THE ABUNDANCE AND SPECIES RICHNESS OF THE SPIDERS (ARACHNIDA: ARANEAE) ASSOCIATED WITH OPEN SAVANNA, WOODLAND AND FALSE GRASSLAND IN THE POLOKWANE NATURE RESERVE, LIMPOPO PROVINCE

by

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DECLARATION

I declare that the dissertation hereby submitted to the University of Limpopo for the degree of Master of Science has not previously been submitted by me for the degree at this or any other university, that it is my own work in design and in execution, and that all material contained therein has been duly acknowledged.

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ABSTRACT

Lack of professional expertise on the taxonomy and systematics of invertebrates in the country leads to significant problems in understanding the invertebrate biodiversity and causes under appreciation of species. Little knowledge exists about the diversity of arachnids in certain eco-regions. South Africa is obliged to develop a strategic plan for the conservation and sustainable use of biodiversity since meaningful conservation cannot take place if the involved species are not known. The South African National Survey of Arachnida (SANSA) was initiated to make an inventory of the arachnid fauna of South Africa. Various projects are underway to prepare inventories of the spider fauna of the different floral biomes and provinces. Surveys of arachnid fauna are more important in conserved areas as conservation strategies are already in place. As part of SANSA, a study was initiated in the Polokwane Nature Reserve during March 2005 until the end of February 2006 to determine the species richness and diversity of spiders associated with *Acacia tortillis* Open Savanna, *Acacia rehmanniana* Woodland and the Pietersburg Plateau False Grassland at the Polokwane Nature Reserve in the Limpopo Province. This is the first survey in the area and provides information to SANSA in terms of conserved areas in the Savanna Biome. During this study four sampling methods (sweep netting, tree beating, active searching and pitfall trapping) were used to collect spiders from all the different vegetation layers. They were identified to morpho-species and a checklist of spiders collected was compiled, adding data to the Limpopo Province check list. The composition of the spider community, seasonal abundance patterns, fluctuations and the influence of vegetation structure on spider populations were determined.

A total of 7 776 spiders were caught belonging to 33 families, 131 genera and representing 219 species. Of these species, 153 (69.8 %) were wanderers and 66 (30.2 %) web-builders. The Oxyopidae was the most abundant family (1575), followed by Eresidae 1 554), Thomisidae (1 411), Araneidae (582), Lycosidae (568) and Salticidae (527). The Araneidae was the most species rich family (33) followed by the Thomisidae (31), Salticidae (25), Gnaphosidae (20), Theridiidae (18), Lycosidae (16) and the Philodromidae (12). The seven most abundant species collected during this study were *Stegodyphus dumicola* (Eresidae) (1 549) followed by two oxyopids, an undescribed oxyopid *Oxyopes* sp.3 (535) and *Oxyopes russoi* (476), *Runcinia flavida (*Thomisidae) *(*437), another oxyopid *Oxyopes pallidecoloratus* (384) followed by a lycosid *Evippomma squamulatum* (282) and another thomisid *Monaeses austrinus (*201). Immature specimens dominated captures, while females and males peaked during December till March with the most diverse species found in April. The highest specimen numbers and species richness was caught in the Woodland site (3 520; 173) followed by the Open Savanna (2 823; 159) and the Grassland site (1 433; 115). The Shannon-Weiner diversity index value calculated for species caught in the three different sampling sites was the highest for the Open Savanna site (H'=3.777), followed by the Woodland site (H'=3.569) and the Grassland site (H'=3.273). During this study the highest number of specimens were caught by sweep netting (2 972), followed by active searching (2 572), tree beating (1 895), pitfall trapping (323) and only a few (14) were caught by one attempt of leaf litter sifting. High evenness values for the Open Savanna (H_E=0.748), the Woodland (H_E=0.692) and the Grassland sites (H_E=0.689) indicated a relatively even distribution of species across these sites. The Bray-Curtis similarities calculated for the methods used to catch species occurring on the three sites was 48 % similar for species caught by sweep netting and tree beating. Species caught by active searching and pitfall traps were 44 % similar. Additionally the species caught by leaf litter sifting were only 8 % similar to that caught using the other four methods. Vegetation structure and the time of year influenced the spider community at the Polokwane Nature Reserve. Temporal changes influenced the species richness, diversity as well as the number of mature, identifiable specimens. No work have previously been undertaken in this area and the species collected represent new distribution records for all species collected. The present study made an important contribution towards increasing our knowledge of spider diversity in the Savanna Biome.

