months. Spiders are seasonally bound, and according to literature the seasonal abundance of tree spiders differs from grass-dwelling spiders. A bottom-up effect from rainfall might be the reason why there are more spiders in the summer season. Vegetation complexity and structure determine the dominant families and species directly by supplying an ideal place for building a web or a place to ambush prey, or indirectly by supplying a food resource for insects which in turn will be food for spiders. The foliage-dwelling spider communities differed from one another, suggesting that either the sampling duration was inadequate or that the vegetation structures were markedly different, affecting community structure through niche specialisation. Grass-dwelling communities were more similar, with fewer unique species per vegetation type, indicating that the grass fauna is probably more flexible in their ecological requirements and can occupy more variable plant communities. It can also be because of grasses being more similar in structure, whereas the structure between shrubs and trees is more variable, which could have lead to the more diverse communities of the foliage. In conclusion, the plant-dwelling families that dominate the Grassland biome are the Araneidae, Philodromidae, Salticidae and Thomisidae, relating mainly to the vegetation structure and complexity.

2.7. References

- AITCHISON, C.W. 1987. Feeding ecology of winter-active spiders. Pp. 264-273. In: Nentwig, W. (ed.) *Ecophysiology of spiders*. Springer-Verlag, Berlin.
- AUBREY, A. & REYNOLDS, Y. 2002. *Acacia karroo Hayne*. South African National Biodiversity Institute, Pretoria. Available online at: <http://www.plantzafrica.com/plantab/acaciakar.htm>.

BREDENKAMP, G., GRANGER, J.E. & VAN ROOYEN, N. 1996. Moist Sandy Highveld Grassland. In: Low, A.B. & Robelo, A.G. (eds.) *Vegetation of South Africa, Lesotho and Swaziland*. Department of Environmental Affairs and Tourism, Pretoria. 870pp.

CHURCHILL, T.B. 1997. Spiders as ecological indicators: an overview for Australia. *Memoirs of the Museum of Victoria* **56**: 331-337.

DASH, M.C. 1993. *Fundamentals of ecology*. Tata McGraw-Hill Publishing Company Limited, New Delhi. 210pp.

DICKINSON, G. & MURPHY, K. 1998. *Ecosystems, a functional approach*. Routledge, London and New York. 190pp.

DIPPENAAR-SCHOEMAN, A.S. & HADDAD, C.R. 2007. *Feedback on projects in the Grassland biome*. SANSA newsletter no. 3. Agriculture Research Council, Pretoria. 17pp.

DIPPENAAR-SCHOEMAN, A.S. & JOCQUÉ, R., 1997. *African spiders, an identification manual*. Plant Protection Research Institute Handbook no. 9, Agricultural Research Institute, Pretoria. 392pp.

DIPPENAAR-SCHOEMAN, A.S., LEROY, A., DE JAGER, M. & VAN DEN BERG, A. 1999. A check list of the spider fauna of the Karoo National Park, South Africa (Arachnida: Araneae). *Koedoe* **42**: 31-42.

DIPPENAAR- SCHOEMAN, A.S., VAN DEN BERG, A. & PRENDINI, L. 2009. Spiders and scorpions (Arachnida: Araneae, Scorpiones) of the Nylsvley Nature Reserve, South Africa. *Koedoe* **51**: 1-9.

DIPPENAAR-SCHOEMAN, A.S., VAN DEN BERG, A.M. & VAN DEN BERG, A. 1989. Species composition and relative seasonal abundance of spiders from the field and tree layers of the Roodeplaat Dam Nature Reserve. *Koedoe* **32**: 25-38.

DIPPENAAR-SCHOEMAN, A.S., VAN DEN BERG, A.M., VAN DEN BERG, M.A. & FOORD, S.H. 2005a. Spiders in avocado orchards in the Mpumalanga Lowveld of South Africa: species diversity and abundance (Arachnida: Araneae). *African Plant Protection* **11**: 8–16.

DIPPENAAR-SCHOEMAN, A.S., VAN DEN BERG M.A., VAN DEN BERG, A.M. & VAN DEN BERG, A. 2001. Spiders in macadamia orchards in the Mpumalanga Lowveld of South Africa: species diversity and abundance (Arachnida: Araneae). *African Plant Protection* **7**: 39–46.

DIPPENAAR-SCHOEMAN, A.S., VAN DER WALT, A.E., DE JAGER, M., LE ROUX, E. & VAN DEN BERG, A. 2005b. The spiders of the Swartberg Nature Reserve in South Africa (Arachnida: Araneae). *Koedoe* **48**: 77–86.

DIPPENAAR-SCHOEMAN, A.S. & WASSENAAR, T.D. 2002. A checklist of the ground-dwelling spiders of coastal dune forests at Richards Bay, South Africa (Arachnida: Araneae). *Bulletin of the British Arachnological Society* **12**: 275-279.

DIPPENAAR-SCHOEMAN, A.S. & WASSENAAR, T.D. 2006. A checklist of spiders from the herbaceous layer of a coastal dune forest ecosystem at Richards Bay, KwaZulu-Natal, South Africa (Arachnida: Araneae). *African Invertebrates* **47**: 63-70.

FOORD, S.H., DIPPENAAR-SCHOEMAN, A.S. & VAN DER MERWE, M. 2002. A check list of the spider fauna of the Western Soutpansberg, South Africa (Arachnida: Araneae). *Koedoe* **45**: 35-43.

GERMISHUIZEN, G., MEYER, N.L., STEENKAMP, Y. & KEITH, M. (eds.) 2006. *A checklist of South African plants*. South African Botanical Diversity Network Report no. 41. SABONET, Pretoria. 1200pp.

GREEN, J. 1996. Spiders in biological control—an Australia perspective. *Revue Suisse de Zoologie* hors série 245-253.

GUNNARSSON, B. 1990. Vegetation structure and the abundance and size distribution of spruce-living spiders. *Journal of Animal Ecology* **59**: 743-752.

HADDAD, C.R. 2005. Ecology of spiders (Arachnida: Araneae) inhabiting *Themeda triandra* Forsskål grassland in semi-arid South Africa. *Navorsinge van die Nasionale Museum Bloemfontein* **21**: 25-36.

HADDAD, C.R. & DIPPENAAR-SCHOEMAN, A.S. 2002. The influence of mound structure on the diversity of spiders (Araneae) inhabiting the abandoned mounds of the snouted harvester termite *Trinervitermes trinervoides*. *Journal of Arachnology* **30**: 403-408.

HADDAD, C.R. & DIPPENAAR-SCHOEMAN, A.S. 2005. Epigeic spiders (Arachnida: Araneae) in Nama Karoo grassland in the Northern Cape Province. *Navorsinge van die Nasionale Museum Bloemfontein* **21**: 1-10.

HADDAD, C.R. & DIPPENAAR-SCHOEMAN, A.S. 2006. Spiders (Araneae) inhabiting abandoned mounds of the snouted harvester termite *Trinervitermes trinervoides* (Sjöstedt) (Isoptera: Termitidae: Nasutitermitinae) in the Free State, South Africa, with notes on their biology. *Navorsinge van die Nasionale Museum Bloemfontein* **22**: 1-15.

HARRIS, S. 2003. *Rhus ciliata* Licht. ex Schult. South African National Biodiversity Institute, Pretoria. Available online at: <http://www.plantzafrica.com/plantqrs/searsiaciliata.htm>.

HARWOOD, J.D., SUNDERLAND, K.D. & SYMONDSON, W.O.C. 2001. Living where the food is: web location by linyphiid spiders in relation to prey availability in winter wheat. *Journal of Applied Ecology* **38**: 88-99.

HATLEY, C.L. & MACMAHON, JA. 1980. Spider community organization: seasonal variation and the role of vegetation architecture. *Environmental Entomology* **9**: 632-639.

HAUGHTON, A.L., BELL, J.R., BOATMAN, N.D. & WILCOX, A. 1999. The effects of different rates of the herbicide glyphosate on spiders in arable field margins. *Journal of Arachnology* **27**: 249-254.

JOCQUÉ, R. & ALDERWEIRELDT, M. 2005. Lycosidae: the grassland spiders. *Acta Zoologica Bulgarica Supl.* **1**:125–130.

JÖGAR, K., METSPALU, L. & HIIESAAR, K. 2004. Abundance and dynamics of wolf spiders (Lycosidae) in different plant communities. *Agronomy Research* **2**: 145-152.

LANGLANDS, P.R., BRENNAN, K.E.C. & PEARSON, D.J. 2006. Spiders, spinifex, rainfall and fire: long-term changes in an arid spider assemblage. *Journal of Arid Environments* **67**: 36-59.

LOTZ, L.N., SEAMAN, M.T. & KOK, D.J. 1991. Surface-active spiders (Araneae) of a site in semi-arid central South Africa. *Navorsinge van die Nasionale Museum Bloemfontein* **7**: 530-540.

MAGURRAN, A.E. 1988. *Ecological diversity and its measurement*. Princeton University Press, New Jersey. 192pp.

MAGURRAN, A.E. 2004. *Measuring biological diversity*. Blackwell Publications, Bodmin. 256pp.

MCNETT, B. & RYPSTRA, A.L. 2000. Habitat selection in a large orb-weaving spider: vegetational complexity determines site selection and distribution. *Ecological Entomology* **25**: 423-432.

MEADOWS, M.E. 1985. *Biogeography and ecosystems of South Africa*. Juta & Co, Ltd., Cape Town. 165pp.

MELLET, M.A., SCHOEMAN, A.S. & DIPPENAAR-SCHOEMAN, A.S. 2006. Effect of Bt-cotton cultivation on spider (Arachnida: Araneae) populations near Marble Hall, Mpumalanga, South Africa. *African Plant Protection* **12**: 40–50.

- MGOBOZI, M.P., SOMERS, M.J & DIPPENAAR-SCHOEMAN, A.S. 2008. Spider responses to alien plant invasion: the effect of short- and long-term *Chromolaena odorata* invasion and management. *Journal of Applied Ecology* **45**: 1189-1197.
- MODIBA, M.A., DIPPENAAR, S.M. & DIPPENAAR-SCHOEMAN, A.S. 2005. A checklist of spiders from Sovenga Hill, an inselberg in the Savanna Biome, Limpopo Province, South Africa (Arachnida: Araneae). *Koedoe* **48**: 109-115.
- NIEMELÄ, J., PAJUNEN, T., HAILA, Y., PUNTTILA, P. & HALME, E. 1994. Seasonal activity of boreal forest-floor spiders (Araneae). *Journal of Arachnology* **22**: 23-31.
- ROMERO, G.O. & VASCONCELLOS-NETO, J. 2003. Natural history of *Misumenops argenteus* (Thomisidae): seasonality and diet on *Trichogoniopsis adenantha* (Asteraceae). *Journal of Arachnology* **31**: 297-304.
- ROMERO, G.O. & VASCONCELLOS-NETO, J. 2004. Foraging by the flower-dwelling spider *Misumenops argenteus* (Thomisidae), at high prey density sites. *Journal of Natural History* **38**: 1287-1296.
- RUTHERFORD, M.C. & WESTFALL, R.H. 1986. *Biomes of southern Africa: an objective categorization*. *Memoirs of the Botanical Survey of South Africa* **54**: 1-98.
- STERN, M. 2002. *Rhus lancea* L.f. South African National Biodiversity Institute, Pretoria. Available online at: <http://www.plantzafrica.com/plantqrs/rhuslancea.htm>.
- STUART, C. & STUART, T. 1997. *Guide to southern African game and nature reserves*. 4th edition. Struik Publishers, Cape Town. 360pp.
- TURNER, M. 1979. Diet and feeding phenology of the green lynx spider, *Peucetia viridans* (Araneae: Oxyopidae). *Journal of Arachnology* **7**: 149-154.
- UETZ, G.W. & BURGESS, J. 1979. Habitat structure and colonial behaviour in *Metepeira spinipes* (Araneae: Araneidae), an orb-weaving spider from Mexico. *Psyche* **86**: 79-90.

UYS, V.M. & URBAN, R.P. 2006. *How to collect and preserve insects and arachnids*. Plant Protection Research Institute Handbook no. 7. 2nd edition, ARC-Plant Protection Research Institute, Pretoria. 112pp.

VAN DEN BERG, A. & DIPPENAAR-SCHOEMAN, A.S. 1991. Ground-living spiders from an area where the harvester termite *Hodotermes mossambicus* occurs in South Africa. *Phytophylactica* **23**: 247-253.

VAN DEN BERG, A. & DIPPENAAR-SCHOEMAN, A.S. 1994. A revision of the Afrotropical species of the genus *Tibellus* Simon (Araneae: Philodromidae). *Koedoe* **37**: 67-114.

VAN ROOYEN, N. 2006. *Plantegroei van Suid-Afrika*. Pp.35-42. In: Bothma, J.D. (ed.) Wildsplasbestuur. Van Schaik Uitgewers, Paarl.

WARUI, C.M., VILLET, M.H., YOUNG, T.P. & JOCQUÉ, R. 2005. Influence of grazing by large mammals on the spider community of a Kenyan savanna biome. *Journal of Arachnology* **33**: 269-279.

WHITMORE, C., SLOTOW, R., CROUCH, T.E. & DIPPENAAR-SCHOEMAN, A.S. 2002. Diversity of spiders (Araneae) in a savanna reserve, Limpopo, South Africa. *Journal of Arachnology* **30**: 344-356.

CHAPTER 3

**The effects of controlled burning on the
diversity and abundance of ground-
dwelling spiders (Arachnida: Araneae)**

3.1. Abstract

Fire is used as a management strategy in conservation areas to maintain ecosystems. Fire frequencies as well as fire season effects are fairly well understood as a result of many studies that have been conducted on plant communities, but the impact of the extent of the area burned on larger animals, remains poorly understood. In September 2005, a project was started to determine the impact of controlled burning on various faunal groups in Erfenis Dam Nature Reserve near Theunissen in the Free State Province. The aim of the study was to determine the effect of controlled burning on ground-dwelling spider communities. Pitfall traps were set out at six different sites in the reserve, with three of the sites located in the burned area and the other three sites in the unburned area, to sample spiders over a twelve month period. A total of 5222 spiders were collected representing 33 families and 121 species. The dominant families in the burned sites were Gnaphosidae, Lycosidae, Caponiidae and Salticidae. The dominant families in the unburned sites were Gnaphosidae, Lycosidae, Amaurobiidae and Corinnidae. Monthly spider abundance and species richness were consistently lower in the burned grassland, suggesting that succession and colonisation processes are slow. Gnaphosidae and Lycosidae were present throughout the year in all six sites, indicating that they may be fire tolerant or are fast colonisers.

Key words: fire, pitfall traps, succession, colonisation, tolerant.

3.2. Introduction

Conservation biologists are increasingly recognising the importance of the invertebrate component in the functioning of healthy ecosystems. Therefore, any approach to conservation need to take into account the composition of these invertebrate fauna (Dippenaar-Schoeman & Leroy 2003) and the effect different disturbances may have on them.

Fire is viewed as an important disturbance event that opens up space and prevents community domination by one or a handful of species (Uys *et al.* 2006). Fire directly

affects plant growth, survival and reproduction of plants, as well as the dynamics of seedlings. It is also one of the disturbances that regularly kill mature plants, either on its own or in combination with other disturbances (Bond & Van Wilgen 1996). Thus, fire can be considered both a natural process and common management technique that can maintain the diversity in habitats where fire was previously present (Hartley *et al.* 2007). In savannah and grassland ecosystems burning is often the only practical alternative for the manipulation of large areas of vegetation. Grass fires reduce the fuel load of old grass that accumulates during the dry season, which promotes new growth for grazing (Uys *et al.* 2006). Because fire is effective in limiting woody plant intrusion it is also frequently utilised to maintain or improve open grasslands in combination with grazing (Lubin & Crouch 2003; Hartley *et al.* 2007).

Fire-prone grassland ecosystems in southern Africa are managed through a prescribed burning system based on a diverse fire regime that is comprised of three basic elements: frequency (how regularly fires occur), season (when fires occur) and intensity (how strongly they burn). In a conservation programme, it is traditionally a fixed prescribed burning system, where areas are divided into equal sized 'blocks' that are burned according to a schedule and under specified weather conditions. By using a technique known as patch mosaic burning procedure, ecological resilience can be encouraged, as well as the promotion of heterogeneity within a landscape by applying fires in a varied manner over successive seasons (Uys *et al.* 2006). Arthropods can be impacted directly by fire through differential mortality and changes in phenology. To coexist with fire arthropods have a number of adaptations, for example, avoidance in space (being able to flee or seek shelter) and escape in time. Even though there are such adaptations to fire, there may be considerable short-term declines of arthropod species locally even though fire may be necessary to maintain the habitat (Hartley *et al.* 2007). Indirectly, fire may influence arthropod communities by changing the environmental conditions or altering the plant community. When fire or other factors impact the plant community by changing environmental conditions, the arthropod community will also be affected because of their sensitivity to changes in vegetation composition, structure and quality. Fire also has the ability to increase the overall net primary productivity, increase plant

species richness and can also alter plant tissue quality, structure and growth. If there are changes in the abiotic factors it may cascade up the food chain to influence not only the plants and herbivores, but also the higher trophic levels, such as predators and parasites, as well (Hartley *et al.* 2007). According to Friend (1995) Araneae appeared to be a very promising indicator group to use in fire ecology studies across a broad range of habitats.

Fire frequency as well as fire season effects on vegetation is fairly well understood, but the impact of the extent of the area burned on fauna remains poorly understood (Uys *et al.* 2006). In September 2005, a project was initiated to determine the arachnofauna of the Erfenis Dam Nature Reserve, located near Theunissen in the Free State Province. The focus of the project was to determine the impact of controlled burning on various faunal groups, which included arachnids, insects and small mammals, but the aim of this particular study was to determine the effect of controlled burning on ground-dwelling spider communities in the reserve. Cursorial or wandering spiders have been the subject of several ecological studies over the last few years. These spiders have been recognised by many arachnologists as a distinct group, moving actively over the ground, running down or pouncing on their prey instead of relying on the use of webs (Uetz & Unzicker 1976).

The study is a part of SANSA (South African National Survey of Arachnida), which is a national project that involves determining the diversity of arachnids in the different biomes, conservation areas, agro-ecosystems and provinces of South Africa (Dippenaar-Schoeman & Craemer 2000).

3.3. Material and methods

3.3.1. Study area: The Erfenis Dam Nature Reserve is located in the central part of the Free State Province, a few kilometers east of Theunissen. The dam is located in the Vet River catchment, with the reserve comprising of about 400 ha of grassland (Stuart & Stuart 1997).

3.3.2. Sampling method: Pitfall trapping is used extensively to study the occurrence, abundance and activity densities of surface-active arthropods. The advantages of using pitfall traps are that they are inexpensive, there is little effort to set them, and many species can be trapped, resulting often in large catches (depending on the duration of the sampling). Pitfall trapping can also be used to sample continuously if needed, and are therefore not prone to the problems of spot sampling in time. Results of this type of sampling have been used to describe phenology, estimate abundance, elucidate diurnal activity cycles, and to compare species assemblages (Topping & Sunderland 1992).

Table 1. The six sites and their coordinates where ten pitfall traps were set out for a study which started in September 2005 till October 2006 in Erfenis Dam Nature Reserve, Free State Province.

Site	Code	Coordinates
Burned site 1	B-1	28°30.373'S, 26°48.437'E
Burned site 2	B-2	28°30.134'S, 26°48.427'E
Burned site 3	B-3	28°29.990'S, 26°48.486'E
Unburned site 1	U-1	28°29.888'S, 26°48.488'E
Unburned site 2	U-2	28°29.706'S, 26°48.281'E
Unburned site 3	U-3	28°29.741'S, 26°48.065'E

Ten pitfall traps (8 cm diameter) was set out in six different sites in the reserve, with three of the sites located in the burned area and the other three sites in the unburned area (Table 1). Sites are referred to hereafter by their codes. B-1 and B-3 were located 50 m from the western and eastern fire margins respectively, and all three burned sites set 50 m from the southern fire margin. U-1 was placed 50 m east of the eastern fire margin, while U-2 and U-3 were located on the opposite side of the dam (Fig. 1). Traps were arranged in a 5x2 grid, with 5 m separating each trap. The traps were buried level with the upper ground surface, and 100 ml of ethanediol was added as a preservative. The traps were left exposed in the open grasslands for 30 days before being emptied (in February 2006 some of the pitfalls were lost in B-2). The spiders caught in the traps were then sorted from the collected material and preserved in 70 % ethanol, after which they were

identified to family level and morphospecies and tallied. Morphospecies (adult specimens) were identified further to genus and species level by Dr. Ansie Dippenaar-Schoeman (ARC-Plant Protection Research Institute, Pretoria), Charles Haddad (University of the Free State, Bloemfontein) and Dr. Wanda Wesolowska (Wroclaw University, Poland) (Table 2).



Fig. 1. The six sites in Erfenis Dam Nature Reserve representing three burned sites and three unburned sites. B-1 to B-3 were located 50 m from the western and eastern margins of the fire (in red), as well as 50 m from the southern fire margin. U-1 was 50 m east of the eastern fire margin, while U-2 and U-3 were located on the opposite side of the dam (in orange) (image from Google Earth).

3.3.3. Statistics: All data were entered into Microsoft Excel 2003, from which data were analysed and resulting graphs drawn. Similarity in species composition of the three burned and three unburned sites types were calculated with Sørensen's quotient of

similarity. This index is represented by the equation $QS = 2j / (a + b)$, where a and b are the number of species in two habitats and j the number of species common to both samples (Magurran 1988). A high value (closer to 1) indicates a more similar fauna at site A compared to site B, while a lower value indicates a more unique fauna at each site. Species richness was used to compare the species composition in three burned and three unburned sites, and was calculated as the number of species collected at a site divided by the total number of species collected in the study.

The species accumulation curves were drawn for monthly site species richness from data that were entered into Microsoft Excel 2003. It is possible to extrapolate the accumulation curve when the curves represent samples taken in a systematic way, being restricted to areas of reasonably homogenous habitat (Magurran 2004). Species richness can be estimated by the following calculation: $Schao_1 = S_{obs} + F_1^2 / 2F_2$. $Chao_1$ is based on the available abundance data, and is a function of the ratio between the singletons and doubletons in the data. It reaches an asymptote when each species is represented by at least two individuals. Thus, F_1 equals the number of observed species represented by one individual and F_2 equals the number of observed species represented by two individuals (Magurran 2004).

Differences in species richness and abundance between the three burned as well as the three unburned sites were compared using repeated measures ANOVA (pooled data of the ten pitfall traps per site). The second set of ANOVA tests analysed the traps individually for differences in species richness and abundance between the three burned and three unburned sites. Unpaired t-tests with Welch correction were calculated to determine the differences in monthly abundance and species richness between the 3 burned and 3 unburned sites (data pooled and individually interposed). All calculations were done in GraphPad Instat.

3.4. Results

The guild classification of spiders follows Dippenaar-Schoeman *et al.* (1999) and Foord *et al.* (2002), which is summarised in Table 1 in Chapter 2.

During the twelve month period a total of 5222 spiders were collected by pitfall trapping, representing 33 families and 121 species (Table 2).

Species accumulation was higher in the unburned sites than in the burned sites, except in B-1. In B-1, species accumulation was higher than in U-1 until March 2006, where the accumulation rate became the same. In May 2006, B-1's accumulation rate increased until it had the same amount of species than U-2 (Fig. 2 & Table 3). The rate of accumulation of B-2 and B-3 stayed comparatively low over the period of twelve months (Fig. 2).

Species accumulation in U-3 began lowest in October 2005, but the rate increased substantially in November 2005. From there, it had the highest accumulation rate until September 2006, where it had the second highest species richness of all the sites (Fig. 2 & Table 3).

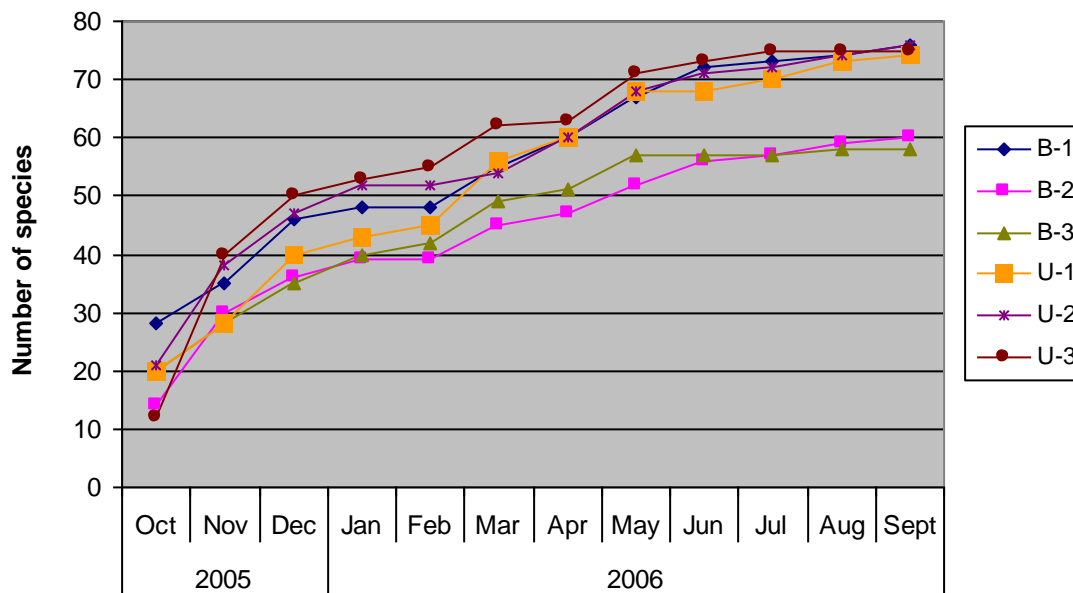


Fig. 2. The species accumulation curve of spider species captured by pitfall trapping in Erfenis Dam Nature Reserve, Free State Province from October 2005 to September 2006. Abbreviations: see Table 1.

Table 2. Species diversity and abundance of spiders collected from six sites (three burned sites and three unburned sites) in Erfenis Dam Nature Reserve in the Free State Province from October 2005 until September 2006. Abbreviations: site abbreviations see Table 1, †- new species, ? – Dubious identification.