Table of contents

Abstract…………...………………………………………………………………………iii

List of Tables……………………………………………………….……………………... vii

List of Figures……………..……………..…………………………………...………………...viii

List of Appendices……………………………………………………………………...……...ix

Acknowledgements……………………………………………..……………………………. x

Chapter 1. Introduction………………………………………………………………………..…1

1.1 Knowledge of invertebrate diversity ………….……………………………………1

1.2 Status of Arachnida in Southern Africa..………………………….………………2

1.3 Spiders in Southern Africa……………………………….…………………………3

1.4 Spider biology………………………………………………………………………..……3

1.5 South African National Survey of Arachnida…………………………………………..4

1.6 Polokwane Nature Reserve – location and characteristics ………………………5

1.7 Savanna Biome ………………………………………………………………………6

1.8 Spiders from Savanna Biome………………………….……………………………6

1.9 Spiders from conserved areas in South Africa……………………………….....7

1.10 Provincial check lists……………….…………………………………………………..7

1.11 Collecting methods for spider………………………………………….…………...8

1.12 The aim of the study……………………………………………………………………9

1.13 The objectives of the study………………………………………………..……...9

Chapter 2. Materials and methods……………….……………………..………………………10

2.1 Sampling site………………………………………………………………...………10

2.2 Vegetation of sampling sites……………………………………………….…………10

2.3 Description of vegetation of the sampling sites……………………………..……11

2.4 Comparison of vegetation of sampling sites…………………………….………12

2.5 Rain fall………………………………………………………………………………..13

2.6 Collecting methods………………………………………………..…………………13

2.7 Analyses……………………………………………………………………..………..15

Chapter 3. Results and discussion.………………….……………..…………………………… 24

3.1 An inventory of spiders from three studied sampling sites and a comparison with other areas…………………...…………………………………………………..………24

3.2. Comparison of the differences among spider communities of the three sampled vegetation types…………………………………….………………………………31

3.3 Comparison of sampling methods used during the survey……………………….34
3.4 Comparison of spiders caught in different months and seasons………………...36
3.5 Comparison of species diversity using the Shannon-Wiener index……………...42
Chapter 4. Conclusion...……………………………...…………………..…………....59
Literature references……………………………………...………………………………..62

List of Tables

1. Guild classification of spiders collected at the Polokwane Nature Reserve, during March 2005-February 2006 (adapted from Dippenaar-Schoeman & Leroy 2002)…………….. 18
2. Vegetation structure of the three sampling sites at the Polokwane Nature Reserve, indicating tree cover, grass cover, grass height and the grass species occurring on each site as well as their percentage dominance values………………………………… 19
3. Herb and shrub species occurring on the three sampling sites as recorded during a study at the Polokwane Nature Reserve (March 2005-February 2006)………………… 20
4. List of families with the total number of individuals and species collected for each family per sampling site expressed as a percentage of total number of specimens and species collected during a study at the Polokwane Nature Reserve (March 2005-February 2006)………………………………………………………………………………...…….43
5. Species caught using the different collecting methods during a study at the Polokwane Nature Reserve (March 2005-February 2006)……………………………………...……..44
6. Numbers of spiders belonging to each family caught per month during a study at the Polokwane Nature Reserve (March 2005-February 2006)…………………………………49
7. Numbers of adult and immature spiders caught per month and season during a study at the Polokwane Nature Reserve (March 2005-February 2006)…………………………….50

List of Figures

1. A map of the Polokwane Nature Reserve, Limpopo Province indicating the distances in km of the roads as well as the location of the three sampling sites (OS = *Acacia tortillis* Open Savanna, W = *Acacia rehmanniana* Woodland, G = Pietersburg Plateau False Grassland)…………………………………………………………......................…………..21
2. A cluster analysis of Bray-Curtis similarities of the percentage dominance values of the grass species occurring on each site during a study at the Polokwane Nature Reserve (March 2005- February 2006)………………………………………………..…. 22
3. A diagram showing the ten pitfall traps per site, placed 10 m apart in three directions from a central trap with the furthest ones being 30 m from the central trap…………………….23
4. A cluster analysis of Bray-Curtis similarities of families caught using different sampling methods during a study at the Polokwane Nature Reserve (March 2005-February 2006)……………………………………………………………………………………… 51
5. Numbers of dominant species caught in different months from three different sites during a study at the Polokwane Nature Reserve (March 2005-February 2006)………………..52
6. Numbers of species caught per site per month as well as total and mean number of species caught per month during a study at the Polokwane Nature Reserve (March 2005-February 2006) (bars indicate standard deviation)………………………………………..53
7. Comparison of the mean number of specimens caught over the four seasons on all sampling sites during a study at the Polokwane Nature Reserve (March 2005-February 2006) (bars indicate standard deviation)……………………………………………………..54
8. MDS ordination for species caught in different months in a study done at the Polokwane Nature Reserve (2005-February 2006). …………………………………………………...55
9. Accumulative species-area plot for the number of families sampled in consecutive months during a study at the Polokwane Nature Reserve (March 2005-February 2006)…………………………………………………………………………...………56
10. Accumulative species-area plot for the number of species sampled in consecutive months during a study at the Polokwane Nature Reserve (March 2005-February 2006)…………………………………………………………………………………..….57
11. The Shannon's diversity index values for the species caught on all three sites during a study at the Polokwane Nature Reserve (March 2005-February 2006)……………… 58