FAMILY /SPECIES	Guilds	B-1	B-2	B-3	U-1	U-2	U-3	Total	% of total
AGELENIDAE									
<i>Benoitia ocellata</i> (Pocock, 1900)	FWB	0	0	0	0	0	1	1	0.02
AMAUROBIIDAE									
<i>Macrobunus caffer</i> (Simon, 1898)?	FWB	16	14	3	1	19	18	71	1.36
<i>Obatala</i> sp. 1	FWB	28	4	5	48	73	96	254	4.86
<i>Obatala</i> sp. 2	FWB	11	1	5	5	28	7	57	1.09
<i>Pseudauximus</i> sp. 1	FWB	3	3	8	12	15	8	49	0.94
AMMOXENIDAE									
<i>Ammoxenus amthalodes</i> Dippenaar & Meyer, 1980	FGW	160	6	1	2	2	744	915	17.52
ARANEIDAE									
<i>Hypsosinga lithyphantoides</i> Caporiacco, 1947	OWB	1	0	0	0	1	0	2	0.04
<i>Kilima decens</i> (Blackwall, 1866)	OWB	2	3	6	1	4	1	17	0.33
<i>Neoscona moreli</i> (Vinson, 1863)	OWB	0	1	0	0	0	0	1	0.02
<i>Pararaneus cyrtoscapus</i> (Pocock, 1898)?	OWB	0	0	1	0	0	0	1	0.02

ATYPIDAE

<i>Calommata</i> sp. 1†	BGW	1	5	0	1	0	1	8	0.15
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CAPONIIDAE

<i>Caponia hastifera</i> Purcell, 1904	FGW	37	31	42	49	8	5	172	3.29
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CORINNIDAE

<i>Cambalida fulvipes</i> (Simon, 1896)	FWG	1	0	0	3	1	0	5	0.10
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<i>Graptartia mutillica</i> Haddad, 2004	FWG	3	1	7	2	6	4	23	0.44
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<i>Orthobula</i> sp. 1†	FWG	17	6	45	56	47	30	201	3.85
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<i>Poachelas striatus</i> Haddad & Lyle, 2008	FWG	0	0	0	0	1	0	1	0.02
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<i>Thysanina absolve</i> Lyle & Haddad, 2006	FWG	1	0	0	0	1	2	4	0.08
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CTENIDAE

<i>Anahita</i> sp. 1	FGW	2	3	2	1	3	1	12	0.23
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CTENIZIDAE

<i>Stasimopus oculatus</i> Pocock, 1897	BGW	3	2	6	2	0	3	16	0.31
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<i>Stasimopus</i> sp. 2	BGW	5	1	0	2	2	1	11	0.21
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CYRTAUCHENIIDAE

<i>Ancylotrypa nigriceps</i> (Purcell, 1902)	BGW	0	0	4	1	0	2	7	0.13
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<i>Ancylotrypa pretoriae</i> (Hewitt, 1913)	BGW	2	2	0	10	1	13	28	0.54
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<i>Ancylotrypa</i> sp. 3	BGW	0	0	3	5	5	0	13	0.25
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ERESIDAE

<i>Dresserus kannemeyeri</i> Tucker, 1920	SHWB	0	2	0	0	2	1	5	0.10
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GNAPHOSIDAE

<i>Amusia</i> sp. 1	FGW	19	12	15	11	27	16	100	1.91
<i>Camillina cordifera</i> (Tullgren, 1910)	FGW	0	2	1	0	4	3	10	0.19
<i>Drassodes splendens</i> Tucker, 1923	FGW	23	5	25	6	18	46	123	2.35
<i>Drassodes stationis</i> Tucker, 1923	FGW	1	0	0	0	0	4	5	0.10
<i>Echemus</i> sp. 1	FGW	4	1	0	4	1	2	12	0.23
<i>Micaria</i> sp. 1	FGW	0	0	0	2	1	4	7	0.13
<i>Pterotricha varia</i> (Tucker, 1923)	FGW	1	0	0	1	0	3	5	0.10
<i>Setaphis subtilis</i> (Simon, 1897)	FGW	37	22	34	49	24	33	199	3.81
<i>Trachyzelotes</i> sp. 1	FGW	0	0	0	1	0	0	1	0.02
<i>Trephopoda</i> sp. 1	FGW	1	0	0	1	0	1	3	0.06
<i>Upognampa aplanita</i> Tucker, 1923	FGW	0	0	0	1	0	0	1	0.02
<i>Xerophaeus aridus</i> Purcell, 1907	FGW	3	2	0	0	0	1	6	0.11
<i>Zelotes frenchi</i> Tucker, 1923	FGW	26	17	18	34	29	35	159	3.04
<i>Zelotes fuligineus</i> (Purcell, 1907)	FGW	0	1	0	3	3	4	11	0.21
<i>Zelotes scrutatus</i> (O. P.-Cambridge, 1872)	FGW	22	4	6	32	44	31	139	2.66
<i>Zelotes zonognathus</i> (Purcell, 1907)	FGW	2	1	0	1	3	2	9	0.17
<i>Zelotes</i> sp. 5	FGW	1	0	0	1	0	0	2	0.04
<i>Zelotes</i> sp. 6	FGW	7	1	0	0	0	0	8	0.15
<i>Zelotes</i> sp. 7	FGW	5	10	3	3	8	5	34	0.65

HAHNIIDAE

<i>Hahn timer tabulicola</i> Simon, 1898	SHWB	0	0	0	0	1	0	1	0.02
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HERSILIIDAE

<i>Tyrotama australis</i> (Simon, 1893)	FPW	0	0	0	0	0	6	6	0.11
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IDIOPIDAE

<i>Galeosoma</i> sp. 1	BGW	0	1	0	0	2	0	3	0.06
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<i>Segregara monticola</i> Hewitt, 1916	BGW	0	0	0	0	1	0	1	0.02
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LINYPHIIDAE

<i>Meioneta habra</i> Locket, 1968	SHWB	3	5	9	8	20	9	54	1.03
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<i>Meioneta</i> sp. 2	SHWB	0	1	3	0	6	0	10	0.19
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<i>Metaleptyphantes familiaris</i> Jocqué, 1984	SHWB	18	9	2	12	19	7	67	1.28
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<i>Ostearius melanopygius</i> (O. P.-Cambridge, 1879)	SHWB	1	3	0	0	4	0	8	0.15
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<i>Pelecopsis janus</i> Jocqué, 1984	SHWB	1	1	0	1	8	0	11	0.21
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Linyphiidae sp. 1	SHWB	0	0	1	1	0	1	3	0.06
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Linyphiidae sp. 2	SHWB	0	0	0	0	1	0	1	0.02
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Linyphiidae sp. 3	SHWB	0	0	0	0	1	0	1	0.02
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LIOCRANIDAE

<i>Rhaeboctesis secundus</i> Tucker, 1920	FGW	1	12	3	16	6	3	41	0.78
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<i>Rhaeboctesis</i> sp. 2	FGW	10	12	10	21	4	11	68	1.30
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LYCOSIDAE

<i>Allocosa tuberculipalpa</i> (Caporiacco, 1940)?	FGW	0	0	0	0	1	0	1	0.02
<i>Amblyothele albocincta</i> Simon, 1910	FGW	0	1	0	1	0	1	3	0.06
<i>Evippomma squamulatum</i> (Simon, 1898)	FGW	15	5	9	24	2	41	96	1.84
Lycosinae sp. 1	FGW	66	79	32	27	14	7	225	4.31
Lycosinae sp. 2	FGW	4	2	5	2	10	9	32	0.61
Pardosinae sp. 1	FGW	3	0	0	0	1	2	6	0.11
<i>Pardosa crassipalpis</i> Purcell, 1903	FGW	1	4	2	1	16	29	53	1.01
<i>Proevippa</i> sp. 1†	FGW	0	0	1	1	0	0	2	0.04
<i>Proevippa</i> sp. 2	FGW	134	38	157	62	95	302	788	15.09
<i>Proevippa</i> sp. 3	FGW	4	5	2	4	9	13	37	0.71
<i>Zenonina</i> sp. 1	FGW	4	1	2	2	0	5	14	0.27

MIMETIDAE

<i>Ero</i> sp. 1	FGW	0	0	0	0	0	1	1	0.02
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MITURGIDAE

<i>Cheiramiona florisbadensis</i> Lotz, 2003	FPW	11	8	4	0	1	0	24	0.46
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ORSOLOBIDAE

<i>Afrilobus</i> sp. 1	FGW	0	0	1	0	0	0	1	0.02
<i>Azania lobus</i> sp. 1†	FGW	8	0	9	12	1	13	43	0.82

OXYOPIDAE

<i>Oxyopes</i> sp. 1	FPW	0	0	0	0	0	1	1	0.02
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PALPIMANIDAE

<i>Palpimanus</i> sp. 1	FGW	10	9	13	9	2	5	48	0.92
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PHILODROMIDAE

<i>Suemus</i> sp. 1?	FGW	0	4	1	1	3	5	14	0.27
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<i>Suemus</i> sp. 2?	FGW	2	0	0	0	3	2	7	0.13
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<i>Thanatus vulgaris</i> Simon, 1870	FGW	0	0	0	0	0	2	2	0.04
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<i>Tibellus minor</i> Lessert, 1919	FGW	0	0	0	1	1	0	2	0.04
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PHYXELIDIDAE

<i>Vidole sothoana</i> Griswold, 1990	FWB	5	0	0	0	6	10	21	0.40
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PISAUROIDAE

<i>Euprostenops</i> sp. 1	FWB	0	0	0	1	0	1	2	0.04
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PRODIDOMIDAE

<i>Theuma capensis</i> Purcell, 1907	FGW	1	0	0	0	0	0	1	0.02
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<i>Theuma fusca</i> Purcell, 1907	FGW	2	3	2	0	6	1	14	0.27
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<i>Theuma schreineri</i> Purcell, 1907	FGW	0	2	0	0	0	0	2	0.04
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SALTICIDAE

<i>Evarcha</i> sp. 1†	FGW	0	0	0	3	0	0	3	0.06
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<i>Nigorella hirsuta</i> Wesolowska, 2009	FGW	4	0	0	1	0	1	6	0.11
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<i>Pellenes bulawaysoensis</i> Wesolowska, 1999	FGW	0	0	1	0	1	1	3	0.06
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<i>Pellenes geniculatus</i> (Simon, 1868)	FGW	2	0	1	1	0	3	7	0.13
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<i>Pellenes tharinae</i> Wesolowska, 2006	FGW	4	10	2	3	1	15	35	0.67
<i>Pellenes</i> sp. 4†	FGW	0	0	0	0	0	1	1	0.02
<i>Phlegra bresnieri</i> (Lucas, 1846)	FGW	3	1	0	3	0	0	7	0.13
<i>Phlegra karoo</i> Wesolowska, 2006	FGW	19	12	10	34	16	7	98	1.88
<i>Phlegra</i> sp. 3†	FGW	17	8	13	21	10	9	78	1.49
<i>Pignus</i> sp. 1†	FGW	0	1	0	0	0	0	1	0.02
<i>Tanzania</i> sp. 1†	FGW	0	0	0	1	0	0	1	0.02
SCYTODIDAE									
<i>Scytodes</i> sp. 1	FGW	8	4	8	19	13	8	60	1.15
THERIDIIDAE									
<i>Anelosimus</i> sp. 1	GWB	1	0	0	0	0	0	1	0.02
<i>Coscinida</i> sp. 1	GWB	4	0	0	0	0	0	4	0.08
<i>Enoplognatha molesta</i> O. P.-Cambridge, 1904?	GWB	1	0	2	0	1	0	4	0.08
<i>Enoplognatha</i> sp. 2	GWB	9	0	0	0	1	0	10	0.19
<i>Euryopsis</i> sp. 1	GWB	3	7	3	11	3	9	36	0.69
<i>Euryopsis</i> sp. 2	GWB	0	0	0	2	0	0	2	0.04
<i>Euryopsis</i> sp. 3	GWB	0	0	0	2	0	0	2	0.04
<i>Steatoda capensis</i> Hann, 1990	GWB	1	1	0	0	0	0	2	0.04
<i>Steatoda</i> sp. 2	GWB	5	5	1	8	8	3	30	0.57
<i>Steatoda</i> sp. 3	GWB	0	0	4	0	0	1	5	0.10
<i>Theridion</i> sp. 1	GWB	0	0	0	1	0	0	1	0.02
Theridiidae sp. 1	GWB	1	0	0	0	0	0	1	0.02

Theridiosomatidae

Theridiosomatidae sp. 1	OWB	0	0	0	8	3	0	11	0.21
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Thomisidae

<i>Heriaeus buffoni</i> (Audouin, 1826)?	FGW	1	0	0	1	2	4	8	0.15
<i>Monaeses quadrituberculatus</i> Lawrence, 1927	FPW	3	0	0	0	0	0	3	0.06
<i>Stiphropus affinis</i> Lessert, 1923	FPW	0	1	0	4	1	0	6	0.11
<i>Xysticus natalensis</i> Lawrence, 1938	FGW	9	5	6	3	14	1	38	0.73
<i>Xysticus urbensis</i> Lawrence, 1952	FGW	10	1	13	7	1	0	32	0.61

Zodariidae

<i>Akyttara</i> sp. 1†	FGW	0	0	0	0	0	1	1	0.02
<i>Cydrela</i> sp. 1	FGW	1	0	0	0	0	0	1	0.02
<i>Cydrela</i> sp. 2	FGW	1	1	3	0	18	3	26	0.50
<i>Diores femoralis</i> Jocqué, 1990	FGW	15	27	53	45	2	16	158	3.03
<i>Diores poweri</i> Tucker, 1920	FGW	2	0	0	0	0	0	2	0.04
<i>Diores</i> sp. 3	FGW	0	0	2	1	0	0	3	0.06
<i>Palfuria</i> sp. 1	FGW	4	1	1	1	12	82	101	1.93
<i>Ranops</i> sp. 1†	FGW	1	0	0	1	1	9	12	0.23

TOTAL		877	453	631	739	733	1789	5222	100.00
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Species diversity and species richness of B-1 was similar to that of the unburned sites. B-2 and B-3 had lower species diversity than the unburned sites, which was to be expected, as the fire caused disturbance in those areas. The largest number of uniquely collected species was collected in B-1, U-1 and U-3, while the fewest unique species was found in B-2 and B-3 (Table 3).

Table 3. Species diversity and richness of ground-dwelling spiders captured by pitfall trapping in Erfenis Dam Nature Reserve, Free State Province. Abbreviations: see Table 1.

Sites	Total species	Species richness	<i>Chao</i> est. sp. Richness	Unique species
B-1	76	0.628	103.56	7
B-2	60	0.496	88.57	3
B-3	58	0.479	64.72	2
U-1	74	0.612	114.50	7
U-2	76	0.628	109.06	6
U-3	75	0.620	130.13	7
Total species	121	-	-	-
Total unique species	32	-	-	-

Sørensen's Quotient values for all site comparisons were greater than 0.67, which indicates that the sites had a relatively homogenous fauna. B-2 and B-3 had the lowest similarity of the sites. The sites that showed the greatest similarity were the following: B-1 and B-2; B-2 and U-2; and U-1 and U-3 (Table 4). This indicates that burning does not necessarily result in major shifts in assemblage composition of spiders.

Table 4. Sørensen's Quotient values for combinations of spider species richness collected by pitfall trapping in three burned and three unburned sites in Erfenis Dam Nature Reserve, Free State Province. Abbreviations: see Table 1.

Sites	B-1	B-2	B-3	U-1	U-2	U-3
B-1	-	0.779	0.672	0.733	0.750	0.768
B-2		-	0.763	0.746	0.779	0.756
B-3			-	0.712	0.701	0.707
U-1				-	0.707	0.779
U-2					-	0.728

Species abundance differed significantly between the three burned sites ($P=0.0165$) and the three unburned sites ($P=0.002$). Species richness did not differ significantly between the three burned sites ($P=0.1775$) and the three unburned sites ($P=0.9189$) (monthly site data pooled).

There was a difference in abundance in October 2005 in both the burned and unburned sites. In November 2005, there was a very significant difference in abundance. From January to June, there was no significance in abundance, but from July there were once again significant differences in abundance. In February 2006 some of the pitfalls were lost in B-2, thus the data in this month is incomplete. In the unburned sites, the greatest significance was in June and September 2006 (Table 5). The greatest significant monthly differences in species richness between the burned sites are in February and July 2006. Differences in species richness between the unburned sites were generally not significant (Table 5).

Table 5. ANOVA tests of differences in monthly abundance and species richness of ground-dwelling spiders between three sites of burned and three sites of unburned grassland in the Erfenis Dam Nature Reserve sampled by pitfall trapping between October 2005 and September 2006. Abbreviations: ns – not significant; * - significance of P value.

Month	Abundance		Species richness	
	Burned	Unburned	Burned	Unburned
October 2005	$P=0.0427^*$	$P=0.0289^*$	$P=0.975$ ns	$P=0.091^*$
November 2005	$P<0.0001^{***}$	$P=0.0021^*$	$P=0.0636$ ns	$P=0.2199$ ns
December 2005	$P=0.0032^*$	$P=0.0020^*$	$P=0.077^*$	$P=0.0891$ ns
January 2006	$P=0.2937$ ns	$P=0.0256^*$	$P=0.3620$ ns	$P=0.1016$ ns
February 2006	$P=0.0002^{***}$	$P=0.2396$ ns	$P=0.0007^{***}$	$P=0.2078$ ns
March 2006	$P=0.1966$ ns	$P=0.0055^*$	$P=0.3967$ ns	$P=0.0083^*$
April 2006	$P=0.2993$ ns	$P=0.0233^*$	$P=0.2541$ ns	$P=0.0135^*$
May 2006	$P=0.3719$ ns	$P=0.5910$ ns	$P=0.6081$ ns	$P=0.8611$ ns
June 2006	$P=0.1410$ ns	$P<0.0001^{***}$	$P=0.0975$ ns	$P=0.0091^*$
July 2006	$P=0.005^{***}$	$P=0.0594$ ns	$P=0.005^{***}$	$P=0.0767$ ns
Augustus 2006	$P=0.0092^*$	$P=0.0123^*$	$P=0.0280^*$	$P=0.7431$ ns
September 2006	$P=0.0017^*$	$P<0.0001^{***}$	$P=0.0200^*$	$P=0.0690$ ns

Controlled burning has a significant negative influence on the monthly abundance ($P=0.038$) and species richness ($P=0.0165$) of ground spiders when data from the burned and unburned are pooled.

When individual pitfall data are considered, there are significant differences in abundance between the burned and unburned sites in seven of the twelve months, with one very significant difference in May 2006 (Table 6). There are significant differences in species richness in only five of the twelve months (Table 6).

Table 6. Unpaired t-tests with Welch correction of differences in monthly abundance and species richness of ground-dwelling spiders between 30 burned versus 30 unburned sites in grassland in the Erfenis Dam Nature Reserve, sampled by pitfall trapping between October 2005 and September 2006. Abbreviations: ns – not significant; * - significance of *P* value; df – degrees of freedom.

Month	Abundance	Species richness
October 2005	<i>P</i> =0.9780 ns, df 56	<i>P</i> =0.0955 ns, df 53
November 2005	<i>P</i> =0.0133*, df 39	<i>P</i> =0.0054*, df 46
December 2005	<i>P</i> =0.0017*, df 39	<i>P</i> =0.0037*, df 57
January 2006	<i>P</i> =0.0323*, df 31	<i>P</i> =0.3143 ns, df 57
February 2006	<i>P</i> =0.0179*, df 38	<i>P</i> =0.0056*, df 41
March 2006	<i>P</i> =0.2046 ns, df 57	<i>P</i> =0.0115*, df 56
April 2006	<i>P</i> =0.2212 ns, df 44	<i>P</i> =0.5645 ns, df 52
May 2006	<i>P</i> <0.0004***, df 57	<i>P</i> =0.0024*, df 55
June 2006	<i>P</i> =0.0020*, df 36	<i>P</i> =0.0955 ns, df 53
July 2006	<i>P</i> =0.7553 ns, df 57	<i>P</i> =0.2424 ns df 57
August 2006	<i>P</i> =0.0413*, df 39	<i>P</i> =0.0587 ns df 51
September 2006	<i>P</i> =0.0352*, df 41	<i>P</i> =0.0779 ns df 57

Lycosidae and Gnaphosidae were present in all three burned sites throughout most of the year (Figs 3a-c). Lycosidae, Ammoxenidae, Gnaphosidae, Amaurobiidae and Salticidae were the five dominant families in B-1. Ammoxenidae were present throughout the year, absent only in September 2006. Amaurobiidae were very dominant from May to July 2006, but were absent through most of the year (Fig. 3a). Zodariidae and Caponiidae replaced Ammoxenidae and Amaurobiidae as the dominant families in B-2. Lycosidae, Gnaphosidae and Salticidae were present throughout most of the year, with Zodariidae being strongly dominant in May, June and August. Caponiidae were very dominant in October, December and January, and were then absent until June and August 2006 (Fig. 3b). Corinnidae replaces Salticidae as one of the dominant families in B-3. Lycosidae were present in great numbers in March 2006. Corinnidae were present throughout the year except in the winter months. Zodariidae were absent only in October and September (Fig. 3c).

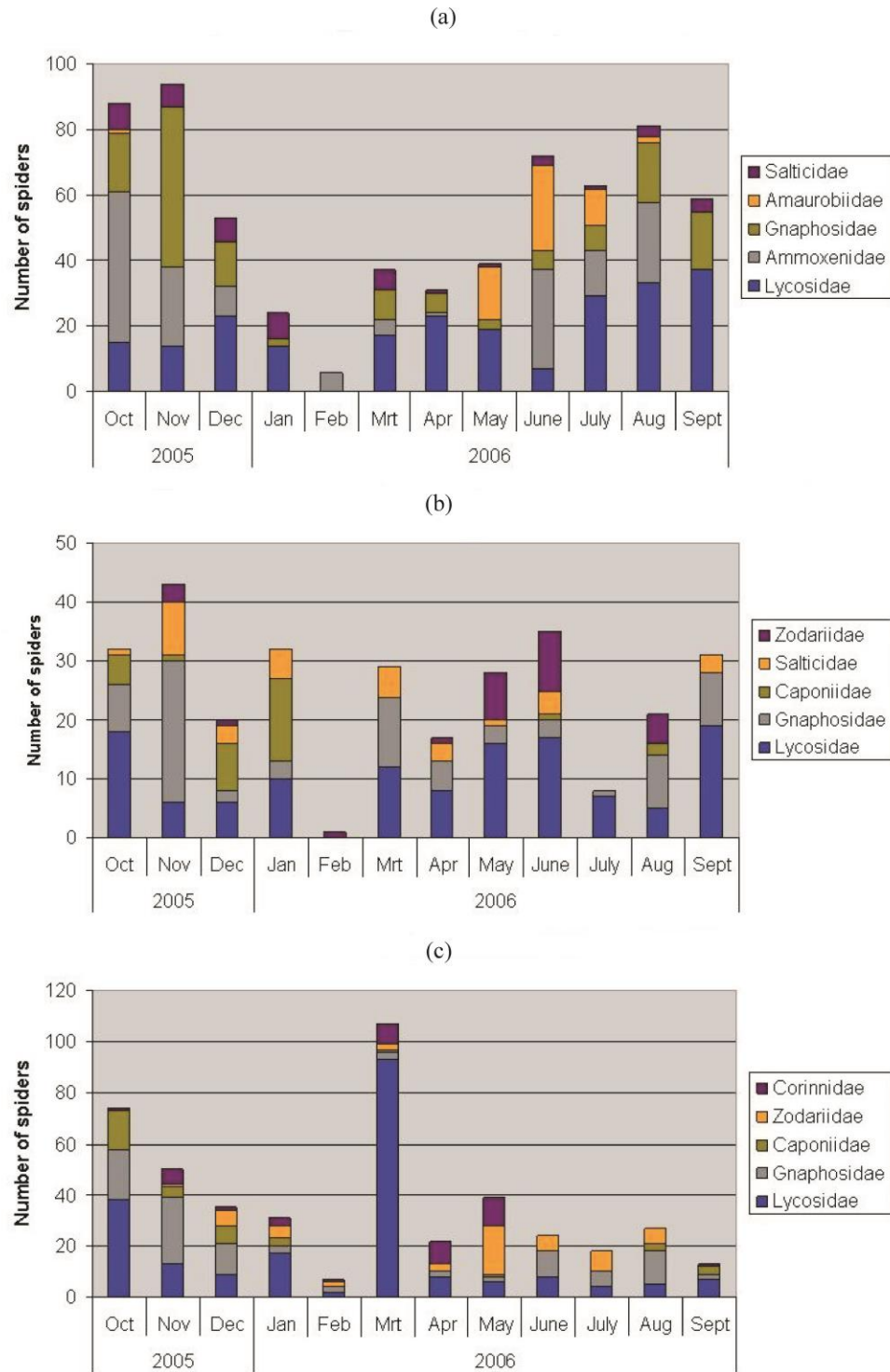


Fig. 3. The five dominant spider families that were collected at (a) B-1, (b) B-2 and (c) B-3, by pitfall trapping in Erfenis Dam Nature Reserve, Free State Province. Abbreviations: see Table 1.

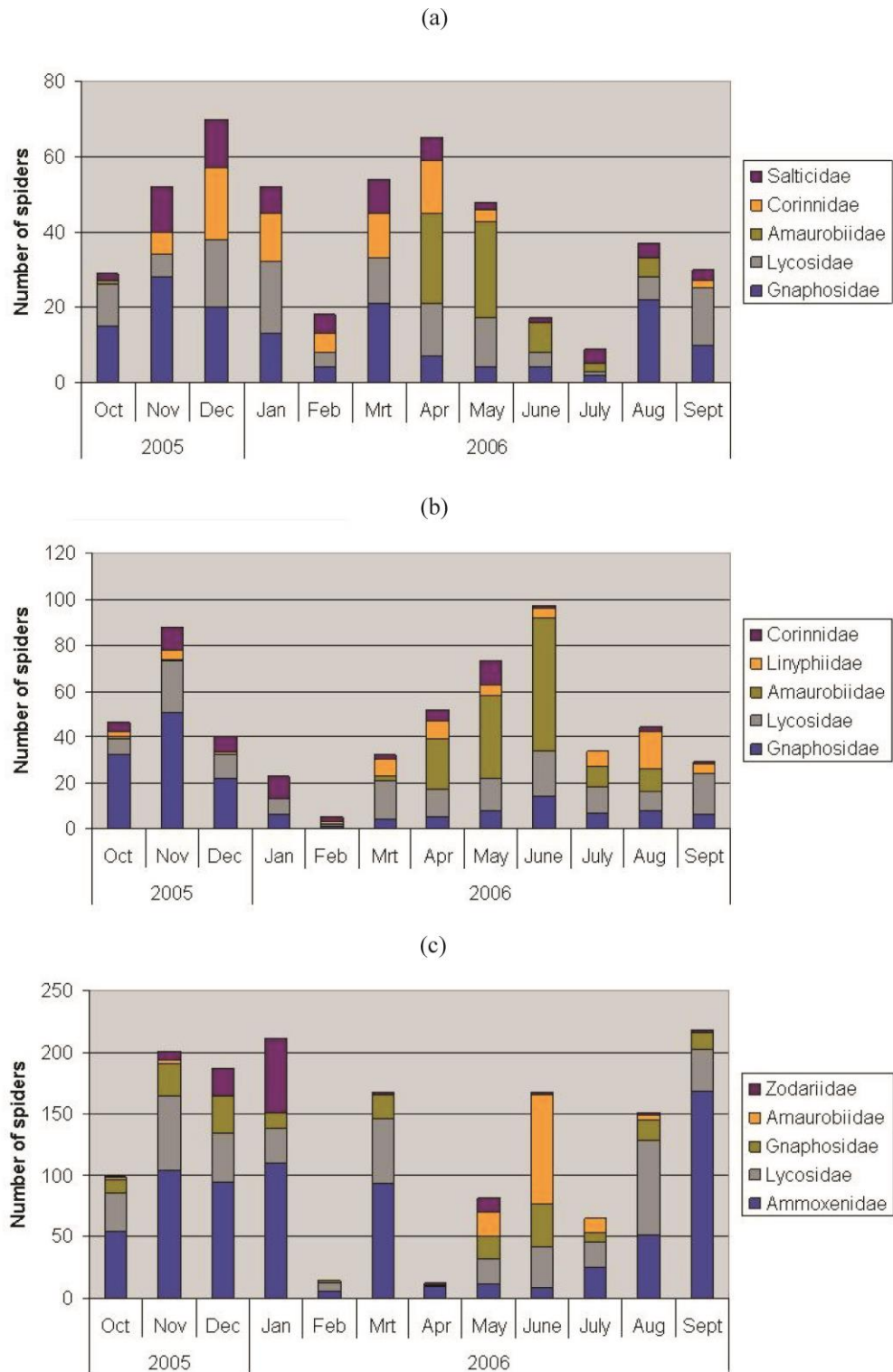


Fig. 4. The five dominant spider families that were collected at (a) U-1, (b) U-2 and (c) U-3, by pitfall trapping in Erfenis Dam Nature Reserve, Free State Province. Abbreviations: see Table 1.

Salticidae, Corinnidae, Amaurobiidae, Lycosidae and Gnaphosidae were the dominant families in U-1. Amaurobiidae was strongly dominant from April to August, while Corinnidae was dominant from November to May (Fig. 4a). Linyphiidae were a dominant family in U-2. This family consists of sheet-web builders and, apart from Amaurobiidae (retreat-web builders), the only web-building family that was abundant at one of the six sites. Linyphiidae were absent in January and February. Amaurobiidae were very dominant from March to August, while Corinnidae, Gnaphosidae and Lycosidae occur almost throughout the year (Fig. 4b). Zodariidae and Ammoxenidae, together with Amaurobiidae, Lycosidae and Gnaphosidae, were the dominant families in U-3. Zodariidae were strongly dominant in December and January, with Amaurobiidae dominant from May to July. Ammoxenidae were present throughout the year (Fig. 4c).

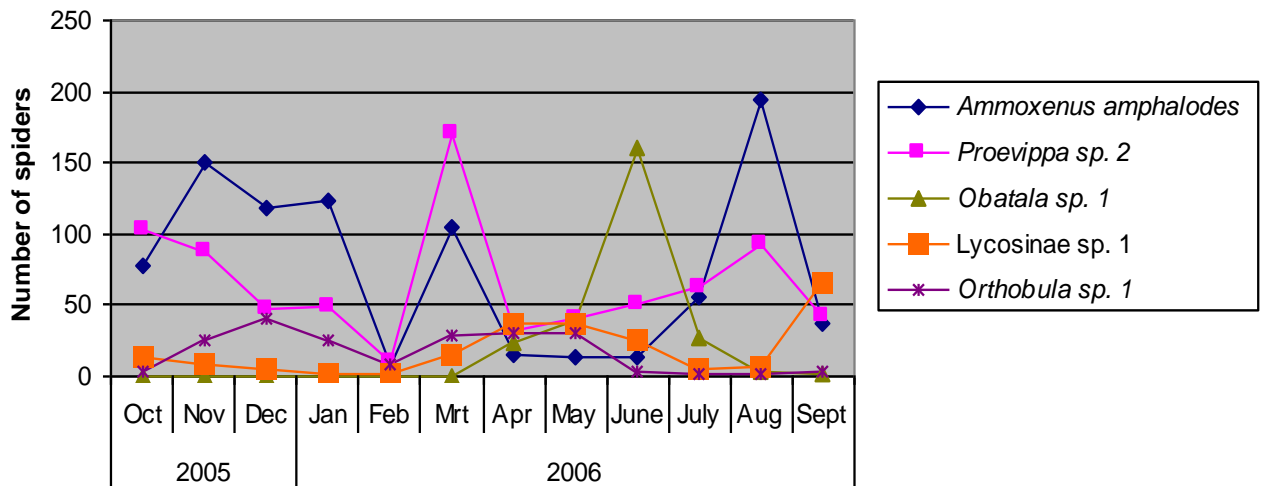


Fig. 5. Phenology of the dominant spider species that were collected by pitfall trapping in Erfenis Dam Nature Reserve, Free State Province (pooled data of six sites).

Ammoxenus amphalodes belongs to the family Ammoxenidae and was the most abundant species (17.52 % of total). This species was abundant till February, decreased in autumn and early winter, and from July the number increased again until a drop in September. *Proevippa sp. 2* (Lycosidae) was most abundant in March and *Obatala sp. 1* (Amaurobiidae) peaked in

June. *Lycosinae* sp. 1 (Lycosidae) was abundant from March to July, with an increase in September. *Orthobula* sp. 1 (Corinnidae) was abundant throughout the year but declined in winter (Fig. 5).

3.5. Discussion

3.5.1. Limitations of pitfall traps: Pitfall trapping does, like all other sampling methods, have its limitations. It has limited value in providing absolute estimates of spider's abundance, as the capture efficiency is affected by many factors like abundance and activity of individual species (Topping & Sunderland 1992; Holland & Smith 1999). Some taxa can be overestimated while other taxa can be underestimated (Lang 2000). Pitfall size catches may be influenced by differences in vegetation cover. Thus, lower catches may be found in denser vegetation than in more open ground (Melbourne 1999). Pitfalls can be trampled by large animals such as cattle (Oxbrough *et al.* 2006), or may be lost after long periods of exposure to the elements (some pitfall traps were lost in site B-2 during February 2006 following heavy rainfall).

3.5.2. Effect of burning on spider diversity in grasslands: Burning is viewed as critical for grassland restoration because it suppresses dominant plant competitors, eliminates litter and modifies resource availability (even though its impacts could be mimicked by other disturbances such as mowing or weeding that suppress the dominants but without some of the risks involved in burning) (MacDougall & Turkington 2007). According to Uys *et al.* (2006) the distance from the edge of a burn has an immediate (of about two weeks) post-burn impact on the species richness, abundance and community structure of invertebrates. There are uncertainties if this is the general pattern since there are few studies on the impact of fire on invertebrates, and none on the effect of the extent of the burned areas. Since the burned sites in the current study were located near the fire margins, it can be concluded that the fire may have had a significant impact on the invertebrate fauna of these sites for the first two weeks following burning (Uys *et al.* 2006). In the latter study, there was a recovery in invertebrate richness, abundance and homogeneity after 12 weeks. Invertebrate taxa commenced numerical recovery after four months in the Kojonup Nature Reserve in Australia after spring burning (Majer 1980).

As most of these were winged invertebrates, the colonisation process was rapid, but as ground-spiders have limited dispersal capabilities, colonisation took place at a slower pace in this study (Gibson *et al.* 1992; Uys *et al.* 2006). During a 50-year fire experiment the responses of ant assemblages to long-term burning regimes were investigated in Kruger National Park. It was found that epigaeic ant assemblages appeared to be highly resistant and resilient to burning, and this was linked to changes in habitat cover and structure (Parr *et al.* 2004). Habitat cover and structure can have an influence in the survival of spiders in the burned areas.

The six sites sampled had a large portion of their fauna in common, indicating that these species are found throughout the reserve. B-1 and B-3 had the lowest similarity in spider fauna, indicating that grass communities and/or soil character may be different in these sites (Table 4). The accumulation of species was low in U-1, B-2 and B-3, but high in B-1 (Fig. 2). This could be attributed to differences in the character of the soil (Appendix A). Soil character can have an indirect influence on the spiders, e.g. termites that choose substrates for their nests and Ammoxenidae that choose their habitat to be near to their preferred termite prey (Dippenaar-Schoeman *et al.* 1996a, b). Soil may also have a direct influence, e.g. burrowing spiders like Atypidae that choose clayey soil types to construct their nests/burrows in. The difference in abundance between the burned sites in October 2005 was likely due to some species surviving the fire and other species succumbing to it, which also influenced the species richness (Table 5). The difference in abundance in the unburned sites may be due to differences in soil character and associated vegetation, which also accounts for the significant difference in species richness (Tables 5 & 6). In the unburned sites, the differences in abundance were significant through most of the year. The very significant difference in abundance in September 2006 was likely due to the emergence of juveniles (Table 5). Species richness in the burned sites was generally not significantly different, as species were slow to colonise the burned grasslands.

The abundance of spiders differed significantly between the burned and unburned sites from November 2005 to February 2006, which is probably due to the combined effect of burning and then the recolonisation of the burned sites. When a burned and unburned site

was compared to each other in an Australian heathland, it was found that the number of spiders increased in the burned site during the early weeks following burning. This was attributed to the original spider populations, which were almost completely destroyed by prescribed burning, that were replaced by a rapid sequence of populations of open-land species (Tap 1996). In south-eastern Australian coastal blackforests where long term effects of frequent burning on litter-dwelling invertebrates were studied, it was found that on average, spider numbers were 63% lower in burned samples (York 1999). This study had a similar result in the spider numbers being lower in the burned samples. Thus, recolonisation may depend on the habitat and the adaptation of spider communities to burning. According to Majer (1980) spring burning would be more detrimental to invertebrates as this is the time when many predators and herbivores numbers is high or increasing. This might have had an effect on the slow colonisation processes of spider species.

3.5.3. Succession: According to Dash (1993) secondary succession in grasslands may take up to fifty to sixty years to reach the climax grass stage if there are no interfering forces to take into account (like man and some natural events). In a study undertaken by Ford (2007) on the community patterns following a fire, it was found that there was a general pattern of increasing species richness in response to the fire in the semiarid grassland which causes a change in spider fauna. This is due to architectural diversity that is increasing through succession (Gibson *et al.* 1992). This colonisation was true for B-1, but species richness accumulated slowly in the other two burned sites. This could be attributed to the differences in soil character of the different sites. B-2 and B-3, as well as U-3, had higher percentages of clay (Appendix A). Means of distribution was probably by ballooning in web-builders, in which silk is used to “fly” through the air (Decae 1987). The other most common means of dispersal was through migrating by ground wandering spiders.

3.5.4. Dominant and fire tolerant families: Species that cannot move away from fire (e.g. through flight), but are still able to survive, can be termed as fire tolerant species. They probably avoid fire by escaping underground or by using refugia within or adjacent

to the burned area. These species are relatively stable in species richness and abundance across burned areas even soon after fire (Uys *et al.* 2006). There are arthropod species that are adapted to living below the soil surface, because it provides a refuge from the biotic and abiotic perturbations existing above the ground, like fire (Villani *et al.* 1999). Temperatures in the soil also stay relatively low, even when there is a fire, and this is why soil invertebrates can survive (Tainton & Mentis 1984). For ground burrowing spiders, like trapdoor-spiders that live in side tunnels, the trapdoor of the burrow can provide good protection against fire (Dippenaar-Schoeman 2002). Lycosidae (most species rich family) and Gnaphosidae were present in all six sites. This would suggest that these two families are fire tolerant or fast colonisers. Some lycosid species (*Pardosa crassipalpis* Purcell) were found to be abundant in disturbed pistachio orchards, which supports the notion that they are efficient colonizers, as some small lycosids can ‘balloon’ to the disturbed habitats (Haddad *et al.* 2008). The dominance of the Linyphiidae in U-2 indicates that this site may have had a more complex habitat structure than the other sites, providing more structures for web construction (Harwood *et al.* 2001). *Ammoxenus amphalodes* is the most abundant species that was sampled. These spiders are specialist predators on *Hodotermes mossambicus* Hagen termites, and are dependent on the termites’ activity (see Chapter 4). The increase in abundance from July is probably due to the emergence of juveniles from their egg sacs, as females lay their eggs from May to July, and the juveniles hatch after 30 days (Dippenaar-Schoeman *et al.* 1996a). The dominance of *Obtala* sp. 1 and *Proevippa* sp. 2 during different times of the year is probably due to seasonality (Russell-Smith 1981; Langlands *et al.* 2006) (Fig. 5). Other families that may be fire tolerant or fast colonisers are Ctenidae, Ctenizidae, Miturgidae and Palpimanidae (Table 2). Colonisation mostly depends on a species ability to access the regrowing vegetation (Swengel 2001).

3.6. Conclusion

Fire is used as a management strategy in conservation as it destroys mature plants effectively and restricts dominance; yet, secondary succession in grasslands can be slow. Monthly spider abundance and species richness were consistently lower in the burned grassland (with the exception of B-1), suggesting that succession and colonisation

processes are slow. Gnaphosidae and Lycosidae were present throughout the year in all six sites, only exceeded in abundance by Ammoxenidae (presence of termites) in U-3. Thus, Gnaphosidae and Lycosidae may be fire tolerant (sheltering in cracks in the soil surface) or are fast colonisers. Some species shows seasonality in the year while the activity of others is related to the availability of prey (e.g. Ammoxenidae and Zodariidae).

3.7. References

BOND, W.J. & VAN WILGEN, B.W. 1996. *Fire and Plants*. Chapman and Hall, London. 263pp.

DASH, M.C. 1993. *Fundamentals of ecology*. Tata McGraw-Hill Publishing Company Limited, New Delhi. 210pp.

DECAE, A.E. 1987. Dispersal: Ballooning and other mechanisms. Pp. 348-358. In: Nentwig, W. (ed.) *Ecophysiology of spiders*. Springer-Verlag, Berlin.

DIPPENAAR-SCHOEMAN, A.S. & CRAEMER, C. 2000. The South African National Survey of Arachnida. *Plant Protection News* **56**: 11-12.

DIPPENAAR-SCHOEMAN, A.S., DE JAGER, M. & VAN DEN BERG, A. 1996a. Behaviour and biology of two species of termite-eating spiders, *Ammoxenus amphalodes* and *A. pentheri* (Araneae: Ammoxenidae), in South Africa. *African Plant Protection* **2**: 15-17.

DIPPENAAR-SCHOEMAN, A.S., DE JAGER, M. & VAN DEN BERG, A. 1996b. *Ammoxenus* species (Araneae: Ammoxenidae)—specialist predators of harvester termites in South Africa. *African Plant Protection* **2**: 103-109.

DIPPENAAR-SCHOEMAN, A.S. & LEROY, A. 2003. A check list of the spiders of the Kruger National Park, South Africa (Arachnida: Araneae). *Koedoe* **46**: 91-100.

DIPPENAAR-SCHOEMAN, A.S., LEROY, A., DE JAGER, M. & VAN DEN BERG, A. 1999. A check list of the spider fauna of the Karoo National Park, South Africa (Arachnida: Araneae). *Koedoe* **42**: 31-42.

FOORD, S.H., DIPPENAAR-SCHOEMAN, A.S. & VAN DER MERWE, M. 2002. A check list of the spider fauna of the Western Soutpansberg, South Africa (Arachnida: Araneae). *Koedoe* **45**: 35-43.

FORD, P.L. 2007. *Shared community patterns following experimental fire in a semiarid grassland*. In: Proceedings of the 4th International Wildland Fire Conference; May 13-17 2007; Seville, Spain.

FRIEND, G.R. 1995. Fire and invertebrates – a review of research methodology and the predictability of post-fire response patterns. In: McCaw, W.L., Burrows, N.D., Friend, G.R. & Gill, A.M. (eds.) *CalmScience Supplement* **4**: 165-174.

GIBSON, C.W.D., HAMBLER, C. & BROWN, V.K. 1992. Changes in spider (Araneae) assemblages in relation to succession and grazing management. *Journal of Applied Ecology* **29**: 132-142.

HADDAD, C.R., LOUW, S. VDM. & PEKÁR, S. 2008. Commercial pistachio orchards in the Northern Cape Province, South Africa, maintain a lower abundance and diversity of epigeic spiders than undisturbed Nama Karoo grassland (Arachnida: Araneae). *African Plant Protection* **14**: 24–36.

HARTLEY, M.K., ROGERS, W.E., SIEMANN, E. & GRACE, J. 2007. Responses of prairie arthropod communities to fire and fertilizer: balancing plant and arthropod conservation. *American Midland Naturalist* **157**: 92-105.

HARWOOD, J.D., SUNDERLAND, K.D. & SYMONDSON, W.O.C. 2001. Living where the food is: web location by linyphiid spiders in relation to prey availability in winter wheat. *Journal of Applied Ecology* **38**: 88-99.

HOLLAND, J.M. & SMITH, S. 1999. Sampling epigeal arthropods: an evaluation of fenced pitfall trapping using mark-release-recapture and comparisons to unfenced pitfall traps in arable crops. *Entomologia Experimentalis et Applicata* **91**: 347-357.

LANG, A. 2000. The pitfalls of pitfalls: a comparison of pitfall trap catches and absolute density estimates of epigeal invertebrate predators in arable land. *Journal of Pest Science* **73**: 99-106.

LANGLANDS, P.R., BRENNAN, K.E.C. & PEARSON, D.J. 2006. Spiders, spinifex, rainfall and fire: long-term changes in an arid spider assemblage. *Journal of Arid Environments* **67**: 36-59.

LUBIN, Y. & CROUCH, T. 2003. Trial by fire: social spider colony demographics in periodically burned grassland. *African Zoology* **38**: 145-151.

MACDOUGALL, A.S. & TURKINGTON, R. 2007. Does the type of disturbance matter when restoring disturbance-dependent grasslands? *Restoration Ecology* **15**: 263-272.

MAGURRAN, A.E. 1988. *Ecological diversity and its measurement*. Princeton University Press, New Jersey. 192pp.

MAGURRAN, A.E. 2004. *Measuring biological diversity*. Blackwell Publishing, Bodmin. 256pp.

MAJER, J.D. 1980. Report on a study of invertebrates in relation to the Kojonup Fire Management Plan. *Western Australian Institute of Technology, Department of Biology Bulletin* **2**: 1-22.

MELBOURNE, B.A. 1999. Bias in the effect of habitat structure on pitfall traps: an experimental evaluation. *Australian Journal of Ecology* **24**: 228–239.

OXBROUGH, A.G., GITTINGS, T., O'HALLORAN, J., GILLER, P.S. & KELLY, T.C. 2006. The initial effects of afforestation on the ground-dwelling spider fauna of Irish peatlands and grasslands. *Forest Ecology and Management* **237**: 478-491.

PARR, C.L., ROBERTSON, H.G., BIGGS, H.C. & CHOWN, S.L. 2004. Responses of African savanna ants to long-term fire regimes. *Journal of Applied Ecology* **41**: 630-642.

RUSSELL-SMITH, A. 1981. Seasonal activity and diversity of ground-living spiders in two African savanna habitats. *Bulletin of the British Arachnological Society* **5**: 145-154.

STUART, C. & STUART, T. 1997. *Guide to southern African game and nature reserves*. 4th edition. Struik Publishers, Cape Town. 360pp.

SWENGEL, A.B. 2001. A literature review of insect responses to fire, compared to other conservation managements of open habitat. *Biodiversity and Conservation* **10**: 1141–1169.

TAINTON, N.M. & MENTIS, M.T. 1984. Fire in Grassland. Pp. 115-147. In: Booysen P. DeV. & Tainton N.M. (eds.). *Ecological effects of fire in South African Ecosystems*. *Ecological Studies* 48. Springer-Verlag, Berlin.

TAP, P.M. 1996. *Arthropods and fire: studies in a southeast Australian heathland*. Ph.D thesis, Department of Biological Sciences, University of Wollongong. 159pp.

TOPPING, C.J. & SUNDERLAND, K.D. 1992. Limitations to the use of pitfall traps in ecological studies exemplified by a study of spiders in a field of winter wheat. *Journal of Applied Ecology* **29**: 485-491.

VILLANI, M.G., ALLEE, L.L. DÍAZ, A. & ROBBINS, P.S. 1999. Adaptive strategies of edaphic arthropods. *Annual Review of Entomology* **44**: 233-256.

UETZ, G.W. & UNZICKER, J.D. 1976. Pitfall trapping in ecological studies of wandering spiders. *Journal of Arachnology* **3**: 101-111.

UYS, C., HAMER, M. & SLOTOW, R. 2006. Effect of burn area on invertebrate recolonization in grasslands in the Drakensberg, South Africa. *African Zoology* **41**: 31-65.

YORK, A. 1999. Long-term effects of frequent low-intensity burning on the abundance of litter-dwelling invertebrates in coastal blackbutt forests of southeastern Australia. *Journal of Insect Conservation* **3**: 191–199.

3.8. Appendix A

Chemical and physical characteristics of soil samples taken by an auger from each of the three burned and the three unburned sites in Erfenis Dam Nature Reserve, Free State Province. Site abbreviations: see Table 1.

Sample	pH (KCl)	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Na (mg/kg)	US	SV %	Ca/Mg	(Ca+Mg)/K	KUK cmol _c kg ⁻¹	Sand %	Clay %	Loam %
B-1	5.8	3.9	277.1 (4)	2441 (75)	411.6 (21)	6.1 (0)	0.00	0.00	3.62	21.98	16.31	28	18	54
B-2	5.4	3.0	305.6 (4)	2328 (67)	616.6 (29)	4.7 (0)	0.00	0.00	2.30	21.36	17.49	21	18	61
B-3	5.4	4.8	351.2 (5)	2461 (67)	632.1 (28)	5.6 (0)	0.00	0.00	2.37	19.47	18.41	28	22	50
U-1	5.6	5.2	169.5 (3)	1478 (57)	600.7 (38)	46.5 (2)	0.00	0.00	1.50	28.40	12.95	43	20	37
U-2	5.4	1.3	244.6 (4)	1876 (61)	641.4 (34)	6.5 (0)	0.00	0.00	1.78	23.40	15.29	44	16	40
U-3	5.3	1.3	194.2 (7)	686 (47)	398.3 (45)	10.7 (1)	0.00	0.00	1.05	13.48	7.24	53	14	33

CHAPTER 4

**The influence of termite activity on the
activity of termite-eating spiders
(Ammoxenidae: *Ammoxenus amphalodes*)**

4.1. Abstract

When a prey type occurs in a spatially concentrated and highly predictable pattern, some predators will inevitably specialise in hunting it. In light of this, several spider families have specialist species feeding on four main prey groups (ants, termites, bees and wasps). *Ammoxenus* Simon 1892 (Ammoxenidae) are specialist predators of harvester termites in southern Africa. Pitfall trapping was used to sample cursorial invertebrates from six sites (three burned and three unburned) in Erfenis Dam Nature Reserve in the Free State Province, as part of an impact study. The abundance of the *Ammoxenus amphalodes* Dippenaar & Meyer was determined as well as where they were sampled. The termites that were captured were also identified into two species, *Hodotermes mossambicus* Hagen (Hodotermitidae) and *Trinervitermes trinervoides* Sjöstedt (Termitidae), and quantified as worker and soldier castes. *A. amphalodes* were concentrated in the two sites that had the greatest termite activity, especially *H. mossambicus* activity. The conclusion is that the activity of termites has an effect on the activity of *A. amphalodes*. It also seems that *A. amphalodes* abundance is only coupled to the presence of *H. mossambicus* and not with the presence of *T. trinervoides*, which supports findings of other studies.

Key words: specialise, *Ammoxenus amphalodes*, *Hodotermes mossambicus*, influence, activity.

4.2. Introduction

The range of prey that may be available to a given spider species is called its potential prey, which is in turn determined by the method of prey capture (Nentwig 1987). According to Nyffeler (1999) about eight arthropod orders (Diptera, Homoptera, Hymenoptera, Heteroptera, Collembola, Coleoptera, Lepidoptera and Araneae) serve as prey for polyphagous spiders. In contrast, Haddad (2003) found nine orders of insects being preyed upon in pistachio orchards, namely Collembola, Orthoptera, Thysanoptera, Hemiptera, Homoptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera. When a prey type occurs in a spatially concentrated and highly predictable pattern, there may be predators that specialise in hunting it (Wesolowska & Haddad 2002).

According to Nentwig (1986) many spider families have specialist species that specialise on five prey groups: ants, termites, bees or wasps, including other spiders. According to Řezáč *et al.* (2008) the genus *Dysdera* (Dysderidae) are the only specialised woodlice predators occurring outside tropical zones. All of these groups (except woodlice) are aggressive, with the insects being highly social groups. These insect groups are also mostly chemically protected, which mean many polyphagous predators are not able to subdue them. The advantages of specialisation are lower competition from other generalist predators, and because the insects are social, they are found in great abundance (Nentwig 1986). This is in tandem with the optimal foraging theory where it is predicted that increasing prey food abundance leads to greater prey food specialisation (Pyke *et al.* 1977). Termite mounds are an example that fulfills the above-mentioned conditions, which is the reason why a wide array of animals, from ants to large mammals, like the aardvark, have taken the opportunity and became (mostly) termitivorous (Sheppe 1970; Wesolowska & Haddad 2002). Natural predators of termites include lizards, birds, mammals and a variety of arthropods (Dippenaar-Schoeman *et al.* 1996b). Sheppe (1970) observed that ants were the most important invertebrate predators. Some of the other predators that were observed by Sheppe (1970) as invertebrate predators included beetles (Coleoptera: Staphylinidae: *Zyras*), members of the Reduviidae family, phasmids and centipedes.

Fifty-four termite genera, in five families, have been recorded from southern Africa (Uys 2002). All the southern African species from the genus *Trinervitermes* (Termitidae) with the exception of one species (*T. rapulum* Sjöstedt) are all harvesters and feed mainly on grass, leaf litter and other non-woody material. They build extensive polycalic nests and are usually subtended on the surface by mounds (Uys 2002). On the other hand, the Hodotermitidae have soil dumps which are indicative of their subterranean and diffuse nest systems (Meyer 1997; Uys 2002). Most species of the latter family build their nests entirely underground with a network of galleries leading above ground and ending in hundreds of foraging holes scattered over large areas (Heidecker & Leuthold 1984). The foraging holes are usually sealed and inconspicuous unless they are in use. Harvesting takes place once a day for a period of one to three hours (Leuthold *et al.* 1976). A single

colony can forage hundreds of square meters of grassland (Van den Berg & Dippenaar-Schoeman 1991). *Hodotermes mossambicus* Hagen have a capacity for both visual and chemical orientation, and can be active outside their underground nests both during the day and night (Heidecker & Leuthold 1984). According to Pearce (1997) different colonies of the same species can have different nest forms. Therefore, termite nests can be structurally diverse, and can offer shelter as well as food for termitophiles.

Spiders are commonly found in the mounds of different termite species and are sometimes the most frequently recorded taxa, except for other termites and ants (Dejean & Bolton 1995; Haddad & Dippenaar-Schoeman 2002, 2005; De Visser *et al.* 2008). According to Haddad & Dippenaar-Schoeman (2002) interactions between spiders and termites vary and therefore three possible interactions exist: 1) the termitophilous species, which will permanently reside in the termite mound; 2) spiders that live in close association with the termites and also prey on them (termitophages); 3) and spiders that use the mounds as shelter and for occasional food. Stable isotope analysis suggests that spiders are the top predators of the invertebrate food web that is located within the termitaria, but that they also rarely feed on the termites themselves directly (De Visser *et al.* 2008). These spiders also feed on the other invertebrates that are termitophagous and thus benefit termites indirectly.

According to Van den Berg & Dippenaar-Schoeman (1991), 13 species representing seven families were known to prey on termites in the Afrotropical Region, but more studies have been done since then and this number of families increased. These families are Ammoxenidae, Gnaphosidae, Philodromidae, Salticidae, Thomisidae, Theridiidae and Zodariidae (Dippenaar-Schoeman *et al.* 1996b) (Table 1).