List of Appendices

1. Spider surveys so far undertaken in floral biomes, provincial, agro-ecosystems and conserved areas in South Africa……………..…...69
2. A check list of the spider families and species, indicating the guild and status of each species collected from the three different sampling sites (*Acacia rehmaniana* woodland, *Acacia tortilis* open savanna and plateau false grassland) in the Polokwane Nature Reserve, Limpopo Province (March 2005-February 2006)…………………………………73

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CHAPTER 1
INTRODUCTION

After the Earth summit in Rio de Janeiro (1992) and the signing of the Convention on Biological Diversity (1995), South Africa is obliged to develop a strategic plan for the conservation and sustainable use of biodiversity (Dippenaar-Schoeman & Craemer 2000). However, biodiversity estimates and meaningful conservation cannot take place if the involved species are not known (De Wet & Schoonbee 1991). Therefore, it is essential to have baseline information concerning the occurrence and distribution of species before making predictions about biodiversity and sustainable use. Once baseline information (e.g. species check lists) for areas are in place additional factors that may influence biodiversity can be assessed and thereafter recommendations concerning conservation can be made.

Human actions like habitat destruction, exploitation and pollution place some species at risk of extinction (McNeely *et al*. 1995). The destruction of natural habitats results in changes of diversity throughout the world (Whitmore 2000). Loss of natural habitat is the biggest single cause of biodiversity loss in terrestrial ecosystems. Therefore, it is important to determine which factors lead to current patterns of biodiversity loss in human transformed landscapes to enable the assessment of the effectiveness of future conservation efforts (Jeanneret *et al*. 2003) and to adapt conservation strategies accordingly. Scientists have a key role to play in describing and developing indicators that can help with land-use planning (Thomas 1972). The traits of some species, such as endemicity, body size, feeding guild, metabolic rate, clutch size/reproductive strategy, natural abundance and phylogeny play a role in species sensitivity to habitat degradation and fragmentation (Nagy 2005). Certain species are restricted by landscape fragmentation to remnant patches of vegetation within a matrix of less favorable habitat conditions. However, even though each species has its own way of responding to landscape patterns, some members of orders such as the Araneae, Hymenoptera and the Orthoptera are generally more cosmopolitan and they occur regardless of landscape boundaries (Deidre & Samways 1996).

1.1 Knowledge of invertebrate diversity

There are an estimated 60 000 described species of invertebrates in South Africa with an average level of 70% being endemic (Le Roux 2002). The enormous abundance and diversity of invertebrates and the lack of information complicates research and conservation of the group.

Due to the diversity of invertebrates, any approach to conservation needs to take the composition of the invertebrate fauna into account. A prerequisite for understanding ecological roles of community members is the knowledge of which species are present and how the addition or removal of certain species will alter the community they live in (Whitmore 2000). Once again, inventories, with resulting check lists, provide valuable baseline information on species present and are the first steps for a better understanding of the complexity of species interactions in an area.

Insufficient research has been done, amongst others, on the invertebrates of South Africa (Le Roux 2002). They represent a group of organisms that are potentially useful in assessing the biodiversity of an area because they are widely distributed, respond rapidly to perturbations and are easy to sample (Whitmore 2000). Little work has been done on the response of invertebrate communities to habitat destruction (Swengel 2001). Many invertebrate groups such as insects decline rapidly in abundance after fire, depending on the intensity and the extent of the burn, and based on the mobility of the insect taxa (Swengel 2001).

Arthropoda make up about 65 % of the diversity of all the invertebrates (Jeanneret *et al*. 2003). Therefore members of the Arthropoda are good representatives of biodiversity and no biodiversity assessment should be considered credible without effectively addressing their diversity (Anderson *et al*. 2004).

1.2 Status of Arachnida in Southern Africa

The Arachnida is a diverse class within the Arthropoda and include organisms that have eight legs. They consist of 17 orders, five of which are extinct (Savory 1977). Globally the arachnids are represented by 570 families with about 93 500 known species. However, many species still need to be discovered and described and a 23 % increase in numbers is predicted per year (Adis & Harvey 2000). The Araneae or spiders is the second most diverse order of the Arachnida and is represented by 111 families, 3 642 genera and 39 490 species worldwide (Platnick 2006).

South Africa is no exception in terms of arachnid diversity with about 4 913 known species belonging to nine of the 12 living orders namely the Acari (mites and ticks), Amblypygi (whip spiders), Araneae (spiders), Opiliones (harvestmen), Palpigradi (micro whip-scorpions), Pseudoscorpiones (false scorpions), Schizomida (schizomids), Scorpiones (scorpions) and the Solifugae (wind spiders) (Dippenaar-Schoeman 2002b). The number of South African species represents 6 % of the global arachnid diversity, with 75 % of them endemic (Dippenaar-Schoeman 2002a). Knowledge of arachnids is still sketchy in terms of their taxonomy, ecology and distribution, with more known about the smaller orders (Amblypygi, Solifugae and Scorpiones) than the larger ones (mites and spiders) (Dippenaar-Schoeman 2002b).

Although arachnids constitute an abundant and successful group of invertebrates in South Africa, they are like other invertebrates still poorly sampled and little is known about their diversity within certain eco-regions (Dippenaar-Schoeman *et al*. 2002b). This is due to lack of professional expertise of invertebrates, in general, within the country. This fact poses significant problems for our sustained understanding of invertebrate biodiversity which leads to under appreciation and estimation of their actual species pool (Gibbons 1999).

1.3 Spiders in Southern Africa

Araneae in Southern Africa is represented by 67 families, 433 genera and 2 000 species (Dippenaar-Schoeman 2002a; 2002b). Spiders represent a very successful group of animals, based firstly on the fact that they are ancient and were recognized as a group since the Devonian period, secondly, they meet four criteria necessary for them to be considered as ecological indicators (Churchill 1997) namely: i) they are diverse and abundant and found in almost any type of terrestrial habitat (Decae 1984; Marc *et al.* 1999), ii) they can be easily sampled, iii) they are functionally significant in ecosystems as predators and food for other predators (Marc *et al.* 1999; Dippenaar-Schoeman 1979) and iv) they exhibit specific ecological demands toward their natural habitat (Marc *et al.* 1999) and v) spider community variations can be detected even for a small area within a given biotope (Marc *et al.* 1999).

The use of spiders as ecological indicators is hampered by mainly a lack of knowledge. This includes knowledge about their taxonomy, distribution and biology (Marc *et al.* 1999). Furthermore, surveys of the spider community of an area should employ different sampling methods in order to sample from different vegetation layers (Marc *et al.* 1999).

1.4 Spider biology

Most spiders live in defined environments, of which limits are set by physical conditions and biological factors (Foelix 1982). They are very diverse in their micro-habitat selection on vegetation and on the ground, and constitute a dominant predator group on invertebrates in ecosystems (Dippenaar-Schoeman & Jocqué 1997). When any factor determining their habitat selection (i.e. habitat structure, microclimatic conditions, competition with other predators and availability of prey) is modified, spiders move (Marc *et al*. 1999).

Species can be grouped into guilds based on the available information on their habitat preferences and predatory methods. A guild is a group of species that potentially compete for jointly exploited, limited resources (Polis & McCormick 1986). In spiders the two main guilds recognized are the web-dwellers and the wanderers. In the web-dwellers the spiders use silk to catch their prey while the wanderers use their agility and legs to overpower the prey (Dippenaar-Schoeman & Jocqué 1997). Although primarily known as web-builders several spider species have abandoned the use of webs and have become free-living hunters making them especially fit as predators.