The Ammoxenidae are a small family consisting of four genera, *Ammoxenus* Simon and *Rastellus* Platnick & Griffin from southern Africa with *Austrammo* Platnick and *Barrowammo* Platnick from Australia (Dippenaar-Schoeman & Joqué 1997, Platnick 2002). *Ammoxenus* species are known predators or more accurately specialist predators of harvester termites, but almost nothing is known of the diet of most *Rastellus* species

(Platnick & Griffin 1990; Dippenaar-Schoeman & Harris 2005). According to Henschel (1997) *R. coccineus* Simon and *R. sabulosus* Platnick & Griffin feed on *Psammotermes allocerus* Silvestri. Ammoxenid spiders are considered free-living soil dwellers and are also known as sand divers due to their ability to dive head first into sand when disturbed (Dippenaar-Schoeman *et al.* 1996a). *Ammoxenus* consists of six described species and are usually found in high numbers in areas infested with harvester termites. These spiders are usually found in the soft soil mounds left after excavation by the termites in close proximity to the nest entrance (Dippenaar-Schoeman & Harris 2005). They vary from small to medium-sized and their chelicerae and legs are modified for burrowing (Dippenaar-Schoeman *et al.* 1996a).

They are active spiders that can run rapidly over the soil surface from shaded area to shaded area. When they dive into the sand, they hold their legs close to their bodies and orient their bodies in an upside-down position beneath the sand (Dippenaar-Schoeman *et al.* 1996b). *Ammoxenus* are able to detect termite foraging activity either through soil vibration or chemical cues (Dippenaar-Schoeman & Harris 2005). Wilson & Clark (1977) observed that harvester termites have erratic bursts of activity and that ammoxenids are able to detect these bursts whether they occur nocturnally or diurnally. Dean (1988) observed that these spiders will move quickly into a crowd of termites near an entrance and select an individual. They will 'test' the termite for size by rapid manipulation and then decide to reject or grab it. During prey capture, the spider grabs the termite, bites it between its head capsule and the thorax (the termite is dead before it can emit an alarm pheromone), and then the dead termite is dragged underneath the soil, before the spider starts feeding (Dippenaar-Schoeman *et al.* 1996a; Dippenaar-Schoeman & Harris 2005). They construct sac-like retreats in the soil mounds. The spiders stay in these retreats when they are inactive and store food in retreats that differ from aforementioned retreats. Ammoxenids usually lay eggs from May to July, where the juveniles will hatch after 30 days (Dippenaar-Schoeman *et al.* 1996a). Ammoxenids also prefer to feed on the worker harvester termites rather than soldiers (Dean 1988; Dippenaar-Schoeman *et al.* 1996a).

The aim of this study was to determine if termite activity have an influence on the activity of *A. amphalodes* Dippenaar & Meyer. The interaction between *A. amphalodes* and the two termite species should follow a cyclically typical predator-prey relationship where, according to a broad definition, both populations tend to fluctuate cyclically (Hickman *et al.* 2004).

4.3. Material and methods

4.3.1. Study area and period: The Erfenis Dam Nature Reserve is located in the central part of the Free State Province, south-east of Theunissen. The dam is part of the Vet River system and the reserve compromises of about 400 ha of grassland (Stuart & Stuart 1997).

Pitfall trapping was used to sample cursorial invertebrates in the reserve as part of the impacts of fire on invertebrate communities study. The study was initiated in September 2005 the day following the burning and continued for the duration of a year. As termites were not retained from the first month's sample (October 2005), an additional month's sampling was conducted in October 2006 to gather twelve months data on *A. amphalodes* and termite abundance. Thus, the present study was conducted from November 2005 to October 2006.

Table 2. The six sites and their coordinates where ten pitfall traps were set out per site for a study which started in November 2005 till October 2006 in Erfenis Dam Nature Reserve, Free State Province.

Site	Coordinates	Soil character
Burned site 1	28°30.373'S, 26°48.437'E	Sand
Burned site 2	28°30.134'S, 26°48.427'E	Clay
Burned site 3	28°29.990'S, 26°48.486'E	Clay and gravel
Unburned site 1	28°29.888'S, 26°48.488'E	Clay
Unburned site 2	28°29.706'S, 26°48.281'E	Sand
Unburned site 3	28°29.741'S, 26°48.065'E	Sand

Table 1. A list of spider species known to prey on termites.

Family	Species	Prey	Country	Literature
Ammoxenidae	<i>Ammoxenus amphalodes</i> Dippenaar & Meyer	<i>Hodotermes mossambicus</i>	South Africa	Dippenaar-Schoeman <i>et al.</i> 1996a;b
	<i>Ammoxenus coccineus</i> Simon	<i>Microhodotermes viator</i> Latreille	South Africa	Dean 1988
	<i>Ammoxenus daedalus</i> Dippenaar & Meyer	<i>Hodotermes mossambicus</i>	South Africa	Van der Berg & Dippenaar-Schoeman 1991
	<i>Ammoxenus pentheri</i> Simon	<i>Hodotermes mossambicus</i>	South Africa	Dippenaar-Schoeman <i>et al.</i> 1996a
	<i>Rastellus coccineus</i> Simon	<i>Psammotermes allocerus</i> Silvestri	Namibia	Henschel 1997
	<i>Rastellus sabulosus</i> Platnick & Griffin	<i>Psammotermes allocerus</i>	Namibia	Henschel 1997
Gnaphosidae	<i>Haplodrassus stationis</i> Tucker	<i>Hodotermes mossambicus</i>	South Africa	Van der Berg & Dippenaar-Schoeman 1991
	<i>Zelotes vryburgensis</i> Tucker	<i>Hodotermes mossambicus</i>	South Africa	Van der Berg & Dippenaar-Schoeman 1991
Salticidae	<i>Heliophanus termitophagus</i> Wesolowska & Haddad	<i>Trinervitermes trinervoides</i> Sjöstedt	Zimbabwe	Wesolowska & Haddad 2002
	<i>Mashonarus guttatus</i> Wesolowska & Cumming	<i>Odontotermes transvaalensis</i> Sjöstedt	Zimbabwe	Wesolowska & Cumming, 2002

Theridiidae	<i>Microheros termitophagus</i> Wesolowska & Cumming	<i>Odontotermes transvaalensis</i>	Zimbabwe	Wesolowska & Cumming 1999
	<i>Stenaelurillus natalensis</i> Haddad & Wesolowska	<i>Odontotermes badius</i> Haviland	South Africa	Haddad & Wesolowska 2006
	<i>Chrosiothes tonala</i> Levi	<i>Tenuirostritermes briciae</i> Snyder	South America	Eberhard 1991
Zodariidae	<i>Latrodectus indistinctus</i> OP-Cambridge	<i>Hodotermes mossambicus</i>	South Africa	Van der Berg & Dippenaar-Schoeman 1991
	<i>Diores magicus</i> Jocqué & Dippenaar-Schoeman	?	Zimbabwe	Jocqué & Dippenaar-Schoeman 1992
	<i>Diores miombo</i> Jocqué	<i>Prorhinotermes inopinatus</i> Silvestri	Tanzania	Jocqué & Dippenaar-Schoeman 1992
	<i>Diores rectus</i> Jocqué	?	Zimbabwe	Jocqué & Dippenaar-Schoeman 1992
	<i>Diores salisburyensis</i> Tucker	<i>Odontotermes latericius</i> Haviland	Zambia	Sheppe 1970
	<i>Diores termitophagus</i> Jocqué & Dippenaar-Schoeman	?	South Africa	Jocqué & Dippenaar-Schoeman 1992

4.3.2 Sampling methods: Ten pitfall traps (diameter 8 cm) was set out per site in six different localities, with three sites being located in the burned area and the other sites in the unburned area (Table 2). Burned sites 1 to 3 were located 50 m from the western and eastern margins of the fire, and all three burned sites were 50 m from the southern fire margin. Unburned site 1 was 50 m east of the eastern fire margin, and unburned sites 2 and 3 were located on the opposite side of the dam. Traps were arranged in a 5x2 grid in each site, with 5 m separating each trap. The traps were buried level with the upper ground surface, and 100 ml of ethanediol was added as a preservative. The traps were left exposed for 30 days before being emptied. The spiders that were caught in the traps were removed and preserved in 70 % ethanol. Following sorting and identification of spiders in the laboratory, the abundance of *A. amphalodes* at the six sites was noted. The termites that were collected were also removed and identified as two species, *Hodotermes mossambicus* (Hodotermitidae) and *Trinervitermes trinervoides* (Termitidae). The abundance of the two species at the six sites, as well as the castes of individual termites was determined.

4.3.3. Statistics: All data were entered into Microsoft Excel 2003 from which graphs were drawn and data analysed. One-way Analysis of Variance ANOVA was done to determine if there is site preference in *A. amphalodes*, *H. mossambicus* and *Trinervitermes trinervoides* in the six sites. All calculations were done in GraphPad InStat.

4.4. Results

4.4.1. Site selection and habitat preference: *Ammoxenus amphalodus* and the two termite species were the most active in the pitfall sites with a sandy substrate (Table 2 & Fig. 1). *Hodotermes mossambicus* had a greater preference for site B-1 than for the other five sites, where *A. amphalodus* preferred site U-3 more than the other sites (Fig. 3). Both *A. amphalodes* and *H. mossambicus* have high *P* values ($P < 0.0001^{**}$) that shows extremely significant preference for certain sites, while *T. trinervoides* also have preference for certain sites ($P = 0.0136^{*}$). The occurrence of *A. amphalodes* and *H.*

mossambicus in relatively high numbers concurrently supports the theory that *H. mossambicus* is the preferred prey of *A. amphalodes*.

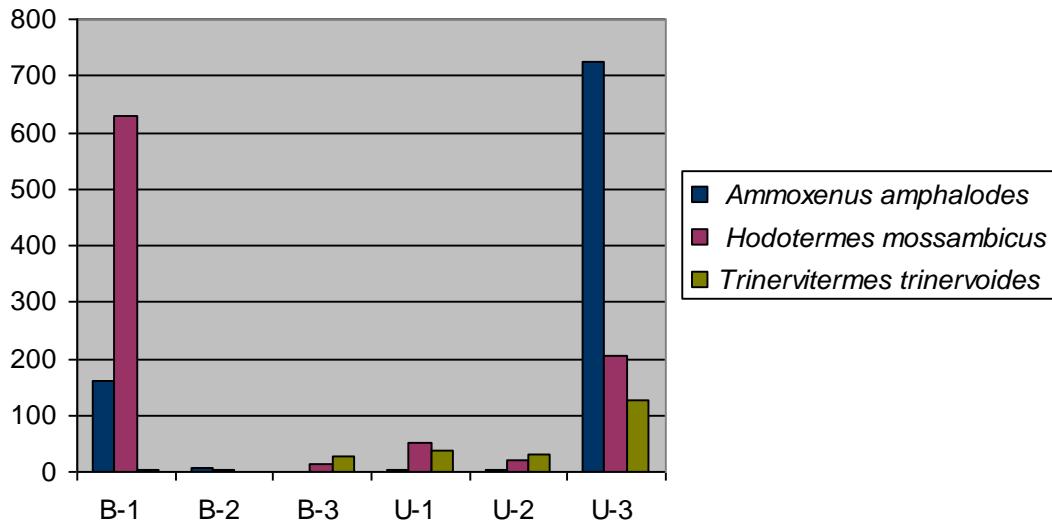


Fig. 1. The total abundance of *Hodotermes mossambicus*, *Trinervitermes trinervoides* and *Ammoxenus amphalodes* collected by pitfall trapping at six sites over the course of one year in Erfenis Dam Nature Reserve. Abbreviations: B-1 - burned site 1, B-2 - burned site 2, B-3 - burned site 3, U-1 - unburned site 1, U-2 - unburned site 2 and U-3 - unburned site 3.

4.4.2. Predator-prey relationship: From November 2005 to February 2006 the abundance of *Ammoxenus amphalodes* was higher than both termite species. February 2006 had the second highest rainfall of that year. This led to the loss of 14 of the 60 pitfall traps, which may have influenced the results. From March 2006 to June 2006 the abundance of *Hodotermes mossambicus* was higher than *A. amphalodes* and *Trinervitermes trinervoides*. Then from July 2006 to October 2006 the abundance of *A. amphalodes* once again exceeded the two termite species. It is interesting to see that *A. amphalodes* became inactive during April 2006-June 2006, but started becoming active again during July 2006. At first it was thought that ammxenids are not active in the winter months (do not actively feed at low temperatures), yet activity increases in July where temperatures are very low. By August 2006 the population started to increase rapidly, but decreased again in September 2006.

T. trinervoides was not as active as either *A. amphalodes* or *H. mossambicus* during the year. During the summer and winter of 2006 there seemed to be almost no foraging activity by *T. trinervoides* (Fig. 2).

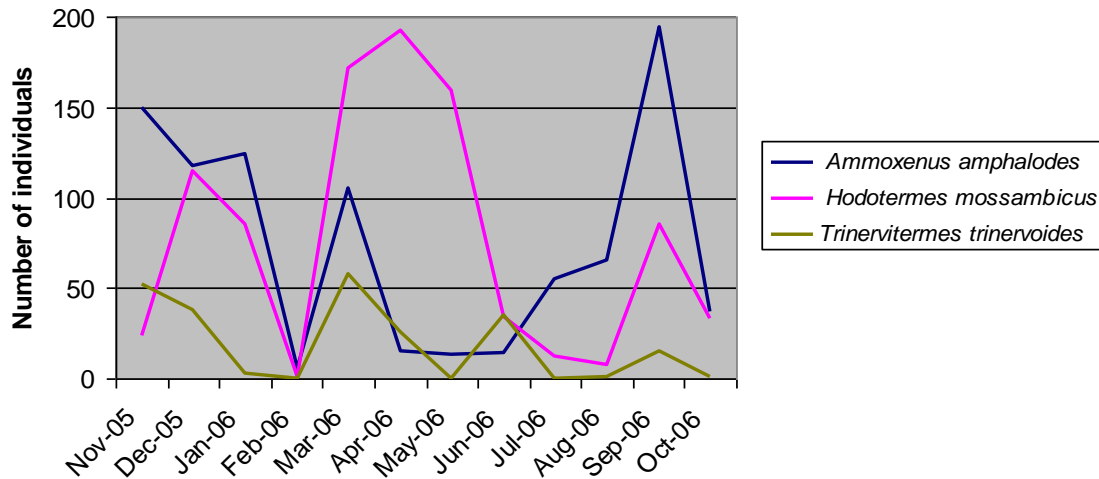


Fig. 2. Seasonal activity densities of *Ammoxenus amphalodes*, *Hodotermes mossambicus* and *Trinervitermes trinervoides* determined by pitfall trapping over a period of one year in Erfenis Dam Nature Reserve.

Despite corresponding activity patterns of *A. amphalodes* and the termites (Fig. 2), in 40.3 % of the site-months both spiders and termites were absent (Fig. 3). There were also sites where the termites were present, but the spiders were absent and *vice versa*. The frequency where both the spiders and two termite species were present was second (29.17 % of the 72 site-month samples) only to the frequency to where neither occurred (40.28 % of the 72 site-month samples) in the sites. This could be due to activity occurring predominantly in only two of the sites.

A. amphalodes and termites were both mostly not present in the six sites (Fig. 3), with 29.17% frequency of both ammxenids and the termites being present. There are a high frequency percentage of only termites present in the site-month samples and a low frequency percentage of only ammxenids present (Fig. 3).

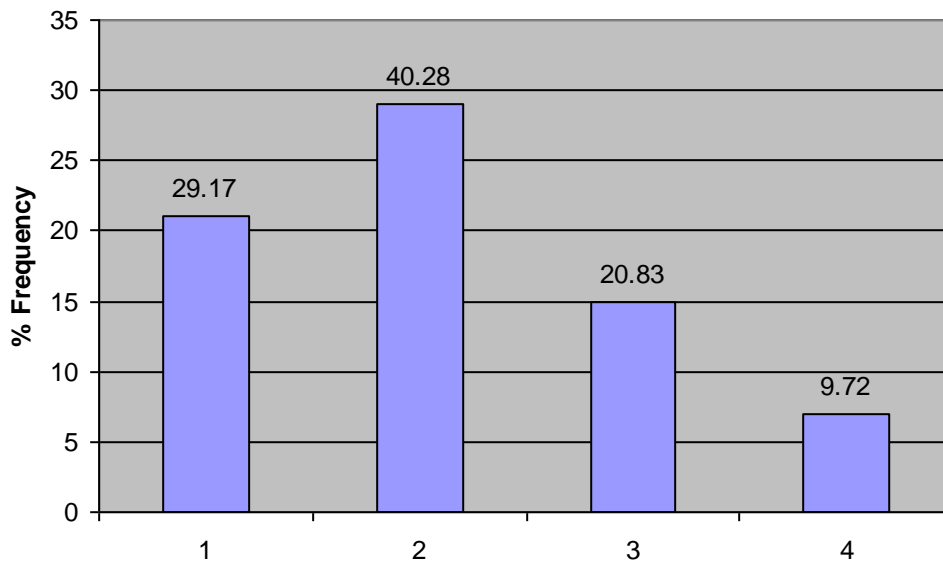


Fig. 3. The frequency of the occurrence of *Ammonoaxenus amthalodes* and the two termite species in the six sites from November 2005–October 2006 in Erfenis Dam Nature Reserve. The index is: 1–both termites and *A. amthalodes* occur in the sites, 2–both termites and *A. amthalodes* do not occur in the sites, 3–only termites occur in the sites and 4–only *A. amthalodes* occur in the sites.

4.4.3. Phenology: Of the 898 ammonoaxenids collected, 10.24 % were females, 26.06 % were males and 63.70 % were juveniles (Fig. 4). The juveniles dominated in late spring (November 2005), and again from mid winter (June 2006) to early spring (September 2006). Thus, the emergence of juveniles is from the late winter months to early spring. Males are also more present (more active as pitfalls measure activity) than the females, with females only more active than the males in February 2006 and April to May 2006 (Fig. 4).

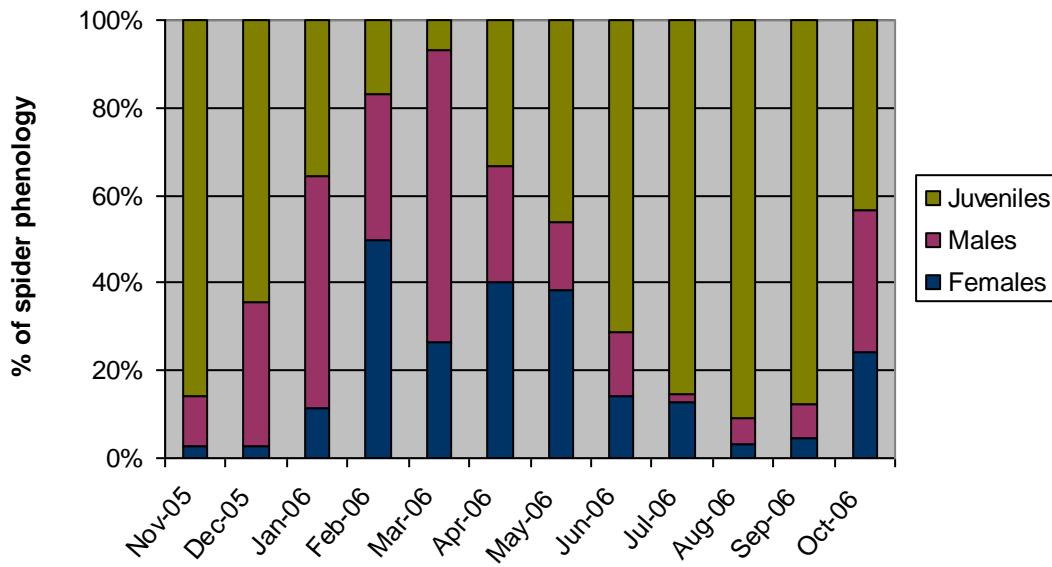


Fig. 4. The phenology of *Ammoxenus amphalodes* in the six sites from November 2005–October 2006 in Erfenis Dam Nature Reserve

4.5. Discussion

In ecology, predation is viewed as an important factor in controlling prey population densities (Dash 1993). In the absence of prey remains found with ammoxenids, their habits have to be argued from observations on their abundance in areas with high termite infestations, frequent occurrence in association with termites, modes of prey detection and capture, and daily and seasonal activity patterns (Dippenaar-Schoeman *et al.* 1996b).

4.5.1. Site selection and habitat preference: The distribution of termites is considered to be affected by differing vegetation and soil conditions (Meyer 1997), but this may not be the determining factors for grass-foraging termites. It seems that clay and sand content of soil play an important part in the construction of mounds. Hess (1955) found that tall and thin mounds of the termite genus *Macrotermes* (three species: *M. goliath* Gerstaecker, *M. bellicosus* Ruelle and *M. natalensis* Haviland) has a sand to clay ratio of 1:1 or 3:1 respectively as opposed to the larger domes with a ratio of 2:1 to 18:1. The mound ratio is usually equal to the surrounding soil composition. The soil characteristics together with the types of grass that occurs in sites B-1 and U-3 may be the reason why

H. mossambicus mainly chose those areas for nest construction (Fig. 2). According to Uys (2002) harvester termites prefer to colonise bare ground with the workers foraging in summer by night and in winter by day. The other four sites are mainly composed from clay or clay and gravel, which may not be the habitat preference for harvester termites. Topography may also play a role in habitat preference in termites as it may provide protection (for example, in birds topography can provide protection against water (Lauro & Nol 1993). Sites B-1 and U-1 was located at a slight incline. In B-1, the abundance of harvester termites was great, while in U-1 the abundance of the snouted harvester termites was the most of all six sites (Fig. 1). The presence of *A. amphalodes* is mainly because of the presence of its prey and its habitat preference (Dippenaar-Schoeman *et al.* 1996a). Selection of habitat, home-range size, as well as spatial and temporal usage of these home ranges was also related to the presence of harvester termites in bat-ear foxes, which also feeds on termites (Mackie & Nel 1989).

Henschel (1997) found that some *Rastellus* species burrows were sometimes very closely situated and may even be directly connected to the tunnels of *Psammotermes allocerus* which indicates that the spiders may catch the termites in their burrows. In 15.28% of the site-months *T. trinervoides* termites were active with no ammoxenids present while in 11.11 % of the site-months *H. mossambicus* were active with no ammoxenids present. Where ammoxenids were recorded, 26.39 % was with *H. mossambicus*, only 13.89 % with *T. trinervoides* and 8.33 % was with no termites in the 72 site-months. The theory that *A. amphalodes* activity is mainly coupled to the presence of *H. mossambicus* (Dippenaar-Schoeman *et al.* 1996b) was supported by the current study. In a study done by Haddad & Dippenaar-Schoeman (2002) five *A. amphalodes* were found inside a *T. trinervoides* mound that was occupied secondarily by *H. mossambicus*. The authors concluded that the presence of *A. amphalodes* was only due to the presence of *H. mossambicus*, as no *A. amphalodes* were collected in mounds with *T. trinerviodes* only.

4.5.2. Predator-prey relationship: Predator-prey and the resulting competitive interactions cannot be easily categorised under field conditions. Some predators can have little discernible effect on their prey's dynamics, while other predators maintain their

prey at very low equilibrium levels. In other interactions, there are episodic prey outbreaks when predation ceases to be limiting (Hassle 1978). When a predator relies primarily on a single prey species, the predator and prey populations fluctuate cyclically (Hassle 1978; Hickman *et al.* 2004). The predators re-adjust their population size by, for example, leaving the area. When the density of the predator population then falls low enough to allow reproduction by prey to outpace mortality from predation, the cycle begins again (Hickman *et al.* 2004). This seems to be the same for the *A. amphalodes* -*H. mossambicus* relationship (Fig. 2). The populations of *A. amphalodes* are mainly greater than *H. mossambicus* in the summer months, with the populations of *H. mossambicus* overtaking *A. amphalodes* populations in the winter months. The dominance of *A. amphalodes* in summer can be because of the emergence of juveniles in early spring. Van den Berg & Dippenaar-Schoeman (1991) also noted that there is a general decline in *H. mossambicus* foraging activity from September. A similar decline in termite activity was seen in this study which will lead to a decline in *A. amphalodes* activity.

4.5.3. Phenology: The sharp rise of the population of *A. amphalodes* (August 2006) is probably due to the emergence of juveniles (Figs 2 & 4). The drop in the population that follows in September is probably due to predation on the juveniles from other predators and inactivity of *A. amphalodes* due to the inactivity of the termites. According to Dippenaar-Schoeman *et al.* (1996b) juveniles will attack worker termites of any size, but it requires more effort from them to drag the prey item into the soil. This is not surprising, since a study of Morse (2000) showed that young *Misumena vatia* (Clerck) (Thomisidae) quickly improved their hunting prowess in successive exposures to prey. It also seemed that the size of the juveniles played a role in successful capture, as bigger juveniles were more successful. Dean (1988) saw up to three *Ammoxenus coccineus* attack worker termites in a short amount of time. It can then be assumed that large numbers of ammxenids can occur near the entrances of termite nests. Thus, a certain degree of intra-specific competition must occur between the ammxenids and the different life stages for space and prey as in many other intraspecific models, for example in insect larvae (Serrano *et al.* 2001). Males were also more active during the year than the females, except in February 2006 and April to May 2006 (Fig. 4) which may be in

preparation for egg-laying or the males might have died. Egg-laying was observed to take place from May to July in both *A. amphalodes* and *A. pentheri* where the juveniles hatch after 30 days (Dippenaar-Schoeman *et al.* 1996a). The abundance of *A. amphalodes* started to increase from July 2006, which was when the juveniles started emerging from their egg sacs (Fig. 2).

The phenology of *A. amphalodes* in Erfenis Dam Nature Reserve differs to a study done by Dippenaar-Schoeman *et al.* (1996b) and Van den Berg & Dippenaar-Schoeman (1991) in Gauteng Province where the highest numbers were recorded in winter while the lowest numbers were recorded in November, December, May and July. The fluctuating numbers of *A. amphalodes* through the year supports the notion that these spiders probably adapt their activity to that of the termite, as demonstrated in *A. daedalus* (Van den Berg & Dippenaar-Schoeman 1991; Dippenaar-Schoeman *et al.* 1996b). The difference may be attributed to the slight difference in temperature during winter months in the Free State and Gauteng Provinces.

4.5.4. Prey ecology: When *Ammoxenus* make a kill, they drag the prey to a soil mound or beneath the substrate and eat it there or store it. Less energy is required to hunt near the nests, where most of the termites are concentrated as opposed to hunting further away from the nest. Van den Berg & Dippenaar-Schoeman (1991) observed *A. amphalodes* preying on *H. mossambicus* on five occasions. When the termites were active, *A. amphalodes* moved freely between them. They have even been observed entering and retreating from the tunnels of the termites (Van den Berg & Dippenaar-Schoeman 1991).

4.6. Conclusion

The activity of termites has an effect on the activity of *A. amphalodes* and it follows the common predator-prey relationship trend. Activity of *A. amphalodes* is mainly coupled to the presence of *H. mossambicus* and not as much with the presence of *T. trinervoides*. It can be assumed that *A. amphalodes* feed mainly on *H. mossambicus* as *A. amphalodes* were concentrated in the two sites that had the greatest *H. mossambicus* activity. Both *A. amphalodes* and *H. mossambicus* abundance was significantly influenced by soil type,

which affects nest construction in *H. mossambicus* and foraging behaviour in *A. amthalodes*. Ammoxenids are recognised as eurychronous since they reproduce throughout the year and overwinter in different stages (Dippenaar-Schoeman *et al.* 1996b).

4.7. References

DASH, M.C. 1993. *Fundamentals of ecology*. Tata McGraw-Hill Publishing Company Limited, New Delhi. 210pp.