Spiders have special adaptations for their predatory life-style e.g. their distensible abdomens allow them to consume large amounts of food in short periods, while their rate of predation may increase during limited periods when prey is abundant (Dippenaar-Schoeman & Jocqué 1997, Marc *et al*. 1999). Their success as predators can be seen in the ways in which they exploit insect populations. Their diet consists mainly of insects and other arachnids, but can also include prey like fishes, birds or even reptiles. Some ground-dwelling spiders are also important in transferring energy from below the ground detritus food webs to above ground terrestrial food webs (Johnston 2000). These ground-dwelling spiders feed mainly on terrestrial insects and larvae hibernating in the soil (Dippenaar-Schoeman & Jocqué 1997). The plant dwelling spiders are found on bark, leaves and flowers of plants where they actively catch their prey. Some web-building spiders spin their webs among leaves, under bark and over the leaf surfaces and frequently entangle flying or crawling pests species in their silk threads (Van den Berg *et al*. 1992). Additionally, spiders are also food sources for other animals e.g. reptiles and birds (Dippenaar-Schoeman 2006a).

1.5 South African National Survey of Arachnida

During the United Nations Conference on the Environment and Development in Rio de Janeiro also known as the Earth summit (1992) one of the key agreements adopted was the Convention on Biological Diversity (CBD). The Convention establishes three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources. In November, 1995, South Africa ratified the Convention on Biological Diversity (CBD). Signatories are obligated to develop a strategic plan for the conservation and sustainable use of biodiversity. South Africa has developed a strategic plan for the conservation and sustainable use of biodiversity under the South African Biodiversity Institute.

The South African National Survey of Arachnida (SANSA) was initiated in 1997 to make biodiversity assessments of the arachnid fauna of South Africa (Dippenaar-Schoeman & Craemer 2000). Several priority research areas within SANSA have been identified for which inventories are underway namely: floral biomes, provinces, agro-ecosystems and conserved areas (Dippenaar-Schoeman 2002b; Dippenaar-Schoeman & Haddad 2006b). However, inventories are especially important in conserved areas to identify the species where conservation strategies are already in place (Dippenaar-Schoeman *et al*. 1999a). Knowledge of the African spider fauna is presently largely restricted to taxonomy and studies concerning ecological, agricultural and evolutionary issues are distressingly scarce. This restriction could be due to the small number of qualified taxonomists working in Africa and many of the taxonomists are based abroad (Van der Merwe *et al*. 1996).

1.6 Polokwane Nature Reserve – location and characteristics

This study was undertaken at the Polokwane Nature Reserve (23˚58'S 29˚28'E), Limpopo Province. This reserve is situated in the Savanna Biome, the Central Bushveld Bioregion and within the Polokwane Plateau Bushveld vegetation unit (Musina & Rutherford 2006). The reserve is 3 km south of Polokwane City and consists of an area of approximately 3 200 ha. It was established in 1962 as a recreation facility for the citizens of Polokwane (then known as Pietersburg). The reserve lies on an elevated plateau with an altitude between 1 200 to 1 500 m above sea level and has a moderate climate with an average annual rainfall of 478 mm.

It was soon realized that a major area within the reserve was one of the last remaining, undisturbed examples of a very localized vegetation type known as the Pietersburg Plateau False Grassland (Acocks 1975). The climax of the False Grassland is an Open Savanna of *Acacia caffra* (Thunb.) Willd. Three variations can be recognized from this type of vegetation, namely the western, central and eastern variations. The western variation occurs on sandy plains and low rocky ridges. This veld is sparse, sour and strongly tufted with clearly transitional types of grasses from *Cymbopogon-Themeda* veld type to the sour bushveld. The central variation is stony or sandy and the rocks are mainly quartzite, shale, dolomite, chert and granite with poor and acidic soils. The eastern variation is flat, sandy and on rocky outcrops, it is transitional to sour bushveld in loosely sandy parts with wiry and sparse grass, which is dominated by species like *Digitaria brazzae* (Franch.) Stapf, *Eragrostis racemose* (Thunb.) Steud., some *Themeda* and *Heteropogon* species (Acocks 1975).

Lately, the Pietersburg Plateau False Grassland is known as the Polokwane Plateau bushveld. According to the National Spatial Biodiversity Assessment’s remote sensing sources (Driver *et al*. 2005), it is least threatened, but more than one third of the remaining vegetation is regarded as degraded. Less than 2 % is statutorily conserved mainly in Percy Fyfe and Kuschke Nature Reserves. Only 0.7 % is conserved at the Polokwane Nature Reserve. The remaining 17 % is transformed, with 10 % being cultivated, 6 % urban and built up. In the eastern and north western parts of the units are dense concentrations of rural human settlements (Mucina & Rutherford 2006).

Today the reserve conserves one of the largest pristine examples of this habitat, together with its associated plant and animal species. The Pietersburg Plateau False Grassland vegetation type is characterized by open *Themeda* grassland with scattered *Acacia* trees and bush clumps. The dominant trees are umbrella thorn *Acacia tortillis* (Forssk.) Hayne and the silky thorn *Acacia rehmanniana* (Barker f. (9) Schinz). Within this vegetation type are several interesting plant communities including riverine and sweet thorn thickets, granite outcrops, quartzite pebble slopes, saline patches and a mountain aloe, *Aloe marlothii* (A. Berger.) thicket (Grosel pers. comm.).

1.7 Savanna Biome

Savannas cover approximately half of the land surface of Africa and a fifth of the land surface of the world. This is the basis of the livestock and game industry in Africa. It is a tropical vegetation type in which both trees and grass are an important component (Scholes & Walker 1993). Savannas are second only to tropical forests in terms of their contribution to terrestrial primary production (Atjay *et al*. 1987). The Savanna Biome is the largest biome in Southern Africa and occupies 46 % of the area, one third of South Africa. Savanna develops in soils with low fertility, under a regime of strongly seasonal rainfalls and is subjected to recurrent disturbances through grazing mainly by cattle or game and fire (Mooney *et al*. 1995; Whitmore 2000). It consists of a grassy ground layer and a distinct upper layer of woody plants and has a high floristic diversity (Low & Rebelo 1996). The vegetation is called a shrubland if the upper layer is near the ground, woodland if the upper layer is dense and a bushveld for intermediate stages. Most of the savanna vegetation types are used by cattle and game for grazing (Low & Rebelo 1996), and therefore savannas are best known for their diversity and biomass of large mammals (Whitmore 2000). However, the Savanna Biome, in general, is poorly represented in biodiversity work with resultant poor understanding of expected levels of diversity (Whitmore 2000). According to Low & Rebelo (1996) the Limpopo Province consists of three biomes (Grassland, Forest and Savanna) with 15 vegetation types that are structurally and floristically defined units of plant communities which share similar climatic, geological and soil requirements, having similar ecosystem processes, management and conservation requirements and similar potential uses.

1.8 Spiders from the Savanna Biome

Some spider surveys of the Savanna Biome outside Africa were undertaken in Australia (Churchill & Ludwig 2004), while Russell-Smith (1981 & 2002) and Russell-Smith and co-workers (1987) did surveys in the African Savanna Biome outside South Africa. These include, a one year study on the surface active spiders in mopane woodland and floodplain grassland in Botswana (Russel-Smith 1981), as well as a survey of surface active spiders of the arid bush land in Kenya

(Russell-Smith *et al*. 1987) and a survey to compare the composition of ground active spiders in 12 different habitat types in protected savanna biomes in Tanzania and Namibia (Russel-Smith 2002). Some inventory research of African savanna arachnids was undertaken for purposes other than biodiversity assessment e.g. a study done to determine the impacts of wildlife and cattle grazing on spiders (Warui *et al*. 2005) or spiders from black cotton soils in Kenya (Warui 2004). Another survey of spider communities of savanna, done in the Ivory Coast was published by Blandin & Célérier (1981).

A number of surveys of spiders from different biomes in South Africa have already been published (Appendix 1). The Savanna Biome is so far the best documented with studies done at Nylsvley Nature Reserve (Heidger 1988); the Roodeplaat Dam Nature Reserve (Dippenaar-Schoeman *et al*. 1989); Makalali Nature Reserve (Whitmore *et al*. 2001, 2002); Western Soutpansberg (Foord *et al*. 2002, Foord & Dippenaar-Schoeman 2003); Kruger National Park (Dippenaar-Schoeman & Leroy 2003); Sovenga Hill in Limpopo Province (Modiba *et al*. 2005) and Ndumo Nature Reserve (Haddad *et al*. 2006c).

1.9 Spiders from conserved areas in South Africa

Conservation biologists are starting to recognize the importance of invertebrates in the functioning of healthy ecosystems (Dippenaar-Schoeman & Wassenaar 2002). However, meaningful conservation management programmes cannot be put in place before species present are known. One of the objectives of SANSA is to survey and assess the number of arachnid species presently protected in conserved areas in the country. Inventories with resulting check lists provide valuable baseline information on species present and are the first step for a better understanding of the fauna present.