DEAN, W.R.J. 1988. Spider predation on termites (Hodotermitidae). *Journal of the Entomological Society of Southern Africa* **51**: 147-148.

DEJEAN, A. & BOLTON, B. 1995. Fauna sheltered by *Procubitermes niapuesensis* termitaries of the African rainforests. *Journal of African Zoology* **109**: 481-487.

DE VISSER, S.N., FREYMAN, B.P. & SCHNYDER, H. 2008. Trophic interactions among invertebrates in termitaria in the African savanna: a stable isotope approach. *Ecological Entomology* **33**: 758-764.

DIPPENAAR-SCHOEMAN, A.S. & HARRIS, R. 2005. Food storage by a wandering ground spider (Araneae, Ammoxenidae, *Ammoxenus*). *Journal of Arachnology* **33**: 850-851.

DIPPENAAR-SCHOEMAN, A.S., DE JAGER, M. & VAN DEN BERG, A. 1996a. Behaviour and biology of two species of termite-eating spiders, *Ammoxenus amthalodes* and *A. pentheri* (Araneae: Ammoxenidae), in South Africa. *African Plant Protection* **2**: 15-17.

DIPPENAAR-SCHOEMAN, A.S., DE JAGER, M. & VAN DEN BERG, A. 1996b. *Ammoxenus* species (Araneae: Ammoxenidae) – specialist predators of harvester termites in South Africa. *African Plant Protection* **2**: 103-109.

DIPPENAAR-SCHOEMAN, A.S. & JOCQUÉ, R. 1997. *African spiders, an identification manual*. Plant Protection Research Institute Handbook no. 9, Agricultural Research Institute, Pretoria. 392pp.

EBERHARD, W.G. 1991. *Chrosiothes tonala* (Araneae, Theridiidae): a web-building spider specializing on termites. *Psyche* **98**: 7-20.

HADDAD, C.R. 2003. *Spider ecology in pistachio orchards in South Africa*. M.Sc Thesis, University of the Free State. 181pp.

HADDAD, C.R. & DIPPENAAR-SCHOEMAN, A.S. 2002. The influence of mound structure on the diversity of spiders (Araneae) inhabiting the abandoned mounds of the snouted harvester termite *Trinervitermes trinervoides*. *Journal of Arachnology* **30**: 403-408.

HADDAD, C.R. & DIPPENAAR-SCHOEMAN, A.S. 2006. Epigeic spiders (Araneae) in pistachio orchards in South Africa. *African Plant Protection* **12**: 12–22.

HADDAD, C.R. & WESOŁOWSKA, W. 2006. Notes on taxonomy and biology of two *Stenaelurillus* species from southern Africa (Araneae: Salticidae). *Annales Zoologici* **56**: 575-586.

HASSLE, M.P. 1978. The dynamics of arthropod predator-prey systems. In: May, R.M. (ed.) *Monographs in population biology* 13. Princeton University Press, New Jersey. 248pp.

HENSCHER, J.R. 1997. Psammophily in Namib Desert spiders. *Journal of Arid Environments* **37**: 695–707.

HEIDECKER, J.L. & LEUTHOLD, R.H. 1984. The organisation of collective foraging in the harvester termite *Hodotermes mossambicus* (Isoptera). *Behavioural Ecology and Sociobiology* **14**: 195-202.

HESS, P.R. 1955. A chemical and physical study of the soils of termite mounds in East Africa. *Journal of Ecology* **43**: 449-461.

HICKMAN, C.P., ROBERTS, L.S., LARSON, A. & I'ANSON, H. 2004. *Integrated Principles of Zoology*. 12th edition. The McGraw-Hill Company, Inc., New York. 872pp.

JOCQUÉ, R. & DIPPENAAR-SCHOEMAN, A.S. 1992. Two new termite-eating *Diores* species (Araneae, Zodariidae) and some observations on unique prey immobilization. *Journal of Natural History* **26**: 1405-1412.

LAURO, B. & NOL, E. 1993. The effect of prevailing wind direction and tidal flooding on the reproductive success of pied oystercatchers, *Haematopus longirostris*. *Emu* **93**: 199-202.

LEUTHOLD, R.H., BRUINSMA, O. & VAN HUIS, A. 1976. Optical and pheromonal orientation and memory for homing distance in the harvester termite, *Hodotermes mossambicus* (Hagen). *Behavioral Ecology and Sociobiology* **1**: 127-139.

MACKIE, A.J. & NEL, J.A.J. 1989. Habitat selection, home range use, and group size of bat-eared foxes in the Orange Free State. *South African Journal of Wildlife Research* **19**: 135-139.

MEYER, V.W. 1997. *Distribution and density of mound-building termites in the northern Kruger National Park*. M.Tech Thesis, Pretoria Technicon. 88pp.

MORSE, D.H. 2000. The effect of experience on the hunting success of newly emerged spiderlings. *Animal Behaviour* **60**: 827-835.

NENTWIG, W. 1986. Non-webbuilding spiders: prey specialists or generalists? *Oecologia* **69**: 571-576.

NENTWIG, W. 1987. The prey of spiders. Pp. 249-263. In: Nentwig, W. (ed.) *Ecophysiology of spiders*. Springer-Verlag, Berlin.

NYFFELER, M. 1999. Prey selection of spiders in the field. *Journal of Arachnology* **27**: 317-324.

PEARCE, M.J. 1997. *Termites: biology and pest management*. CAB International, Cambridge. 172pp.

PLATNICK, N.I. 2002. A revision of the Australasian ground spiders of the families Ammoxenidae, Cithaeronidae, Gallieniellidae, and Trochanteriidae (Araneae: Gnaphosoidea). *Bulletin of the American Museum of Natural History* **271**: 1-244.

PLATNICK, N.I. & GRIFFIN, E. 1990. On *Rastellus*, a new genus of the spider family Ammoxenidae (Araneae, Gnaphosoidea). *American Museum novitates* **2995**: 1-11.

PYKE, G.H., PULLIAM, H.R. & CHARNOV, E.L. 1977. Optimal foraging: a selective review of theory and tests. *Quarterly Review of Biology* **52**: 137-154.

ŘEZÁČ, M., PEKÁR, S. & LUBIN, Y. 2008. How oniscophagous spiders overcome woodlouse armour. *Journal of Zoology* **275**: 64-71.

SERRANO, J.M., DELGADO, J.A., LÓPEZ, F., ACOSTA, F.J. & FUNGAIRIÑO, S.G. 2001. Multiple infestation by seed predators: the effect of loculate fruits on intraspecific insect larval competition. *Acta Oecologica* **22**: 153-160.

SHEPPE, W. 1970. Invertebrate predation on termites of the African savanna. *Insectes Sociaux, Paris* **17**: 205-218.

STUART, C. & STUART, T. 1997. *Guide to southern African Game and Nature Reserves*. 4th edition. Struik Publishers, Cape Town. 360pp.

UYS, V. 2002. *A guide to the termite genera of southern Africa*. Plant Protection Research Institute Handbook No. 15. Agricultural Research Council, Pretoria. 116pp.

VAN DEN BERG, A. & DIPPENAAR-SCHOEMAN, A.S. 1991. Ground-living spiders from an area where the harvester termite *Hodotermes mossambicus* occurs in South Africa. *Phytophylactica* **23**: 247-253.

WESOLOWSKA, W. & CUMMING, M.S. 1999. The first termitivorous jumping spider (Araneae: Salticidae). *Bulletin of the British Arachnology Society* **11**: 204-208.

WESOLOWSKA, W. & CUMMING, M.S. 2002. *Mashonarus guttatus*, gen. and sp.n., the second termitivorous jumping spider from Africa (Araneae: Salticidae). *Bulletin of the British Arachnological Society* **12**: 165-170.

WESOLOWSKA, W. & HADDAD, C.R. 2002. A new termitivorous jumping spider from South Africa (Araneae: Salticidae). *Tropical Zoology* **15**: 197-207.

WILSON, D.S. & CLARK, A.B. 1977. Above ground predator defence in the harvester termite, *Hodotermes mossambicus* (Hagen). *Journal of the Entomological Society of southern Africa* **40**: 271-282.

CHAPTER 5

**A revision of the genus *Calommata*
(Araneae: Atypidae) in the Afrotropical
Region, with notes on the phenology and
conservation importance of *C.*
meridionalis n. sp.**

5.1. Abstract

The poorly known purse-web spider genus *Calommata* Lucas, 1837 is revised in the Afrotropical Region. *C. transvaalica* Hewitt, 1916 is removed from synonymy with *C. simoni* Pocock, 1903 and revalidated. The females of both species are redescribed as well as *C. simoni*'s male and *C. transvaalica*'s male is described for the first time. Four new species are described: *C. megae* n. sp. (Zimbabwe), *C. meridionalis* n. sp. (South Africa), *C. namibica* n. sp. (Namibia) and *C. tibialis* n. sp. (Ivory Coast and Togo). The phenology of *C. meridionalis* n. sp. was studied by pitfall trapping in the Free State Province, South Africa. This species shows a clear preference for clay soils, and males are only active from October to November.

Key words: *Calommata*, revised, revalidated, new species, *C. meridionalis* n. sp., described.

5.2. Introduction

The family name Atypidae was established by Simon (1903) cited in Gertsch & Platnick 1980, to include a small group of distinctive Mygalomorphae with representatives in both the northern and southern hemispheres. Presently it is represented by three genera, *Atypus* Latreille, 1804; *Calommata* Lucas, 1837 and *Sphodros* Walckenaer, 1835, representing 43 species in Africa, Europe, Asia and North America (Gertsch & Platnick 1980; Platnick 2009). Atypids are burrowing spiders that spin a line burrow with tough webbing in ground, which is prolonged and camouflaged in the aerial segment as a trap for wandering arthropods. Atypidae represents an ancient branch of the infraorder Mygalomorphae, with the family retaining many plesiomorphic features. Yet, they also have derived features in both their morphology and technique of prey capture (Gertsch & Platnick 1980).

Within the family, the three genera are each distinguished by a unique type of spermathecal structure. In *Atypus*, there are two broad plates each bearing two or more small receptacula, whereas in *Calommata* there are four spermathecae, each bearing several closely packed terminal receptacula positioned in a cauliflower-like arrangement.

In *Sphodros*, the four spermathecae are each highly coiled and without distinct receptacula (Gertsch & Platnick 1980). Kraus & Baur (1974) cited in Dippenaar-Schoeman & Jocqué (1997), suggested that *Calommata* not be included in the Atypidae, but did not indicate whether they believed the genus to be different to *Atypus* and *Sphodros* or whether they are more closely related to another group of spiders.

Only one genus, *Calommata*, has been recorded in the Afrotropical Region and was thought to be represented by a single species (*C. simoni* Pocock, 1903), described from Cameroon (Gertsch & Platnick 1980; Dippenaar-Schoeman & Jocqué 1997). Pocock (1903) compared it only with *Actinopus fulvipes* Lucas, 1837, seemingly regarding the other species that had been described from Eastern Asia as synonyms of *P. fulvipes* (Hewitt 1916). The main differences lay in the structural differences of the distal teeth between the two species (Pocock 1903). Hewitt (1916) described a second species, *C. transvaalica*, from Roodeplaat, South Africa. The type specimen was a single immature female specimen found in grassveld in a nine cm deep nest. The record was of real interest since at that time no members of the family had been recorded in South Africa. Benoit (1967) later synonymised this species with *C. simoni*.

In South Africa, *C. simoni* was last collected in 1920 (as *C. transvaalica*), following the collection of specimens from Roodeplaatdam in Gauteng Province and the Soutpansberg by Van Dam & Roberts (1917). Subsequently, no material of the genus was collected in South Africa until the recent rediscovery in 2003 of these spiders by Marianne Forsythe in the Groenkloof Nature Reserve in Gauteng Province, where a single male was collected by pitfall trapping. This led to an intense search to locate viable populations in Gauteng, which to date have not yielded additional specimens. Another male was subsequently collected in 2005 in the Blouberg Nature Reserve in Limpopo Province. In 2005 a new species of *Calommata* was discovered in the Erfenis Dam Nature Reserve during a year-long pitfall survey, which extended the range of the genus by more than 200 km south-west of Gauteng (Dippenaar-Schoeman & Haddad 2008). As *Calommata* are considered to be spiders of conservation importance in South Africa (Dippenaar-Schoeman 2002; Engelbrecht 2008), and will be included in an upcoming Red Data List

assessment (Dippenaar-Schoeman & Haddad, in prep), it is essential to revise the genus and provide updated information on the distribution and habitat preferences of the genus. In this chapter the *Calommata* of the Afrotropical Region are revised, *C. transvaalica* is removed from synonymy with *C. simoni*, and four new species are described. The phenology and microhabitat (soil) preferences of *C. meridionalis* n. sp. were studied in greater detail in the Free State Province, South Africa.

5.3. Material and methods

5.3.1. Taxonomy: All spiders were studied under an Olympus SZX10 stereomicroscope under 10X magnification. Measurements (body and legs) were taken in millimeters (mm). The proportional indices used are the carapace index (length divided by width), and patella-tibia index (combined length of patella and tibia segments of the first leg divided by length of carapace). Descriptions follow the format of Levy (2007).

The following abbreviations are used in the text:

AL – abdomen length	CL – carapace length
AW – abdomen width	CW – carapace width
TL – total length	

Material of *Calommata simoni*, *C. tibialis* n. sp., *C. namibica* n. sp. and *C. meridionalis* n. sp. were prepared for Scanning Electron Microscopy (SEM). Specimens were transferred to absolute (100 %) ethanol and left overnight. After critical-point drying, the specimens were glued to rounded aluminium rivets using two-sided copper strips and then coated with gold for examination using a JEOL JSM-6480. Digitised micrographs were taken.

A montage photograph of the habitus of a dorsal *C. simoni* female was taken with a Leica MZ16 and the LAS automontage software at the MRAC. Montage photographs of the dorsal habitus of the remaining species and a *C. simoni* male were taken using a Nikon Coolpix 8400 mounted on a Nikon SMZ800 stereomicroscope. The extended focal range

images were staked using CombineZM software to increase depth of field (www.hadleyweb.pwp.blueyonder.co.uk).

The material used in this revision is deposited in the following collections:

MRAC - Royal Museum for Central Africa, Tervuren, Belgium,

NCA – ARC-Plant Protection Institute, National Collection of Arachnida, Pretoria, South Africa,

NMBA - National Museum, Bloemfontein, South Africa,

NMSA - Natal Museum, Pietermaritzburg, South Africa,

TMSA – Northern Flagship Institute, Transvaal Museum, Pretoria, South Africa.

5.3.2. Biology of *Calommata meridionalis* n. sp.

5.3.2.1. Pitfall trapping: Ten pitfall traps was set out in six different sites in Erfenis Dam Nature Reserve (EDNR) that is located in the central part of the Free State Province, South Africa. For localities of traps set out in EDNR during 2005 to 2006, refer to Fig. 1 in Chapter 3. Traps were arranged in a 5x2 grid, with 5 m separating each trap. The traps were buried level with the upper ground surface, and 100 ml of ethanediol was added as a preservative. The traps were left exposed for 30 days before being emptied. The spiders that were caught in the traps were removed and preserved in 70 % ethanol. Eight male *Calommata* were identified in the material sorted for October and November 2005, extending the range of the genus in South Africa by more than 200 km south-west of Gauteng Province. Of these specimens collected, six were found in burnt grassland (Burned site 1 and Burned site 2) and two in unburned grassland (Unburned site 1 and Unburned site 3), with four specimens sampled in each month.

Pitfall trapping was carried out at several localities in the northern and central Free State (Willem Pretorius Nature Reserve, EDNR, National Botanical Gardens in Bloemfontein, Doornkloof farm near Kroonstad/Lindley, Vaal Dam near Oranjeville, and Sandveld Nature Reserve) and southern North West Province (Thabela Thabong Mountain Retreat) to try and determine the distribution of *C. meridionalis* n. sp. in particular. In EDNR (the main study site), three sites where *C. meridionalis* n. sp. were previously collected as

well as five additional sites were selected to set out pitfall traps (Fig. 1). In the other localities, two sites were chosen to set out pitfall traps (each site representing a different habitat). The traps were set out in the last week of August 2009 and emptied monthly until the first week of December 2009, using the same methodology described above.

5.3.2.2. Grid transects for web location: A second study was initiated in May 2008 (representing autumn) to further investigate the biology of *C. meridionalis* n. sp. (by finding burrows), as well as to try and collect females. Once, the last week of every third month (representing a season), a day was spent in EDNR searching for burrows in three sites where *C. meridionalis* n. sp. were collected (Fig. 1). In each site, ten poles marked with a yellow light reflector were set out (twenty meters apart) in a straight line transect. A one by one meter grid was divided into four equal 0.25 m² areas. One area was allocated to a season, starting top left that represented autumn, and moving the seasons clockwise (i.e. winter was top right, etc.). The grid was placed next to the pole starting at the top left facing south and moving clockwise around the pole, scraping the soil surface of the allocated area with a trowel. This was done to expose the webbing of the nest so that a subsequent search could be made and the complete nest studied (Van Dam & Roberts 1917).

5.3.3. Analysis of soil samples: Soil samples were taken from each of the six sites where pitfalls were set out during 2005-2006 with an auger (about 20 cm deep). The samples were placed in plastic bags, marked, and were taken to the Soil Analysis Laboratory of the ARC-Small Grain Institute in Bethlehem, South Africa for analysis.



Fig. 1. The locations of the eight pitfall trap sites (marked in yellow) and the three grid transects for web locations (marked in red) in EDNR, Free State Province, South Africa (image from Google Earth).

5.4. Taxonomy

The Atypidae, with the dorsal residual scutum on the opisthosoma, are an ancestral spider family of the infraorder Mygalomorphae. They are characterized by: 1) the extremely elongate inner portion of the palpal coxa, and 2) the structure of the posterior median spinnerets with their obliquely truncated tips (Levy 2007).

5.4.1. *Calommata* Lucas, 1837

Type species: *Actinopus fulvipes* Lucas, 1835 (Java, Sumatra)

5.4.2. Diagnosis: Within the Atypidae, the three genera are distinguished from each other by a unique spermathecal structure. In *Atypus*, there are two broad plates each bearing two or more small receptacula. In *Calommata*, four spermathecae are present, each bearing several closely packed terminal receptacula positioned in a cauliflower-like arrangement. In *Sphodros*, there are also four spermathecae, but each is highly coiled and without a distinct receptacula (Gertsch & Platnick 1980).

5.4.3. Description (as described by Levy 2007; Gertsch & Platnick 1980): Males and females differ greatly in morphology (Figs 2-9). The carapace has an anterior strongly elevated ocular tubercle, with a flattened posterior part traversed by the thoracic furrow with a small deep pit in the middle (fovea). Three faint lines run from the eye area, and converge at fovea. Chelicerae are large, directed forward, and dorsally expanded with flattened sides, bearing sharp teeth in a row and a long arched fang (Figs 13, 34-35, 49). Endites are strongly elongated on the prolateral side (Fig. 14). Sternum has a distinctive labial sclerite in front. The tibiae of male palpi are swollen, and both embolus and haematodocha present in male palp (Figs 10-12, 20-21, 22-24, 26-29, 31-33, 43-45, 46-48, 53-63). Legs are of normal size in males with tarsi leg IV longest (Figs 2-4, 6-7, 9), but are rather short and stout in females (Figs 5, 8). Tarsi armed with three claws, outer two claws serrated (Fig. 37); tarsi pseudosegmented in males (Fig. 16), with ventral scopulae consisting of pointed setae (Figs 19, 51) or setae with a rounded tip (Fig. 42). Six spinnerets: anterior laterals and posterior medians one segmented, posterior laterals three-segmented (Figs 17-18, 38-41). There is also a wide separation of the anal tubercle from the spinnerets.



Figs 2-9. General appearance of *Calommata* species from the Afrotropical Region: 2) *C. megae* n. sp. (male), 3) *C. meridionalis* n. sp. (male), 4) *C. namibica* n. sp. (male), 5) *C. simoni* Pocock, 1903 (female), 6) *C. simoni* (male), 7) *C. tibialis* n. sp. (male), 8) *C. transvaalica* Hewitt, 1916 (female), 9) *C. transvaalica* (male).

5.4.4. *Calommata megae* n. sp.

Figs 2, 10-12

Etymology: This species was named after the collector of the holotype, Meg Cumming, in recognition of her contributions to African arachnology.

Diagnosis: The male of this species is recognised by the haematodocha that narrows and makes a half twist before broadening distally (Figs 10-12). The carapace is broadest anteriorly at coxae II and is slightly wider than long.

Description:

Holotype male from Harare, Zimbabwe (Fig. 2). Carapace and chelicerae brown in colour. Carapace flat and robust. Eye area raised, darker in colour. Sternum and coxae light brown, remainder of legs dark brown, fading to light yellow brown at tarsi. Legs weakly covered with bristles; prolateral side of patellae, tibiae and metatarsi of legs II-IV covered with spinules (thicker and shorter than bristles). Abdomen dark brown with an irregular brown scutum present in the anterior half (Fig. 2).

Palp: Haematodocha narrow making a half twist before broadening distally. Embolus short and straight (Figs 10-12).

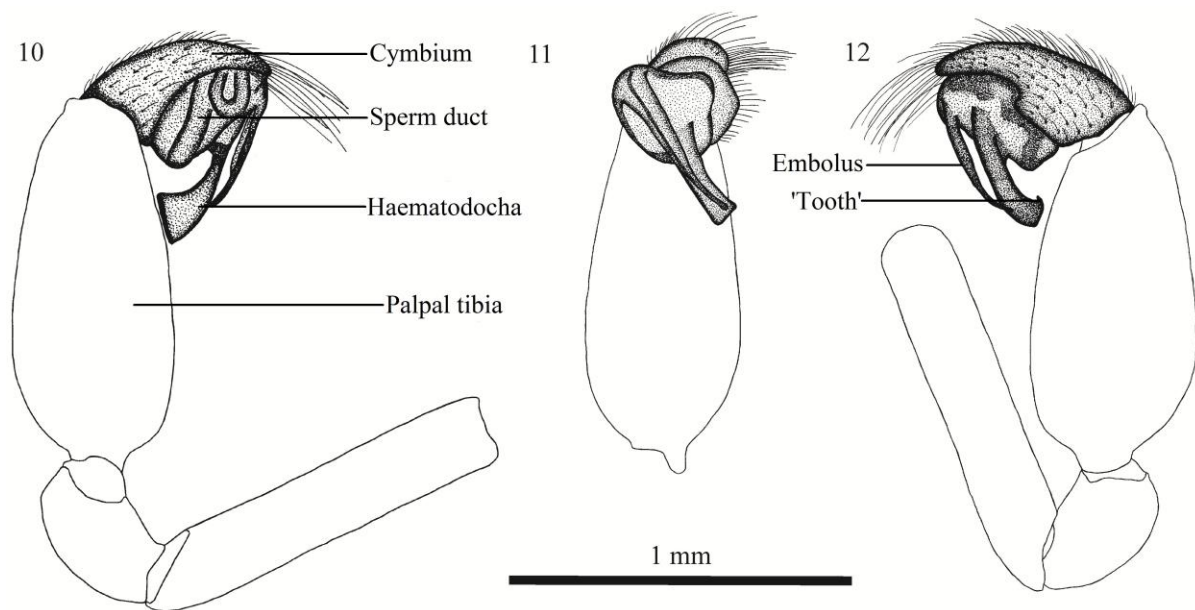
Measurements: CL 1.9; CW 2.2; AL 3.1; AW 1.7; TL 7.0. Length of legs: I 8.6; II 8.8; III 9.0 and IV 11.6. Carapace index 0.9; patella-tibia index 1.4.

Female: Unknown.

Holotype: ♂ ZIMBABWE: Harare, Highlands, 13.I.2003, Meg Cumming, on soil, hand (NCA 2004/362).

Other material examined: 1 J ZIMBABWE: Harare, Highlands, 21.II.2000, Meg Cumming, in garden (NCA 2004/1361).

Distribution: Northern Zimbabwe (Fig. 64).



Figs 10-12. Right male palp of *Calommata megae* n. sp.: 10) retrolateral view, 11) ventral view, 12) prolateral view.

5.4.5. *Calommata meridionalis* n. sp.

Figs 3, 13-24

Etymology: This species name is taken from the Latin for southern, referring to the distribution of the species, southernmost in the genus.

Diagnosis: The male of this species can be recognised by the haematodocha ending broadly in area of prominent 'tooth' (Figs 20-24), and the transversely orientated curved embolus (Fig. 23). Raised eye area broader than in other species.

Description:

Holotype male from Erfenis Dam Nature Reserve, South Africa (Fig. 3). Carapace and chelicerae dark brown in colour. Eye area raised, darker in colour. Raised eye area broader than in other species. Sternum and coxae pale brown, remainder of legs brown, gradually fading to yellow at tarsi. Legs weakly covered with bristles; prolateral side of

patellae, tibiae and metatarsi of legs II-IV covered with spinules. Tarsi with fine ventral scopulae consisting of pointed setae (Fig. 19). Abdomen pale grey in colour with a round brown scutum in anterior half (Fig. 3). Trichobothriae present on palpal tibiae (Fig. 15).

Palp: Haematodocha end broadly in area of prominent 'tooth', with a transversely orientated curved embolus (Figs 22-24).

Measurements: CL 1.7-2.1; CW 1.4-1.5; AL 2.4-4.0; AW 1.8-2.2; TL 5.6-8.3. Length of legs: I 5.8-6.3; II 6.0-6.6; III 6.3-7.0, IV 6.88-7.3. Carapace index 1.2-1.4; patella-tibia index 1.1-0.9.

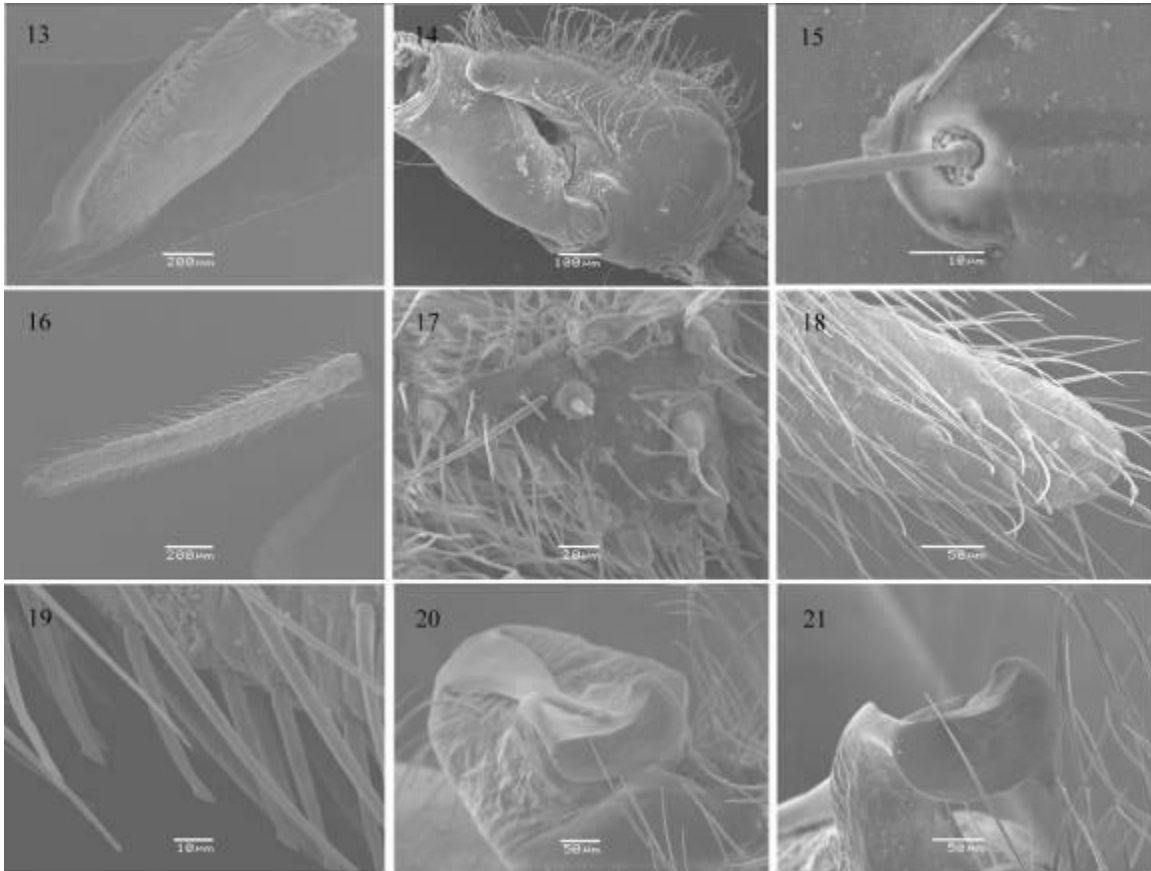
Female: Unknown.

Holotype: ♂ SOUTH AFRICA: *Free State Province*, Erfenis Dam Nature Reserve, 28°29.888'S, 26°48.488'E, 21.IX–22.X.2005, C. Haddad, S. Otto & R. Poller, pitfall traps, unburned site 1 (NCA 2009/3488).

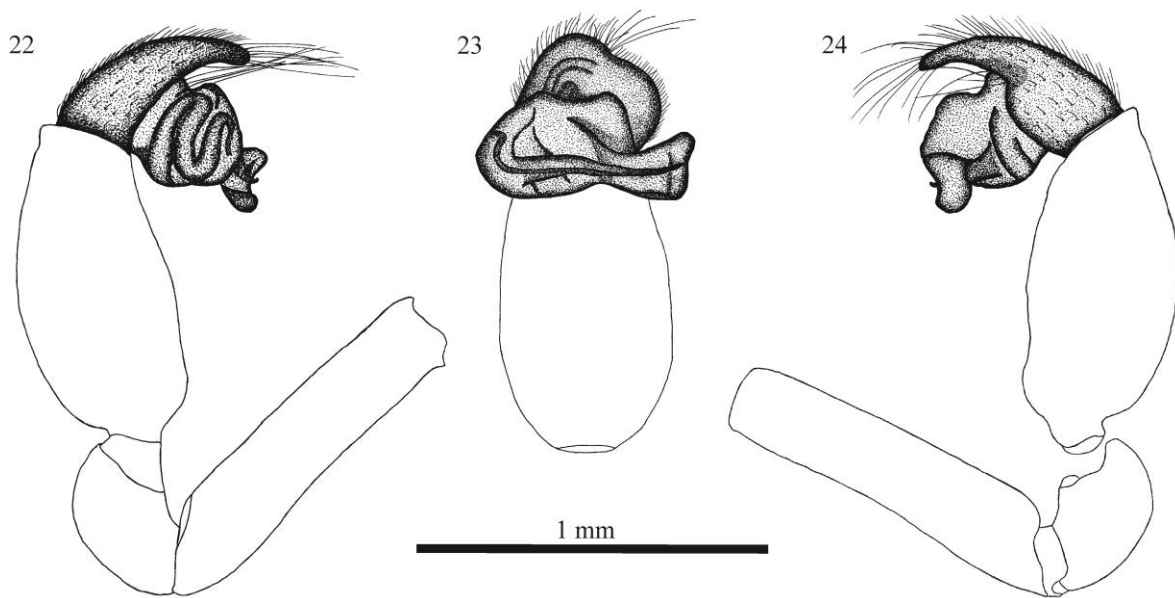
Paratypes: SOUTH AFRICA: 1 ♂ *Free State Province*, Erfenis Dam Nature Reserve, 28°30.373'S, 26°48.437'E, 21.IX–22.X.2005, C. Haddad, S. Otto & R. Poller, pitfall traps, burned site 1 (NCA 2009/3663); 4 ♂ Same locality, 28°30.134'S, 26°48.427'E, 22.X–22.XI.2005, C. Haddad, S. Otto & R. Poller, pitfall traps, burned site 2 (NCA, 2007/3142); 1 ♂ Same locality, 28°29.741'S, 26°48.065'E, 21.IX–22.X.2005, C. Haddad, S. Otto & R. Poller, pitfall traps, unburned site 3 (NCA 2009/3664); 1 ♂ Oranjeville district, Vaal Dam, 26°59.523'S, 28°15.737'E, 1–29.X.2009, R. Fourie & A. Grobler, pitfall traps, grassland (NCA 2009/3539); 3 ♂ Bloemfontein, National Botanical Gardens, 29°03.006'S, 26°12.701'E, 27.X-16XI.2009, C. Haddad, pitfall traps, grassland (NMBA 13981); 7 ♂ Same locality, 16-21.XI.2009, C. Haddad, pitfall traps, grassland (NMSA 22616); 1 ♂ Same locality, 21. XI-7.XII.2009, C. Haddad & R. Fourie, Pitfall traps grassland (MRAC).

Other material examined: SOUTH AFRICA: 1 ♂ Free State Province, Erfenis Dam Nature Reserve, 28°30.134'S, 26°48.427'E, 21.IX–22.X.2005, C. Haddad, S. Otto & R. Poller, pitfall traps, burned site 2 (prepared for SEM).

Distribution: Central and northern Free State Province, South Africa (Fig. 64).



Figs 13-21. Scanning electron micrographs of *Calommata meridionalis* n. sp. (male): 13) ventral view of chelicerae, 14) ventral view of right endite, 15) trichobothrium on palpal tibia, 16) lateral view of tarsus and claw of leg IV, 17) ventral view of posterior median spinneret, 18) lateral view of last apical segment of posterior lateral spinneret, 19) scopula present on ventral side of tarsus IV, 20) retrolateral view of haematodocha, 21) close-up retrolateral view of haematodocha and embolus.



Figs 22-24. Left male palp of *Calommata meridionalis* n. sp.: 22) prolateral view, 23) ventral view, 24) retrolateral view.

5.4.6. *Calommata namibica* n. sp.

Figs 4, 25-33

Etymology: The species is named after the country in which it was collected.

Diagnosis: The male of this species can be recognised by the haematodocha ending in a very prominent, very long and slender ‘tooth’ (Figs 26-33).

Description:

Holotype male from Namibia (Fig. 4). Carapace and chelicerae dark brown. Eye area raised, narrow, darker in colour. Sternum and coxae light brown, femora dark brown. Subsequent segments fading to light yellow at tarsi. Legs weakly covered with bristles; prolateral side of patellae, tibiae and metatarsi of legs II-IV covered with spinules. Abdomen dark grey in colour with brown scutum present in the anterior half (Fig. 4). Trichobothriae present on palpal tibia (Fig. 25).

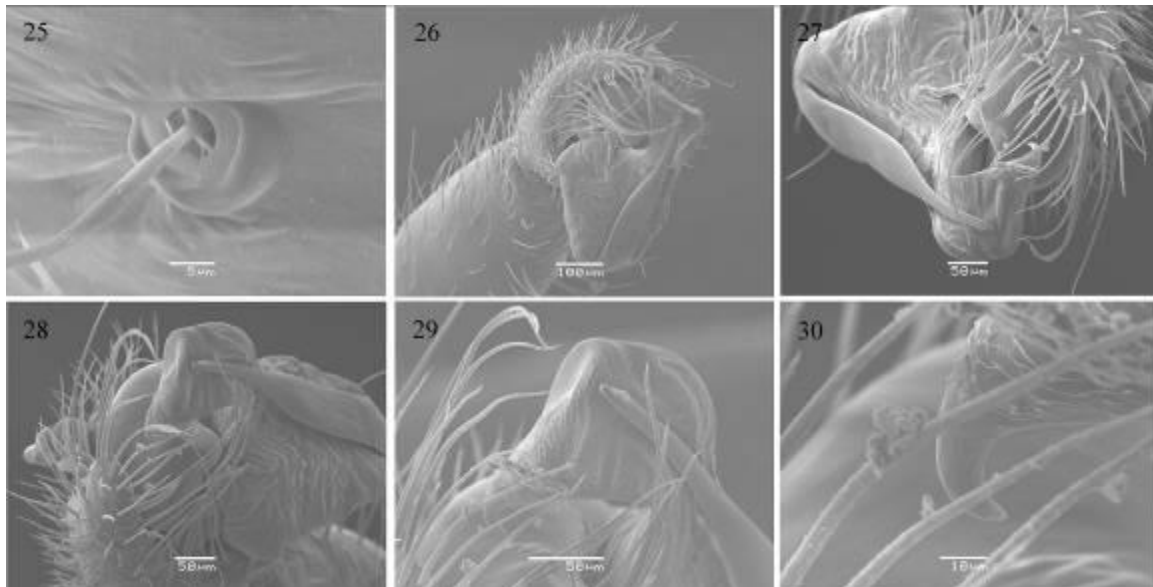
Palp: Haematodocha end in a very prominent, very long and slender ‘tooth’, with a straight and short embolus (Figs 31-33).

Measurements: CL 1.5-2.1; CW 1.0-1.6; AL 2.2-2.9; AW 1.3-1.4; TL 4.6-6.1. Length of legs: I 3.7-4.4; II 3.9-4.6; III 4.3-5.6; IV 4.6-6.1. Carapace index 1.5-1.8; patella-tibia index 0.67-0.6.

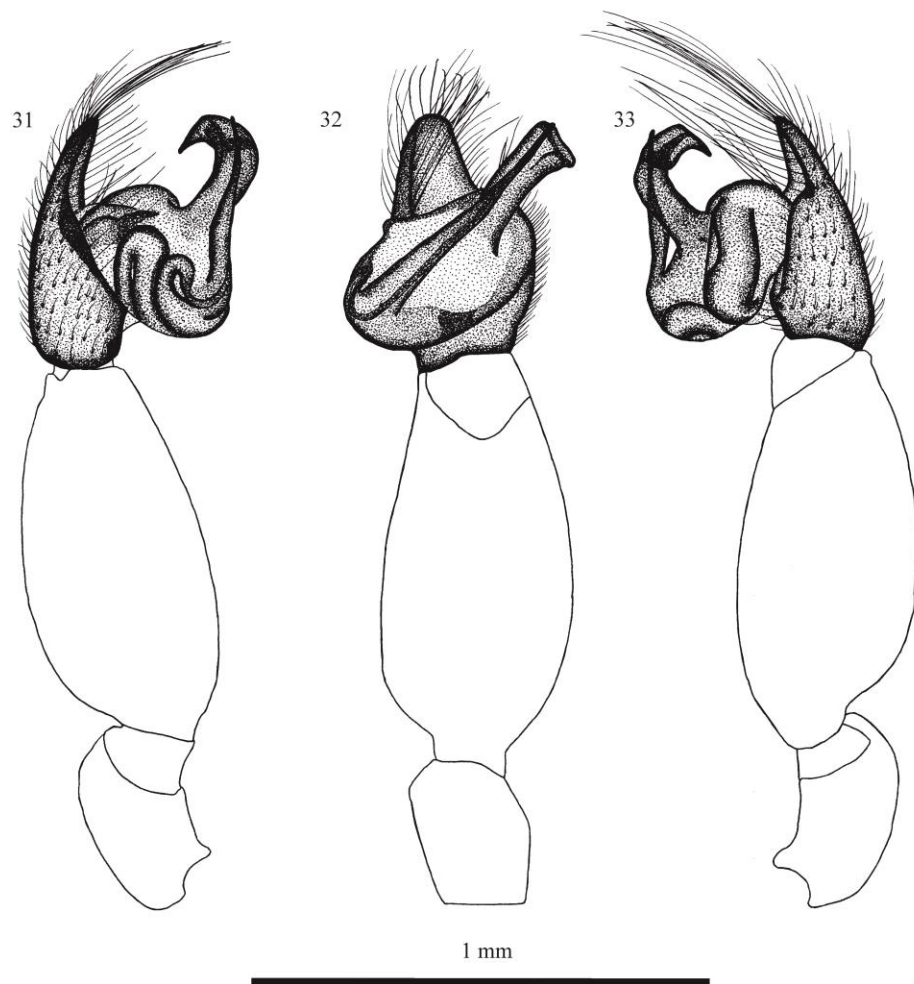
Female: Unknown.

Holotype and paratype ♂: NAMIBIA: Beisebvlakte, Etosha National Park, 18° 32’S, 17° 02’ E, 10-14.XI.1996, A. Russell-Smith (MRAC 215409).

Distribution: North-western Namibia (Fig. 64).



Figs 25-30. Scanning electron micrographs of *Calommata namibica* n. sp. (male): 25) trichobothrium on palpal tibia, 26) dorsal-lateral view of palp, 27) lateral view of haematodocha and embolus, 28) dorsal view of haematodocha and embolus, 29) dorsal view of end of haematodocha and embolus, enlarged, 30) lateral view of very prominent ‘tooth’ at distal end of haematodocha.



Figs 31-33. Left male palp of *Calommata namibica* n. sp.: 31) prolateral view, 32) ventral view, 33) retrolateral view.

5.4.7. *Calommata simoni* Pocock, 1903

Figs 5-6, 34-48

C. s. Pocock, 1903e: 259 (Df).

C. s. Benoit, 1967a: 283 (S).

C. s. Kraus, 1978: 245, Fig. 13 (f).

C. s. Dippenaar-Schoeman, 2002: 21, Fig. 9, 10a-g (Dm).

C. s. Jocqué & Dippenaar-Schoeman, 2006: 82, Fig. 18a-h (m).

Diagnosis: Female of this species has 11-12 teeth on chelicerae varying in size, in one row. Leg I have fewer spines (longer and thicker than bristles) than *Calommata transvaalica*. Leg II also has less spinules on retrolaterally than *C. transvaalica*. The male of this species is recognised by haematodocha ending broadly prominent ‘tooth’ and sharp edge, appearing to be a second ‘tooth’ under a light microscope (Figs 42-48).

Description:

Female from Cameroon (Fig. 5). Female robustly built. Chelicerae robustly built and stained darker at margins. Carapace longer than wide. Eye area raised, narrow, sloping sharply at fovea. Single median line running from anterior of eye area to approximately middle of chilum. Endites strongly elongated prolaterally. Legs short and stout. Legs III and IV more robust than legs I and II. Leg I not covered with bristles or spinules. Leg II with few spinules on patellae, several spinules on tibiae and metatarsi. Legs III and IV with spinules from patellae to tarsi (mainly dorsal and prolateral) and covered in bristles. Abdomen globose and pale grey with pattern on anterior half of abdomen (Fig. 5). Colour has likely faded over time in 70 % ethanol.

Measurements: CL 7.8-10.0; CW 4.6-6.6; AL 11.9-16.9; AW 7.7-11.6; TL 23.3-33.9. Length of legs –I 7.3-9.4; II 8.2-11.1; III 8.3-12.3; IV 8.7-14.2. Carapace index 1.7-1.5; patella-tibia index 0.3-0.4.

Male from Cameroon (Fig. 6). Carapace and chelicerae brown. Carapace in ovoid form with anteriorly expanded/extended membranous portion exposing the chilum. Eye area raised, narrow, darker in colour. Sternum and coxae light yellowish brown, rest of legs brown, fading to light yellow at tarsi. Legs weakly covered with bristles; prolateral side of patellae, tibiae and metatarsi of legs II-IV covered with spinules. Tarsi with fine ventral scopulae comprising setae with round tips (Fig. 42). Abdomen light grey brown scutum present in the anterior half (Fig. 6). Trichobothriae present on palpal tibia (Fig. 36).

Palp: Haematodocha end broadly distally with a prominent 'tooth' and sharp edge opposite the 'tooth', appearing as a second 'tooth'. Embolus straight and short (Figs 46-48).

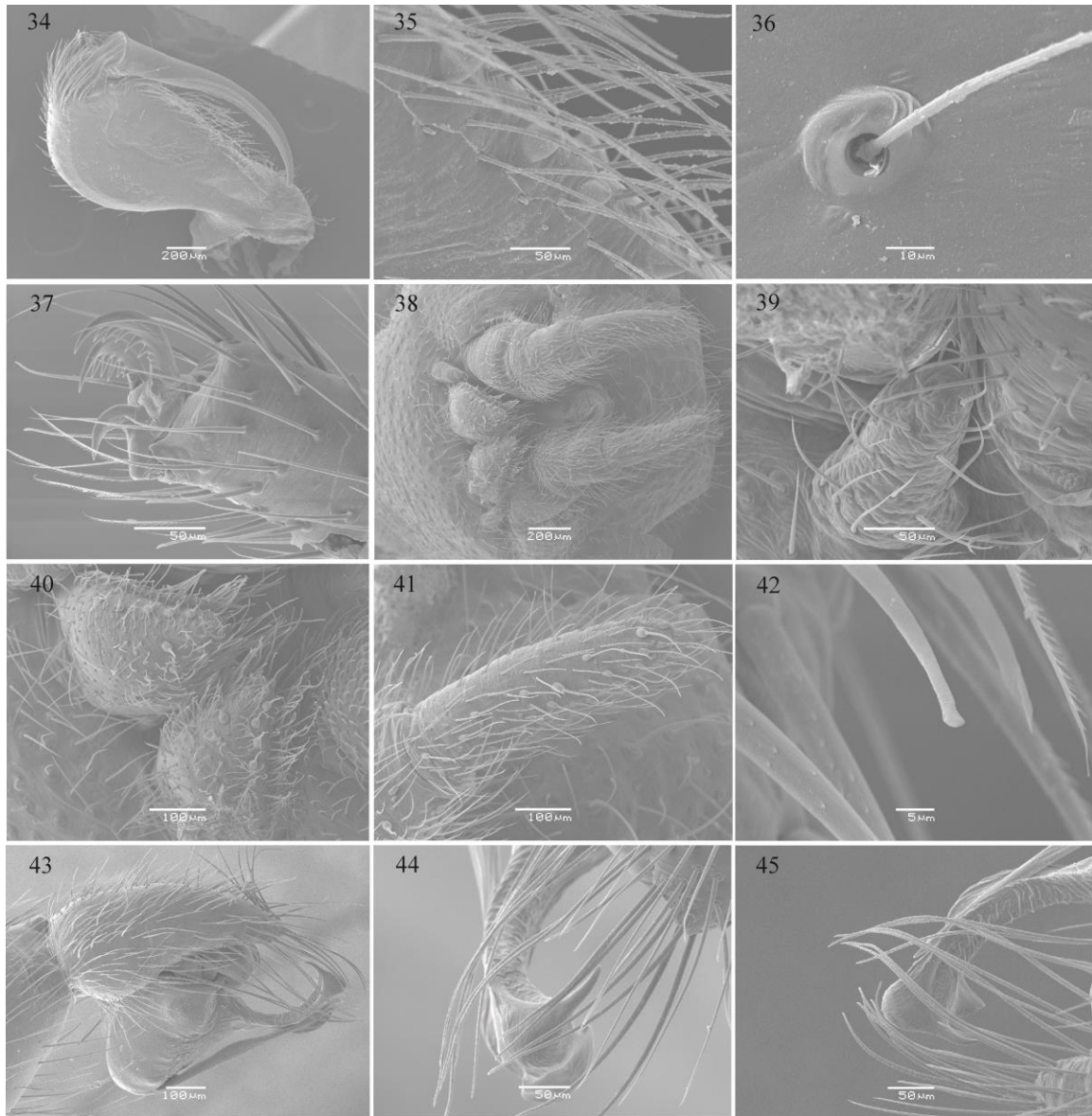
Measurements: CL 1.9-2.1; CW 1.5-1.7; AL 2.6-2.8; AW 1.6-2.1; TL 6.1-7.0. Length of legs: I 5.6-7.8; II 6.2-8.1; III 6.8-8.8; IV 8.1-11.2. Carapace index 1.2-1.2; patella-tibia index 1.0-1.2.

Holotype ♀: CAMEROON: Efulen, G.L. Bates. Deposited in British Museum (not examined).

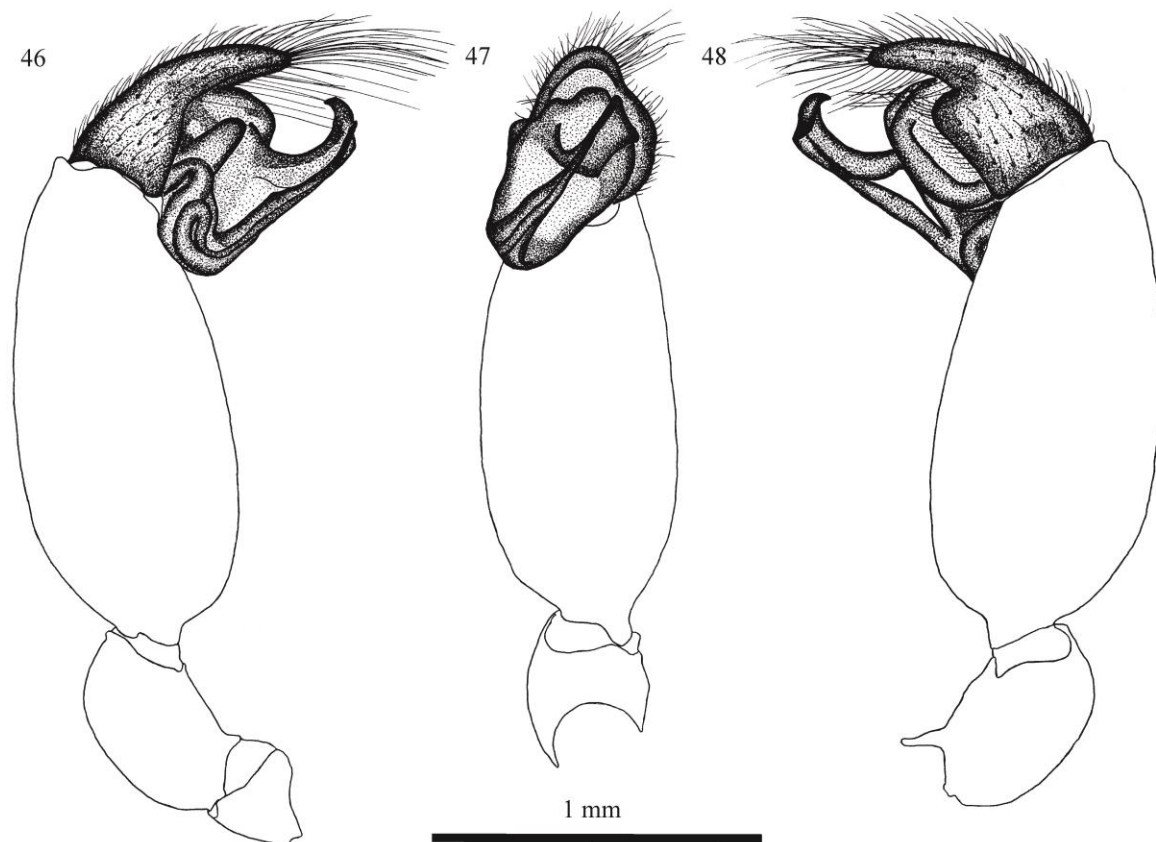
Other material examined: CAMEROON: 3 ♂ Dja Nature Reserve, 13°14'N, 003°41'E, 8.III.2005, I. Deblauwe, old secondary forest, pitfall (MRAC 220674); 1 ♂ Same locality, 8.III.2005, I. Deblauwe, riverine forest, pitfall (MRAC 220663); 6 ♂ Same locality, 8.III.2005, I. Deblauwe, young secondary forest, pitfall (MRAC 220659); 1 ♂ Same locality, 6.V.2005, I. Deblauwe, riverine forest, pitfall (MRAC 219754); 1 ♀ Galim, 15.VIII-19.VIII.1971, F. Puylaert (MRAC 143.671). CONGO, D.R.: 1 ♂ Kisangani, Masako forest, 00°35'N, 025°11'E, 25.II.2003, J.L. Juakaly (MRAC 216031); 3 ♂ Same locality 11.III.2003, J.-L. Juakaly, primary forest, pitfall (MRAC 214347, 214354, 214385); 1 ♀ Kisantu, 05°08'S, 015°06'E, 1927, R. Vanderyst (MRAC 5201). COTE D'IVOIRE: 1 ♂ Appouesso, Bossematié forest, 06°35'N, 003°28'W, 19.IX.1994, R. Jocqué & N. Séabé, rain forest, pitfall traps (MRAC 202481); 1 ♂ Same locality, 12.III.1995, R. Jocqué & Tanoh, forest, pitfall (MRAC 205382); 1 ♂ Same locality, 26.III.1995, R. Jocqué & Tanoh, forest, pitfall (MRAC 205383). GUINÉE: 3 ♂ F.C. de Ziam, 08°24'N, 009°17'W, 22.IV.1998, D. Flomo, rain forest, pitfalls (MRAC 216239); 2 ♂ Same locality, 31.III.1999, D. Flomo, rain forest, pitfalls, (MRAC 216245; 216246); 2 ♂ Same locality, 22.V.1999, D. Flomo, rain forest, pitfalls (MRAC 216240); 1 ♂, 2 ♂, 1 ♂ Same locality, 9.V.1999, D. Flomo, rain forest, pitfalls (MRAC 216242, 216243, 216244); 3 ♂ Same locality, 14.VI.1999, D. Flomo, rain forest, pitfalls (MRAC 216247, 216250, 216251); 2 ♂, 2 ♂ Same locality, 14.VI.1999, D. Flomo, rain forest, pitfalls (MRAC 216248, 216249); 1 ♂ Same locality, 17.VI.1999, D. Flomo, rain forest, pitfalls (MRAC 216241). MALAWI: 2 ♂ S. Chintcheche, Chisasira forest, 11°50'S, 33°13'E,

1.XII.1977, R. Jocqué, pitfall, Brachystegia Woodland (MRAC 169498, 169499).
KENYA: 1 ♂ Kakamega Forest, Alt: 1626 m, 24.I.2002, D. Shilabira Smith, pitfall trap
(MRAC 228141); 1 ♂ Same locality, 00°13'N, 034°54'E, 13.IV.2002, D. Shilabira
Smith, pitfall trap (MRAC 220536). TANZANIA: 1 J Bunduki, Uluguru Mountains,
07°02'S 037°38'E, 2.V.1957, P. Basilewsky & N. Leleup, Nest, forest ground (MRAC
111792)

Distribution: Widespread across tropical Africa and savanna woodlands (Fig. 64).



Figs 34-45. Scanning electron micrographs of *Calommata simoni* Pocock, 1903 (male): 34) retrolateral view of chelicerae, 35) teeth on chelicerae, 36) trichobothrium on palpal tibia, 37) lateral view of tarsal claws on leg IV, 38) dorsal view of spinnerets, 39) anterior lateral spinneret, 40) posterior median spinneret, 41) posterior lateral spinneret, 42) scopulae present on ventral side of tarsus IV, 43) prolateral view of palp, 44) dorsal view of haematodocha, 45) prolateral view of haematodocha.