Check lists of spiders are now available for three national parks, four nature reserves and a conservancy (see Appendix 1). These include the Mountain Zebra National Park (Dippenaar-Schoeman 1988, 2006a); Karoo National Park (Dippenaar-Schoeman *et al*. 1999a); Kruger National Park (Dippenaar-Schoeman & Leroy 2003); Roodeplaat Dam Nature Reserve (Dippenaar-Schoeman *et al.* 1989); Makalali Nature Reserve (Whitmore *et al.* 2001, 2002); the Soutpansberg Conservancy (Foord *et al*. 2002); Swartberg Nature Reserve (Dippenaar-Schoeman *et al*. 2005b) and Ndumo Game Reserve (Haddad *et al*. 2006c) and Polokwane Nature Reserve (Dippenaar *et al.* 2008) (as a result of the current study).

1.10 Provincial check lists

With the new Biodiversity Act the provinces are under pressure to determine the status of their biodiversity towards meeting the State’s obligation to the requirements of the International

Convention on Biological Diversity (CBD). Very little is still known about the invertebrate diversity in most of the provinces. As part of SANSA a total of 24 surveys have contributed towards Provincial check lists (Appendix 1). Surveys on the spider fauna of Limpopo Province are restricted to surveys of spiders in mammal holes at Nylsvley Nature Reserve (Heidger 1988); the Makalali Nature Reserve (Whitmore *et al*. 2001 & 2002); the spiders of the Western Soutpansberg (Foord *et al*. 2002); surveys of the spiders of the Kruger National Park (Dippenaar-Schoeman & Leroy 2003) and the spiders of Sovenga Hill (Modiba *et al*. 2005).

1.11 Collecting methods for spiders

Different methods are used to sample spiders (Eardley & Dippenaar-Schoeman 1996) from different vegetation layers and constituting the two main guilds, namely wandering spiders (W) which are free-living spiders running around in search of prey when active and the web builders (WB), which construct webs in open spaces. These are further subdivided based on the micro-habitat they occupy and general behaviour and web type (see Table 1). The wandering spiders can be subdivided into the ground wanderers (GW) and the plant wanderers (PW). The ground wandering spiders are either free living or burrow living, while the plant wandering spiders are all free living (FPW). The web building spiders (WB) construct different types of webs namely: orb-webs (OWB), funnel-webs (FWB), gumfoot-webs (GWB), retreat-webs (RWB), sheet-webs (SWB) and space-webs (SPWB) (Dippenaar-Schoeman & Leroy 2003).

In order to catch spiders from the different vegetation layers, a variety of sampling methods are generally used (Marc *et al*. 1999). This includes sweep netting, tree beating, active searching, pitfall trapping and leaf litter sifting (Eardley & Dippenaar-Schoeman 1996). With sweep nets specimens are dislodged and knocked from the grass and herb layer while during beating specimens are collected underneath branches of trees in a tray. During leaf litter sifting, litter is collected from underneath the trees into a wooden box with a chicken wired bottom and specimens are then sieved from the litter and the decomposing wood and collected from a tray. Pitfall trapping involves the burying of containers into the ground with the upper rim level with the ground surface. A funnel leads to a smaller container filled with 70% ethanol. Ground active specimens are caught, immobilized and preserved in the alcohol. Active searching is done by searching for spiders on all possible vegetation layers and ground surface by the active lifting of stones and other debri (Eardley & Dippenaar-Schoeman 1996).

Most of the published surveys have employed only one or two methods (see Appendix 1) and some of the surveys are based only on *ad hoc* collecting excluding quantitative surveys. Surveys by Lotz *et al*. (1991), Van den Berg & Dippenaar-Schoeman (1991), Van der Merwe *et al*. (1996), and Dippenaar-Schoeman & Wassenaar (2002) only used pittraps to survey ground active spiders while the Roodeplaat Dam Nature Reserve's survey (Dippenaar-Schoeman *et al*. 1989) focused on the grass and tree layers and the study done by Dippenaar-Schoeman & Wassenaar (2006) focused on the herbaceous layer. Results of surveys that have included all the field layers are those reported by Whitmore *et al*. (2002), Modiba *et al*. (2005), Haddad & Dippenaar-Schoeman 2005 and Haddad *et al*. (2006c). They showed that it is important that all layers are sampled in order to obtain a more complete picture of species present in an area.

1.12 The aim of the study

To do a survey of the cryptic ground-living, grass-living and tree-living spiders found in the following vegetation types in the Polokwane Nature Reserve in the Savanna Biome: *Acacia tortillis* Open Savanna, *Acacia rehmanniana* Woodland and the Pietersburg Plateau False Grassland.