Figs 46-48. Left male palp of *Calommata simoni* Pocock, 1903: 46) prolateral view, 47) ventral view, 48) retrolateral view.

5.4.8. *Calommata tibialis* n. sp.

Figs 7, 49-60

Etymology: This species is named for the male's distinctly shorter, more swollen palpal tibia compared to other African congeners.

Diagnosis: The male of the species can be recognised by the short, swollen palpal tibia and the narrow haematodocha ending in thick prominent 'tooth' (Figs 53-60). The carapace is nearly equal in length and width (Fig. 7).

Description:

Holotype male from Togo (Fig. 7). Carapace and chelicerae orange brown. Eye area raised, narrow, darker in colour. Sternum and coxae yellow, remainder of legs orange, fading to pale yellow at tarsi. Legs weakly covered with bristles; prolateral side of patellae, tibiae and metatarsi of legs II-IV covered with spinules. Tarsi with fine ventral scopulae comprising setae with sharp tip (Fig. 51-52). Abdomen pale grey with pale brown scutum in anterior half (Fig. 7). Specimens have likely faded over time in 70% ethanol.

Palp: Tibia short and more swollen than other five species. The narrow haematodocha end in a thick prominent 'tooth'. Embolus straight and short (Figs 58-60).

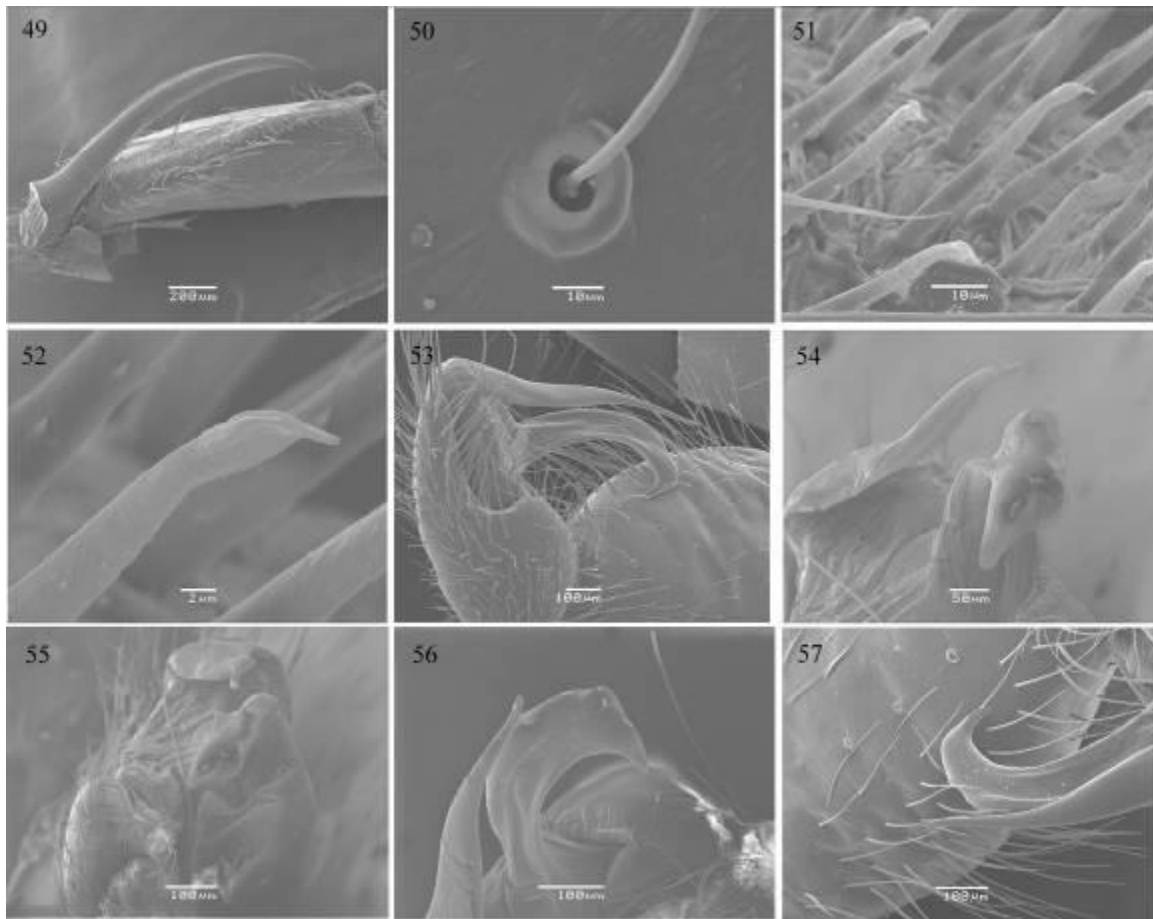
Measurements: CL 1.7-1.8; CW 1.6-1.8; AL 2.5-3.9; AW 1.9-2.0; TL 5.8-6.5. Length of legs: I 5.4-6.8; II 6.8-7.0; III 7.1-7.2; IV 7.3-8.3. Carapace index 1.1-1.0; patella-tibia index 0.9-0.9.

Female: Unknown.

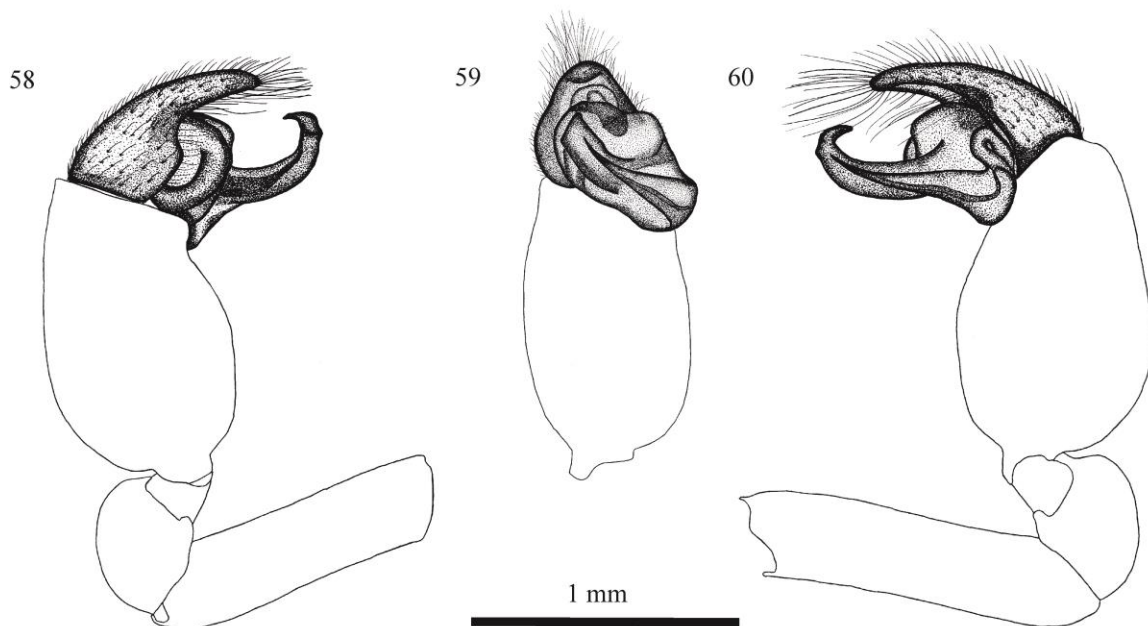
Holotype ♂ and paratype ♂: TOGO: Between Bassari and Sokodé, 09°15'N, 00°47'E, V-VII.1984, P. Douben, pitfall in wooded savanna (MRAC 169501).

Other material examined: IVORY COAST: 2 ♂ Kossou 06°57'N, 04°58'W, 28.IV.1975, R. Jocqué, pitfall, wooded savanna (MRAC 169500).

Distribution: Central Ivory Coast and northern Togo in woodland savanna (Fig. 64).



Figs 49-57. Scanning electron micrographs of *Calommata tibialis* n. sp. (male): 49) ventral view of chelicerae, 50) trichobothrium on palpal tibia, 51) scopula present on ventral side of tarsi, 52) lateral view of scopular setae, enlarged, 53) prolateral view of palp, 54) dorsal view of haematodocha and embolus, 55) dorsal-lateral view of haematodocha and embolus, 56) retrolateral view of haematodocha and embolus, 57) lateral view of haematodocha tip.



Figs 58-60. Right male palp of *Calommata tibialis* n. sp.: 58) retrolateral view, 59) ventral view, 60) prolateral view.

5.4.9. *Calommata transvaalica* Hewitt, 1916 stat. nov.

Figs 8-9, 61-63

C. transvaalica Hewitt, 1916b: 180, Fig. 3, pl. 26, Fig. 11 (Df) revalidated

Diagnosis: Female of this species has 11-12 teeth on chelicerae varying in size. In one specimen, 4 teeth were present prolaterally from the other teeth, forming its own row. Leg I have more spines than *C. simoni*. Leg II has more spinules retrolaterally than *C. simoni*. The male of species recognised by the hip of the haematodocha (where the haematodocha is connected to the bulbus) that is positioned near the retrolateral margin of the cymbium, ending broadly with 'one tooth' (Figs 61-63), and the straight embolus orientated transversely (Fig. 62).

Description:

Female from Blouberg Nature Reserve (Fig. 8). Robustly built. Chelicera robust and stained darker at margins. Eye area raised, narrow, sloping sharply at fovea. Single median line running from anterior of eye area to approximately middle of chilum. Endites strongly elongated and slender prolaterally. Legs short and stout. Legs III and IV more robust than legs I and II. Leg I with three to five spines on patellae and two on tibiae. Leg II with few spinules on patella and several spinules on tibia and metatarsus. Legs III and IV have spinules from patella to tarsus (mainly dorsal and prolateral). Legs II to IV covered in bristles. Abdomen globose and pale grey, with pattern on anterior half (Fig. 8). Colour has likely faded over time in 70 % ethanol.

Measurements: CL 5.8-10.0; CW 3.9-5.5; AL 11.9-12.5-; AW 5.6-7.7; TL 20.5-22.3. Length of legs: I 5.8-9.4; II 6.0-10.1; III 6.8-10.9; IV 7.5-12.5. Carapace index 1.5-1.8; patella-tibia index 0.3-0.32.

Male from Groenkloof Nature Reserve, South Africa (Fig. 9). Carapace and chelicerae dark brown in colour. Carapace almost oval in shape. Eye area raised, narrow, darker in colour. Sternum and coxae yellow-brown, femora, patellae and tibiae brown, metatarsi yellow-brown, tarsi yellow. Legs weakly covered with bristles; prolateral side of patellae, tibiae and metatarsi of legs II-IV covered with spinules. Abdomen dark grey in colour brown scutum present in the anterior half (Fig. 9).

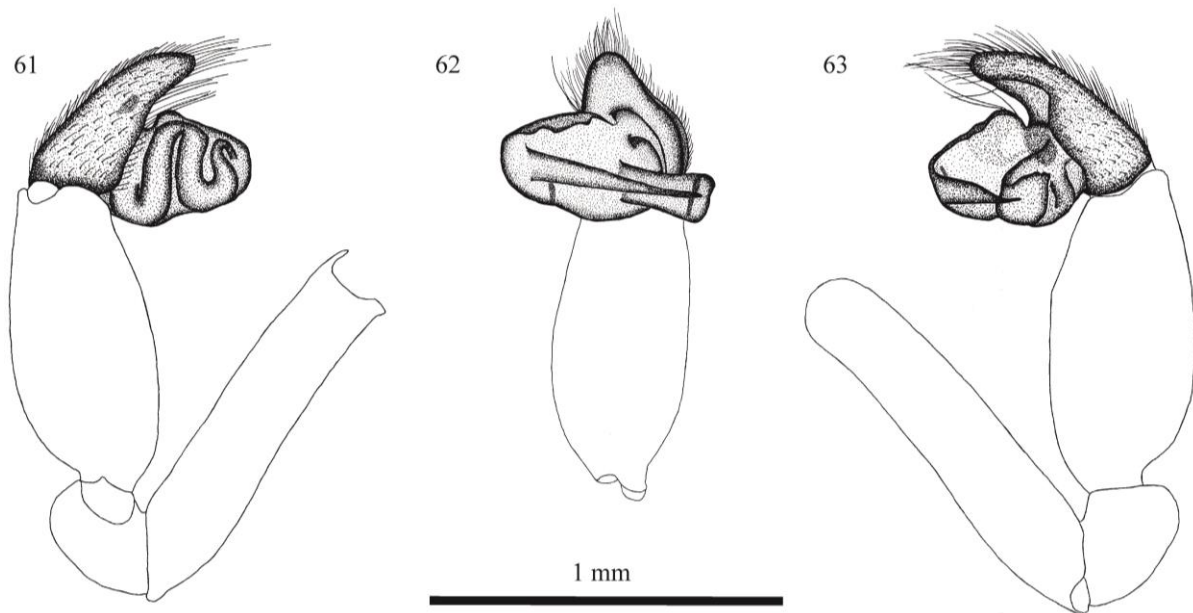
Palp: The hip of the haematodocha is positioned near the retrolateral margin of the cymbium, ending broadly distally with 'one tooth', and the straight, short embolus is orientated transversely (Figs 61-63).

Measurements: CL 1.9-2.0; CW 1.5-1.8; AL 2.5-2.6; AW 1.5-1.8; TL 6.2-6.4. Length of legs: I 4.9-6.0; II 5.2-6.2; III 5.6-6.4; IV 6.8-7.7. Carapace index 1.2-1.1; patella-tibia index 0.6-0.9.

Holotype: 1 ♀ SOUTH AFRICA: *Gauteng Province*, Pretoria district, Roodeplaat, 3.IV.1915, G. van Dam (TMSA 2999 - examined).

Other material examined: SOUTH AFRICA: 1 ♀ *Gauteng Province*, Pretoria district, Hatfield, 25.IV.1915, G. van Dam (TMSA 4639); 1 ♂ *Gauteng Province*, Groenkloof Nature Reserve, 21.I.2003, M. Forsythe, reptile trap (NCA 2004/750). 1 ♂ *Limpopo Province*, Blouberg Nature Reserve, 23°00.065'S, 29°03.855, 29.XI.2005, A. Dawood, searching below the knee, *Philenoptera violaceae* (NCA 2009/3665); 1 ♀ *Limpopo Province*, Zoutpansberg district, Wilhan's Hohe, Blouberg, 28.VIII.1923, G.P.F. van Dam (TMSA 2772); 1 ♀ Same locality, 29.VIII.1923, G.P.F. van Dam (TMSA 2773).

Distribution: Limpopo Province and Gauteng Province, South Africa (Fig. 64).



Figs 61-63. Left male palp of *Calommata transvaalica* Hewitt, 1916: 61) prolateral view, 62) ventral view, 63) retrolateral view.

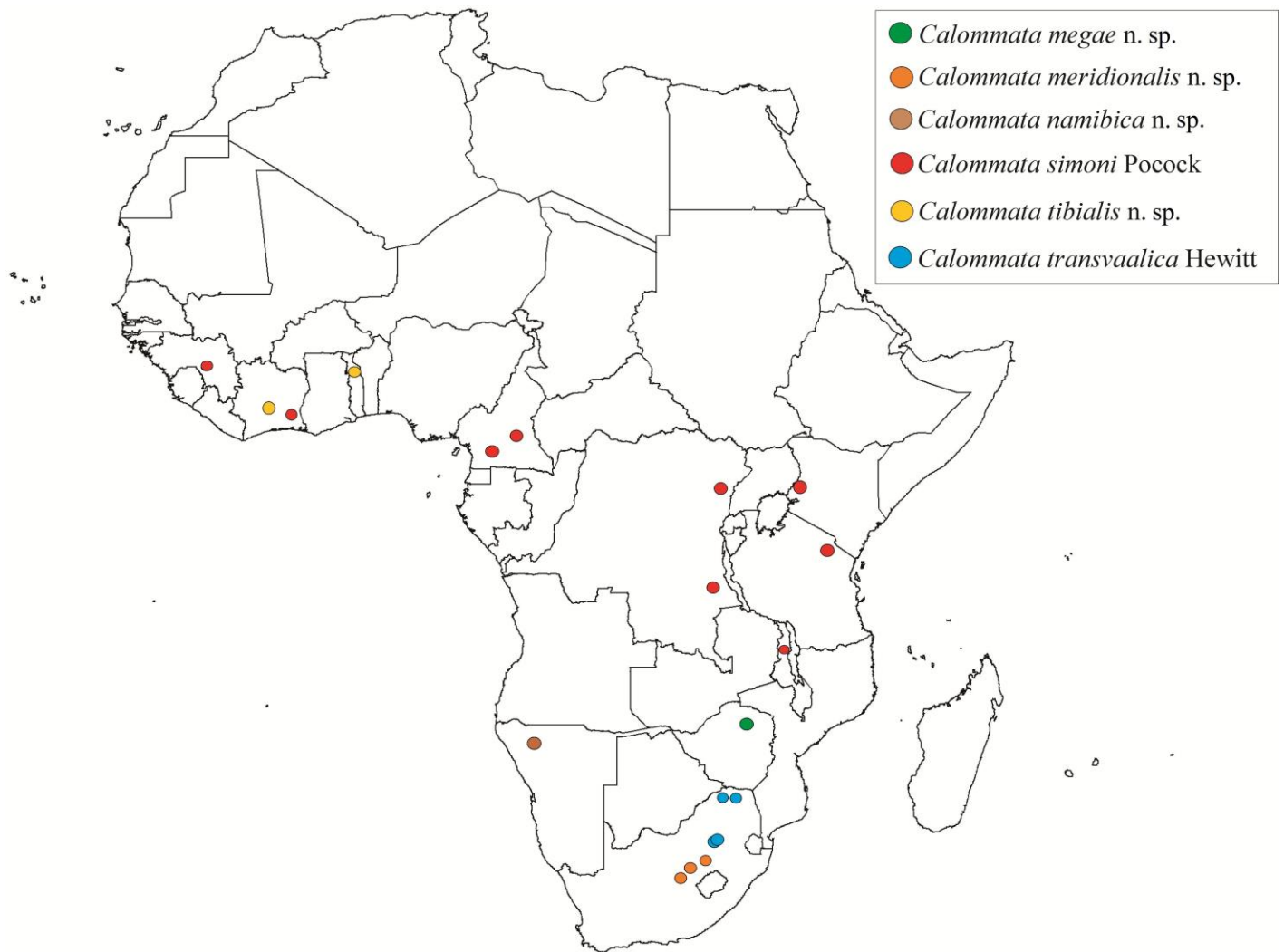


Fig. 64. The distribution of the six species of *Calommata* in the Afrotropical Region.

5.5. Biology of *Calommata meridionalis* n. sp.

5.5.1. Preferences for soil characteristics: The pH levels for the soil samples in the six sites were relatively similar, falling in the range of 5.3 to 5.8. The six samples seem to be slightly acidic in character (Appendix A). This might be a soil character for the whole Erfenis Dam Nature Reserve (EDNR). Calcium is the element that was highest in concentration followed by magnesium and potassium. In unburned site three, these elements were present in low concentrations. Loam percentages were highest in the burned sites and sand percentages were highest in the unburned sites. The percentages of

clay were mostly the same throughout the six sites, but were lowest in unburned sites two and three. None of the elements or soil characteristics had a definite influence on the occurrence of *Calommata meridionalis* n. sp. in the reserve. *C. meridionalis* n. sp. is most common in soil where the sand percentages are low and loam percentages are high (B-2) (Appendix A; Fig. 65).

5.5.2. Phenology: Eight *C. meridionalis* n. sp. males were caught in October and November 2005 in four of the six sites sampled in EDNR, with four males collected in each month (Fig. 65). During the pitfall trapping carried out in the central and northern Free State from September to November 2009, *C. meridionalis* n. sp. were collected only at Oranjeville (northernmost locality) and Bloemfontein (southernmost locality) (Fig. 66). Surprisingly, no material was collected EDNR, despite pitfalls being set out in three of the four sites where *C. meridionalis* n. sp. was sampled in 2005 (Fig. 65), as well as five additional sites in the reserve.

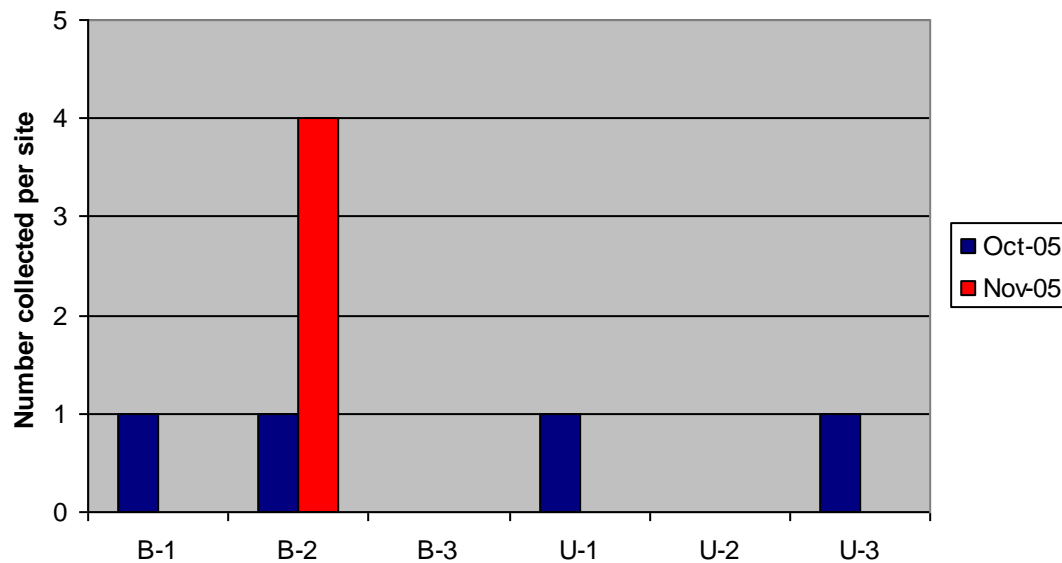


Fig. 65. The number of *C. meridionalis* n. sp. caught in each of the six pitfall trap sites in EDNR from October 2005 to September 2006. Specimens were only collected in October (blue) and November (red). Site abbreviations: B-1 - burned site 1; B-2 - burned site 2; B-3 - burned site 3; U-1 - unburned site 1; U-2 - unburned site 2 and U-3 - unburned site 3.

Males seem to be most active in October and November as all specimens from the Free State Province were collected during these months (Fig. 66).

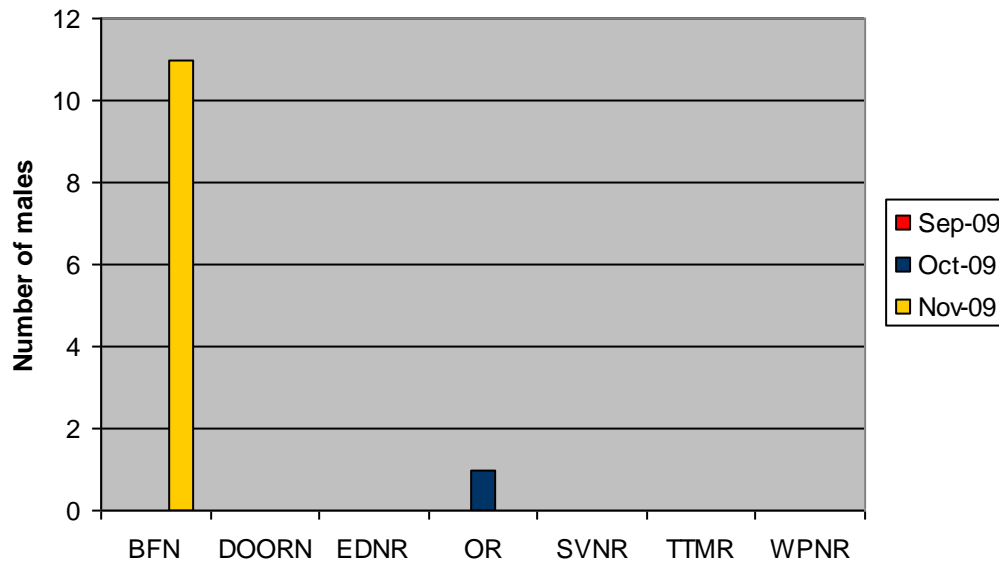


Fig. 66. The number of *Calommata meridionalis* n. sp. collected in six localities in the northern and central Free State Province from September – November 2009. Site abbreviations: BFN – National Botanical Gardens in Bloemfontein, DOORN – Doornkloof farm, EDNR – Erfenis Dam Nature Reserve, OR – Vaal Dam in Orangeville district, SVN – Sandveld Nature Reserve, TTMR – Thabela Thabang Mountain Retreat, and WPNR – Willem Pretorius Nature Reserve.

5.5.3. Grid transects for web location: No webs were found with this method. A new, more effective method is needed to find the webs.

5.6. Discussion

Four new species have been added to the genus in the Afrotropical Region and *Calommata transvaalica* from South Africa was revalidated.

5.6.1. Natural history: What is known of the natural history of these spiders is mainly from literature since no burrows or live specimens were found during this study. Female *Calommata* were usually found in their burrows while males are probably free-living

burrowing spiders, as they are mostly collected by pitfall traps (Dippenaar-Schoeman 2002). All the males that were collected thus far in the Free State were collected between October and November, which indicates an increase in activity that is probably connected to reproduction. Charpentier (1995) found hatched egg-sacs of *C. simoni* in May in tropical Benin. It also seems that *Calommata* excavate their burrows near water, as most of the recent specimens that were sampled in EDNR, Vaaldam (near Oranjeville) and near the marsh in the Botanical Gardens in Bloemfontein. Charpentier (1995) reported that he collected twelve specimens of *C. simoni* in Benin, West Africa. Four of the burrows that were found were also in close proximity to water. In one of the habitats he found *Calommata*, the soil was described as sandy, of poor quality and relatively acidic, and covered in 'grassland' vegetation. The soil at the sites in EDNR ranged from sandy to loam with a relative content of clay, and the soil was slightly acidic.

Burrows are reported to have a silk lined entrance with an excavated ambush chamber that is lined with a silk layer that is used to trap prey, and that atypids live permanently in these burrows (Dippenaar-Schoeman 2002). Van Dam & Roberts (1917) collected *C. transvaalica* at Roodeplaat near Pretoria for the first time by a tuft of grass that was kicked up, which disclosed white webbing, and was found after heavy rain. They described the nests as slightly raised above the ground at the top, and then from the inner rim it neatly rounded off, gradually sloping outwards and downwards to the level of the ground with the outer surface covered with earth that resembled the surroundings. The webbing was adhesive, which probably affords the spider protection against the intrusion of enemies. The nests were deep (22 – 25 cm) and vertical for the greater part of their depth (Van Dam & Roberts 1917).

Prey capture by *Calommata* can be seen as unique. When an insect is walking over the aerial part it generates vibrations, which are then being transmitted to the purse-web spider below (Dippenaar-Schoeman 2002). The spider will then strike with its long fangs through the silk to impale the prey. Once the prey has been immobilized in this manner, the spider will then cut the silk with one fang and drag the prey through it. The prey remains as well as liquid droppings are subsequently ejected through an opening that

occurs at the top of the tube (Dippenaar-Schoeman 2002). Hewitt (1916) commented that *C. transvaalica* specimens had a very pronounced and objectionable odour and even compared it to decomposing stable manure.

5.6.2. Distribution: *Calommata* is a small genus which is known from Africa, Israel and South East Asia. Two species are present in West Africa, one species in Central Africa and four species in southern Africa. The type of habitat seems to play a role in separating the species biogeographically. *Calommata simoni* are mostly found in forests and *C. tibialis* n. sp. was found in wooded savanna in West Africa. In South Africa, *C. transvaalica* occurs in the Savanna biome and *C. meridionalis* n. sp. occurs in the Grassland biome (Fig. 66). *C. megae* n. sp. and *C. namibica* n. sp. also occur in contrasting moist and dry savanna types, respectively.

5.6.3 Conservation: *Calommata simoni* was submitted for the Red List Assessment in April 2008. During this process of assessment, questions regarding the taxonomic status of this species arose. After examination of the adult male specimens available in the National Collection of Arachnida by Dr Ansie Dippenaar Schoeman, it was found that at least three different species are present in southern Africa. The primary cause for uncertainty for addition to the Red List in the report was the current taxonomic status of the species and was included in the Data Deficient category for taxonomic reasons (Engelbrecht 2008). As the genus has been revised, it can be resubmitted to the Red Data List to conserve these spiders.

5.7. References

- BENOIT, P.L.G. 1967. Le genre *Calommata* Lucas en Afrique (Aran.-Orth.-Atypidae). *Bulletin et Annales de la Société royale entomologique de Belgique* **103**: 283-288.
- CHARPENTIER, P. 1995. New data on the African atypid spider *Calommata simoni*, Pocock Orthognatha Atypidae. *Journal of the British Tarantula Society* **10**: 81-86.

DIPPENAAR-SCHOEMAN, A.S. 2002. *Baboon and trapdoor spiders of southern Africa: an identification manual*. Plant Protection Research Institute Handbook No. 13. Agricultural Research Council, Pretoria. 128pp.

DIPPENAAR-SCHOEMAN, A.S. & HADDAD, C.R. 2008. *SANSA newsletter no. 5*. Agriculture Research Council, Pretoria. 17pp.

DIPPENAAR-SCHOEMAN, A.S. & JOCQUÉ, R. 1997. *African spiders, an identification manual*. Plant Protection Research Institute Handbook no. 9, Agricultural Research Institute, Pretoria. 392pp.

ENGELBRECHT, I. 2008. *Red List Assessment: The baboon spiders Harpactira hamiltoni Pocock 1904 and Brachionopus pretoriae Purcell 1904 (Araneae: Theraphosidae) and the African Purse Web Spider Calommata simoni Pocock 1903 (Araneae: Atypidae)*. Red list assessment report. Gauteng Department of Agriculture, Conservation and Environment, Johannesburg. 4pp.

GERTSCH, W.J. & PLATNICK, N.I. 1980. A revision of the American spiders of the Family Atypidae (Araneae, Mygalomorphae). *American Musuem Novitates* **2704**: 1-39.

HEWITT, J. 1916. Descriptions of new South African spiders. *Annals of the Transvaal Museum* **5**: 180-213.

LEVY, G. 2007. *Calommata* (Atypidae) and new spider species (Araneae) from Israel. *Zootaxa* **1551**: 1-30.

PLATNICK, N.I. 2009. *The World Spider Catalog, Version 10.0*. American Museum of Natural History. Available online at: <http://research.amnh.org/entomology/spiders/catalog/index.html>.

POCOCK, R.I. 1903. Some new spiders from the Camaroons collected by Mr G. L. Bates. *Annals and Magazine of Natural History* **11**: 258-264.

VAN DAM, G. & ROBERTS, A. 1917. Notes on nests of some trapdoor spiders and the nest of *Calommata transvaalicus* Hewitt. *Annals of the Transvaal Museum* **5**: 218-233.

5.8. Appendix A

Chemical and physical characteristics of soil samples taken by an auger from each of the three burned and the three unburned sites in Erfenis Dam Nature Reserve, Free State Province. Site abbreviations: B-1 - burned site 1; B-2 - burned site 2; B-3 - burned site 3; U-1 - unburned site 1; U-2 - unburned site 2 and U-3 - unburned site 3.

Sample	pH	P	K	Ca	Mg	Na	US	SV	Ca/Mg	(Ca+Mg)/K	KUK cmol _c kg ⁻¹	Sand	Clay	Loam
	(KCl)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)		%				%	%	%
B-1	5.8	3.9	277.1 (4)	2441 (75)	411.6 (21)	6.1 (0)	0.00	0.00	3.62	21.98	16.31	28	18	54
B-2	5.4	3.0	305.6 (4)	2328 (67)	616.6 (29)	4.7 (0)	0.00	0.00	2.30	21.36	17.49	21	18	61
B-3	5.4	4.8	351.2 (5)	2461 (67)	632.1 (28)	5.6 (0)	0.00	0.00	2.37	19.47	18.41	28	22	50
U-1	5.6	5.2	169.5 (3)	1478 (57)	600.7 (38)	46.5 (2)	0.00	0.00	1.50	28.40	12.95	43	20	37
U-2	5.4	1.3	244.6 (4)	1876 (61)	641.4 (34)	6.5 (0)	0.00	0.00	1.78	23.40	15.29	44	16	40
U-3	5.3	1.3	194.2 (7)	686 (47)	398.3 (45)	10.7 (1)	0.00	0.00	1.05	13.48	7.24	53	14	33

CHAPTER 6

**Concluding thoughts on spider
(Arachnida: Araneae) ecology in Erfenis
Dam Nature Reserve**

6.1. Check list of arachnofauna in Erfenis Dam Nature Reserve

The arachnofauna of Erfenis Dam Nature Reserve were determined through several studies from September 2005 to November 2009. The first study was to determine the ground-living spider community by pitfall trapping from September 2005 to September 2006. The second study was to determine the foliage- and -grass dwelling spider community by beating and sweeping netting from November 2005 to September 2007. A third study was initiated in September 2009 to November 2009 in an attempt to locate more specimens of *Calommata meridionalis* n. sp. by pitfall trapping. Active searching was also conducted in the reserve as a supplement to the other sampling methods. A checklist of the above studies was compiled and includes other non-acarine arachnids that were collected in the reserve as well. The guild classification of spiders follows Dippenaar-Schoeman *et al.* (1999) and Foord *et al.* (2002), which is summarised in Table 1 in Chapter 2.

Four orders of arachnids (Araneae, Pseudoscorpiones, Scorpiones and Solifugae) were collected with Araneae being the most abundant and species rich of the four orders. The Araneae was represented by 41 families, 114 determined genera and 235 species. All but one species, *Poachelas striatus* Haddad & Lyle, are new records for the reserve as this was the first intensive study that was done in the reserve. Fourteen new species were collected including the new *Calommata* species (Table 1). Of these species collected, 29.36 % were web-building spiders and 70.64 % were wandering spiders. The most species rich families were the Salticidae (n=32), followed by Gnaphosidae (n=24), Thomisidae (n=23), and Araneidae (n=22). With pitfall trapping, the most abundant species were *Ammoxenus amphalodes* Dippenaar & Meyer (n=915); with beats *Philodromus browningi* Lawrence (n=69); and with sweepnetting *Tibellus minor* Lessert (n=178).

Table 1. Checklist of non-acarine arachnids collected by various methods from September 2005 – November 2009, in the Erfenis Dam Nature Reserve, Free State Province. Guild abbreviations: BGW - burrow-living ground wanderer; GWB - gumfoot-web builder; FGW - free-living ground wanderer; FPW – free-living plant wanderer; FWB – Funnel-web builder; OWB – orb-web builder; RWB – retreat-web builder; SHWB – sheet-web builder; SPWB – space-web builder. Sampling method abbreviations: ASB- active searching, bark; ASG- active searching, grass tussocks; ASR- active searching, under rocks; BTS- beating foliage; LL-leaf litter; PTR-pitfall traps; SWN- sweep netting grassland, †- new species, ? – Dubious identification.

	GUILDS	SAMPLING METHODS
ARANEAE		
AGELENIDAE		
<i>Benoitia ocellata</i> (Pocock, 1900)	FWB	BTS, PTR
AMAUROBIIDAE		
<i>Macrobunus caffer</i> (Simon, 1898)?	FWB	PTR
<i>Obatala</i> sp. 1	FWB	PTR
<i>Obatala</i> sp. 2	FWB	PTR
<i>Pseudauximus</i> sp. 1	FWB	PTR
AMMOXENIDAE		
<i>Ammoxenus amphalodes</i> Dippenaar & Meyer, 1980	FGW	PTR
ARANEIDAE		
<i>Araneus</i> sp. 1	OWB	BTS
Araneidae sp. 1	OWB	BTS, SWN
Araneidae sp. 2	OWB	SWN
<i>Araniella</i> sp. 1	OWB	SWN
<i>Caerostris</i> sp. 1	OWB	BTS
<i>Cyclosa insulana</i> (Costa, 1834)	OWB	SWN
<i>Hypsosinga lithyphantoides</i> Caporiacco, 1947	OWB	BTS, PTR, SWN
<i>Hypsosinga</i> sp. 2	OWB	SWN
<i>Hypsosinga</i> sp. 3	OWB	SWN
<i>Kilima decens</i> (Blackwall, 1866)	OWB	PTR

<i>Kilima</i> sp. 2†	OWB	SWN
<i>Kilima</i> sp. 3?	OWB	SWN
<i>Larinia</i> sp. 1?	OWB	SWN
<i>Lipocrea longissima</i> (Simon, 1881)	OWB	BTS, SWN
<i>Nemoscolus cotti</i> Lessert, 1933	OWB	ASG, SWN
<i>Neoscona blondeli</i> (Simon, 1886)	OWB	BTS, SWN
<i>Neoscona moreli</i> (Vinson, 1863)	OWB	PTR
<i>Neoscona rapta</i> Thorell, 1899	OWB	BTS
<i>Neoscona subfusca</i> (C.L. Koch, 1837)	OWB	BTS
<i>Pararaneus cyrtoscapus</i> (Pocock, 1898)?	OWB	PTR
<i>Pararaneus</i> sp. 2	OWB	BTS
<i>Pararaneus</i> sp. 3?	OWB	BTS
ATYPIDAE		
<i>Calommata meridionalis</i> n. sp.	BGW	PTR
CAPONIIDAE		
<i>Caponia hastifera</i> Purcell, 1904	FGW	ASG, ASR, PTR
CLUBIONIDAE		
<i>Clubiona</i> sp. 1	FPW	BTS, SWN
<i>Clubiona</i> sp. 2	FPW	ASG
CORINNIDAE		
<i>Cambalida fulvipes</i> (Simon, 1896)	FGW	PTR
<i>Castianeira</i> sp. 1	FGW	LL, PTR
<i>Cetonana</i> sp. 1†	FPW	ASB
<i>Copa flavoplumosa</i> Simon, 1885	FGW	PTR
<i>Copa lacustris</i> Strand, 1916	FGW	ASB, ASG
<i>Copa</i> sp. 3†	FGW	ASR, BTS, PTR
<i>Graptartia mutillica</i> Haddad, 2004	FGW	PTR
<i>Orthobula</i> sp. 1†	FGW	ASG, PTR
<i>Poachelas striatus</i> Haddad & Lyle, 2008	FGW	ASG, PTR, SWN
<i>Thysanina absolve</i> Lyle & Haddad, 2006	FGW	ASG, PTR, SWN
<i>Trachelas pusillus</i> Lessert, 1923	FGW	ASG, PTR

<i>Zelotes frenchi</i> Tucker, 1923	FGW	ASR, PTR
<i>Zelotes fuligineus</i> (Purcell, 1907)	FGW	PTR
<i>Zelotes sclateri</i> Tucker, 1923	FGW	ASR
<i>Zelotes scrutatus</i> (O. P.-Cambridge, 1872)	FGW	PTR
<i>Zelotes zonognathus</i> (Purcell, 1907)	FGW	PTR
<i>Zelotes</i> sp. 6	FGW	SWN
<i>Zelotes</i> sp. 7	FGW	PTR
<i>Zelotes</i> sp. 8	FGW	PTR
<i>Zelotes</i> sp. 9	FGW	PTR
HAHNIIDAE		
<i>Hahnia tabulicola</i> Simon, 1898	SHWB	PTR
HERSILIIDAE		
<i>Tyrotama australis</i> (Simon, 1893)	FPW	ASR, PTR
IDIOPIDAE		
<i>Galeosoma</i> sp. 1	BGW	PTR
<i>Segregara monticola</i> Hewitt, 1916	BGW	PTR
LINYPHIIDAE		
<i>Meioneta habra</i> Locket, 1968	SHWB	PTR
<i>Meioneta</i> sp. 2	SHWB	ASG, PTR
<i>Metaleptyphantes familiaris</i> Jocqué, 1984?	SHWB	PTR
<i>Microlinyhia sterilis</i> (Pavesi, 1883)	SHWB	BTS, SWN
<i>Ostearius melanopygius</i> (O. P.-Cambridge, 1879)	SHWB	PTR, SWN
<i>Pelecopsis janus</i> Jocqué, 1984	SHWB	PTR
Linyphiidae sp. 1	SHWB	PTR, SWN
Linyphiidae sp. 2	SHWB	PTR, SWN
Linyphiidae sp. 3	SHWB	PTR, SWN
Linyphiidae sp. 4	SHWB	PTR
Linyphiidae sp. 5	SHWB	PTR
LIOCRANIDAE		
<i>Rhaeboctesis secundus</i> Tucker, 1920	FGW	PTR
<i>Rhaeboctesis</i> sp. 2	FGW	PTR, SWN

LYCOSIDAE

<i>Allocosa tuberculipalpa</i> (Caporiacco, 1940)?	FGW	PTR
<i>Amblyothele albocincta</i> Simon, 1910	FGW	PTR
<i>Evippomma squamulatum</i> (Simon, 1898)	FGW	ASR, PTR
Lycosidae sp. 1	FGW	SWN
Lycosinae sp. 1	FGW	PTR
Lycosinae sp. 2	FGW	PTR
Pardosinae sp. 1	FGW	PTR
<i>Pardosa crassipalpis</i> Purcell, 1903	FGW	PTR
<i>Pardosa</i> sp. 1	FGW	SWN
<i>Proevippa</i> sp. 1†	FGW	PTR, SWN
<i>Proevippa</i> sp. 2	FGW	PTR
<i>Proevippa</i> sp. 3	FGW	PTR
<i>Trabea purcelli</i> Roewer, 1951	FGW	ASG, BTS
<i>Zenonina</i> sp. 1	FGW	ASR, PTR

MIMETIDAE

<i>Ero</i> sp. 1	FGW	PTR
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MITURGIDAE

<i>Cheiramiona florisbadensis</i> Lotz, 2003	FPW	PTR, SWN
<i>Cheiracanthium furculatum</i> Karsch, 1879	FPW	BTS, SWN
Miturgidae sp. 1	FPW	SWN

MYSMENIDAE

Mysmenidae sp. 1	OWB	BTS
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OONOPIDAE

Oonopidae sp. 1	FGW	ASR
Oonopidae sp. 2	FGW	ASR

ORSOLOBIDAE

<i>Afrilobus</i> sp. 1	FGW	PTR
<i>Azanialobus</i> sp. 1†	FGW	PTR

OXYOPIDAE

<i>Oxyopes affinis</i> Lessert, 1915?	FPW	BTS, SWN
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<i>Oxyopes jacksoni</i> Lessert, 1915	FPW	SWN
<i>Oxyopes russoi</i> Caporiacco, 1940	FPW	ASG, BTS, SWN
<i>Oxyopes</i> sp. 4	FPW	PTR
<i>Oxyopes</i> sp. 5	FPW	BTS
<i>Oxyopes</i> sp. 6	FPW	SWN
<i>Peucetia striata</i> Karsch, 1878?	FPW	SWN
PALPIMANIDAE		
<i>Palpimanus</i> sp. 1	FGW	PTR
PHILODROMIDAE		
<i>Gephyrota</i> sp. 1	FGW	BTS, SWN
<i>Philodromus browningi</i> Lawrence, 1952	FGW	BTS
<i>Philodromus</i> sp. 2	FGW	SWN
<i>Philodromus</i> sp. 3	FGW	BTS
<i>Philodromus</i> sp. 4	FGW	BTS
<i>Suemus</i> sp. 1	FGW	PTR, SWN
<i>Suemus</i> sp. 2?	FGW	PTR
<i>Tibellus hollidayi</i> Lawrence, 1952	FGW	SWN
<i>Tibellus minor</i> Lessert, 1919	FGW	BTS, PTR, SWN
<i>Thanatus dorsilineatus</i> Jézéquel, 1964?	FGW	SWN
<i>Thanatus vulgaris</i> Simon, 1870	FGW	PTR, SWN
PHOLCIDAE		
<i>Smeringopus sambesicus</i> Kraus, 1957	SPWB	BTS
PHYXELIDIDAE		
<i>Vidole sothoana</i> Griswold, 1990	FWB	PTR
PISAUROIDAE		
<i>Cispus kimbius</i> Blandin, 1978	FPW	ASR
<i>Euprosthénops</i> sp. 1	FWB	PTR
PRODIDOMIDAE		
<i>Theuma capensis</i> Purcell, 1907	FGW	ASR, PTR
<i>Theuma fusca</i> Purcell, 1907	FGW	PTR
<i>Theuma schreineri</i> Purcell, 1907	FGW	PTR

SALTICIDAE

<i>Baryphas ahenus</i> Simon, 1902	FPW	BTS
<i>Cyrba nigrimana</i> Simon, 1900	FGW	ASR
<i>Evarcha prosimilis</i> Wesolowska & Cumming, 2008	FPW	BTS
<i>Evarcha</i> sp. 2†	FGW	PTR
<i>Heliophanus charlesi</i> Wesolowska, 2003?	FPW	SWN
<i>Heliophanus debilis</i> Simon, 1901	FPW	BTS, SWN
<i>Heliophanus nanus</i> Wesolowska, 2003	FPW	BTS, SWN
<i>Heliophanus pistaciae</i> Wesolowska, 2003	FPW	BTS, PTR, SWN
<i>Heliophanus proshynskii</i> Wesolowska, 2003	FPW	PTR, SWN
<i>Heliophanus transvaalicus</i> Simon, 1901	FPW	BTS
<i>Nigorella hirsuta</i> Wesolowska, 2009	FGW	PTR
<i>Pellenes bulawayoensis</i> Wesolowska, 1999	FGW	PTR, SWN
<i>Pellenes geniculatus</i> (Simon, 1868)	FGW	PTR
<i>Pellenes tharinae</i> Wesolowska, 2006	FGW	PTR
<i>Pellenes</i> sp. 4†	FGW	PTR
<i>Phlegra bresnieri</i> (Lucas, 1846)	FGW	PTR
<i>Phlegra karoo</i> Wesolowska, 2006	FGW	PTR, SWN
<i>Phlegra</i> sp. 3†	FGW	PTR
<i>Phintella aequipes</i> (Peckham & Peckham, 1903)	FPW	BTS
<i>Pignus</i> sp. 1†	FGW	PTR
<i>Pseudicius</i> sp. 1	FPW	BTS
<i>Pseudicius</i> sp. 2	FPW	BTS
<i>Rhene</i> sp. 1†	FPW	BTS
<i>Rhene</i> sp. 2?	FPW	SWN
Salticidae sp. 1	FPW	BTS, SWN
Salticidae sp. 2	FPW	SWN
<i>Tanzania</i> sp. 1†	FGW	PTR
<i>Thyene aperta</i> (Peckham & Peckham, 1903)	FPW	PTR, SWN
<i>Thyene inflata</i> (Gerstäcker, 1873)	FPW	SWN
<i>Thyene semiargentea</i> (Simon, 1884)	FPW	SWN
<i>Thyene</i> sp. 4	FPW	BTS
<i>Tusitala</i> sp. 1	FPW	BTS

SCYTODIDAE

<i>Scytodes</i> sp. 1	FGW	ASR, PTR
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SELENOPIIDAE

<i>Anyphops</i> sp. 1	FGW	ASR, LL
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SPARASSIDAE

<i>Olios correvoeni</i> Lessert, 1921	FGW	SWN
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<i>Pseudomicrommata longipes</i> (Bösenberg & Lenz, 1895)	FPW	BTS
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TETRAGNATHIDAE

<i>Tetragnatha ceylonica</i> O. P.-Cambridge, 1869	OWB	BTS
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THERIDIIDAE

<i>Achaeearanea</i> sp. 1	GWB	BTS
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<i>Achaeearanea</i> sp. 2	GWB	BTS
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<i>Anelosimus</i> sp. 1	GWB	PTR
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<i>Anelosimus</i> sp. 2?	GWB	SWN
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<i>Coleosoma</i> sp. 1	GWB	BTS
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<i>Coscinida</i> sp. 1	GWB	PTR
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<i>Enoplognatha molesta</i> O. P.-Cambridge, 1904?	GWB	PTR
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<i>Enoplognatha</i> sp. 2	GWB	PTR
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<i>Euryopsis</i> sp. 1	GWB	PTR
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<i>Euryopsis</i> sp. 2	GWB	PTR
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<i>Euryopsis</i> sp. 3	GWB	PTR
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<i>Latrodectus cinctus</i> Blackwall, 1865	GWB	LL
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<i>Latrodectus renivulvatus</i> Dahl, 1902	GWB	SWN
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<i>Phoroncidia</i> sp. 1	GWB	SWN
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<i>Steatoda capensis</i> Hann, 1990	GWB	PTR
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<i>Steatoda</i> sp. 2	GWB	PTR
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<i>Steatoda</i> sp. 3	GWB	PTR
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<i>Theridion</i> sp. 1	GWB	ASG, BTS , PTR, SWN
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<i>Theridion</i> sp. 2	GWB	BTS, SWN
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<i>Theridion</i> sp. 3	GWB	SWN
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Theridiidae sp. 1	GWB	PTR
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THERIDIOSOMATIDAE

Theridiosomatidae sp. 1	OWB	PTR
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THOMISIDAE

<i>Heriaeus buffoni</i> (Audouin, 1826)?	FGW	PTR
<i>Heriaeus</i> sp. 2†	FPW	SWN
<i>Misumenops rubrodecoratus</i> Millot, 1942	FPW	BTS, SWN
<i>Monaeses gibbus</i> Dippenaar-Schoeman, 1984	FPW	SWN
<i>Monaeses quadrituberculatus</i> Lawrence, 1927	FPW	PTR
<i>Monaeses</i> sp. 3	FPW	SWN
<i>Pherecydes</i> sp. 1	FPW	BTS
<i>Runcinia aethiops</i> (Simon, 1901)?	FPW	SWN
<i>Runcinia affinis</i> Simon, 1897	FPW	SWN
<i>Runcinia erythrina</i> Jézéquel, 1964?	FPW	SWN
<i>Runcinia flavida</i> (Simon, 1881)	FPW	SWN
<i>Runcinia grammica</i> (C.L. Koch, 1837)	FPW	ASG, SWN
<i>Stiphropus affinis</i> Lessert, 1923	FGW	ASG, PTR, SWN
<i>Synema</i> sp. 1	FPW	BTS
Thomisidae sp. 1	FPW	SWN
Thomisidae sp. 2	FPW	SWN
<i>Thomisops sulcatus</i> Simon, 1895	FPW	SWN
<i>Thomisus stenningi</i> Pocock, 1900	FPW	BTS, SWN
<i>Thomisus</i> sp. 2 imm.	FPW	SWN
<i>Tmarus cameliformis</i> Millot, 1942	FPW	BTS
<i>Xysticus natalensis</i> Lawrence, 1938	FGW	ASG, PTR
<i>Xysticus urbensis</i> Lawrence, 1952	FGW	PTR
<i>Xysticus</i> sp. 3	FGW	SWN

ZODARIIDAE

<i>Akyttara</i> sp. 1†	FGW	PTR
<i>Cydrela</i> sp. 1	FGW	PTR
<i>Cydrela</i> sp. 2	FGW	PTR
<i>Diores femoralis</i> Jocqué, 1990	FGW	PTR
<i>Diores poweri</i> Tucker, 1920	FGW	ASR, PTR
<i>Diores</i> sp. 3	FGW	PTR
<i>Palfuria</i> sp. 1	FGW	PTR
<i>Ranops</i> sp. 1†	FGW	PTR

PSEUDOSCORPIONES

PTR

6.2 Summary of spider ecology

This is one of the few long term surveys that have been done in the Grassland biome. Doing surveys and determining the species present is one of the first steps to understanding the diversity and ecology in a habitat. It must be remembered that the sampling techniques that were used each have their limitations, and many more spider species may be present in Erfenis Dam Nature Reserve. Because of the limitations of the techniques, they should be used in combination with others (active searching, leaf litter shifting ect.) to provide a better representation of the spider fauna. Some of the pitfalls was also lost in B-2 in February 2006 which resulted in the lost of information. A shortcoming of the study was the use of only Sørensen's Quotient index and that the main focus was on univariate analysis, thus excluding an important component of diversity.

The ecology of spider communities is influenced by many factors, for example habitat complexity, soil character, disturbances, seasons or activity of prey. More complex vegetation structures will have more niches available for different guilds of spiders. Disturbances such as fire inevitably alter the species composition of a habitat by altering the vegetation structure and density, which may influence spiders directly or indirectly. As fire is used as a management strategy in conservation, the study contributes knowledge as to what the impact of burning on spider communities are. Gnaphosidae and Lycosidae were identified as being fire tolerant or are fast colonisers. Monthly spider abundance and species richness were consistently lower in the burned grassland (with the exception of B-1), suggesting that colonisation processes for spiders are slow. Seasons affect species composition as well as species abundance, as most spiders are less active during the winter months. Rainfall has a bottom-up effect on the abundance of spiders. In specialist spiders like the Ammoxenidae and Zodariidae, the activity of their prey influences their occurrence, activity and preference in a habitat.

It is important to conduct surveying in the different biomes to determine the distribution of species and discover new species. The discovery of the new species of *Calommata* in the reserve led to a revision of the genus in the Afrotropical Region. Through this study it is now evident that the Afrotropical Region has six *Calommata* species instead of just the assumed one species. This may be important for conservation reasons as *Calommata* will be included in the South African Red Data List for arachnids, and accurate identification of the species is a necessity for accurate assessment of their conservation importance.

This study also contributes to the South African National Survey of Arachnida (SANSA), and SANSA will in turn contribute to the Grasslands Programme that was launched on 20 May 2008. Presently, the spiders in the Grassland Biome are represented by approximately 65 families, 200 genera and 350 species (Dippenaar-Schoeman & Haddad 2008).

6.3. References

DIPPENAAR-SCHOEMAN, A.S. & HADDAD, C.R. (eds.) 2008. *Launch of Grasslands Programme*. SANSA newsletter no. 6. Agriculture Research Council, Pretoria. 13pp.

DIPPENAAR-SCHOEMAN, A.S., LEROY, A., DE JAGER, M. & VAN DEN BERG, A. 1999. A check list of the spider fauna of the Karoo National Park, South Africa (Arachnida: Araneae). *Koedoe* **42**: 31-42.

FOORD, S.H., DIPPENAAR-SCHOEMAN, A.S. & VAN DER MERWE, M. 2002. A check list of the spider fauna of the Western Soutpansberg, South Africa (Arachnida: Araneae). *Koedoe* **45**: 35-43.