1.13 The objectives of the study

- To provide an inventory of spiders from three sampling sites studied in the Polokwane Nature Reserve and comparison with other areas,
- To compare differences among the spider communities of the vegetation types sampled,
- To compare spiders caught with different sampling methods,
- To compare spiders caught during different months and seasons of the year.

CHAPTER 2
MATERIALS AND METHODS

2.1 Sampling site

The study was done at the Polokwane Nature Reserve (23˚58'S 29˚28'E) over a 12-month period from March 2005 until February 2006.

For the purpose of the study, sites were selected in three different vegetation types where sampling was conducted: the first site was in the *Acacia tortillis* Open Savanna (Open Savanna = OS) (23˚58'S 29˚28'E) habitat type with scattered trees and grass cover; the second site was in the *Acacia rehmanniana* Woodland (Woodland = W) (23˚58'S 29˚30'E) and the third site was in the Pietersburg Plateau False Grassland (Grassland = G) (23˚58'S 29º30'E) (Fig. 1).

2.2 Vegetation of sampling sites

An examination of the dominance of grass species, grass cover, grass height and tree cover on each site was done during February 2006 when grasses were flowering and inflorescences distinct. The dominance (%) of grass species in each site was estimated by using a transect of 200 m during which the grass species at every 2 m interval was identified. This information was used to determine the percentage occurrence of each grass species and thus the dominant species. Emphasis was placed on the grass since Savanna consists of a continuous grass layer with only scattered shrubs and isolated trees (Low & Rebelo 1996).

The grass height was determined according to the following four classes:

- very short grass (0-50 mm)
- short grass (50-250 mm)
- medium grass (250-500 mm)
- tall grass (500 mm and upwards).

Grass cover was determined according to the following five classes:

- bare ground, no grass cover (100 % no grass)
- low grass cover (0-25 %)
- average grass cover (25-50 %)
- high grass cover (50-75 %)
- full grass cover (75-100 %).

The tree cover was determined according to the following four classes (Edwards 1983):

- sparse woodland (0-25 %)
- open woodland (25-50 %)
- closed woodland (50-75 %)
- forest (75-100 %).

2.3 Description of vegetation of the sampling sites

Woodland: It is a closed woodland with 50-75 % tree cover, average to high (50-75 %) grass cover and medium grass height (250-500 mm). The dominant tree species are the silky thorn *Acacia rhemanniana*, the umbrella thorn *Acacia tortillis* and the mountain aloe *Aloe marlotti* (A. Berger.). A total of 11 grass species occur on this site (Table 2), with *Themeda triandra* (red grass) (25 % occurrence) being the most dominant grass species, followed by *Cymbopogon excavates* Spreng. with 20 % occurrence. Three species, *Tragus berteronianus* (Schult), *Brachiaria nigropedata* (Ficalho & Hiern) Stapf and *Chloris virgata* (Sw.) were present in low numbers (1 %). Fifteen grass species recorded from the other two sampling sites were absent from this site while *Bothriochloa insculpta* (A. Rich.) A. Camus and *Cymbopogon excavates* were found only on this site. Seven different herb and shrub species also occurred on this site (Table 3).

Open Savanna: It is an open shrubland on granite soil with few trees (0-25 % tree cover) and with an average (25-50 %) grass cover of medium (250-500 mm) height. The dominant tree species is *Acacia tortillis*. Sixteen grass species were recorded (Table 2), with *Themeda triandra* (33 %) the most abundant followed by *Brachiaria nigropedata* (19 %). Five species (*Digitaria eriantha* Steud., *Elionurus muticus* (Spreng.) Kuntze, *Eragrostis micrantha* Hack., *Heteropogon contortus* (L.)Roem. & Schult. and *Melinis repens* (Willd.) Zizka) were represented by only 1 % occurrence. Ten species recorded from the other two sites were absent on this site while *Anthephora pubescens* (Nees) and *Eragrostis gummiflua* (Nees) were found only on this site. Eleven shrub and herb species were also recorded from this site (Table 3).

Grassland: This site is an open grassland with Huttom soil type. Few trees (0-25 % tree cover) occur on this site with an average (25-50 %) grass cover consisting of short (50-250 mm) grass height. Nineteen grass species occurred on this site (Table 2), with *Elionurus muticus* the more abundant (16 %) followed by *Melinis repens* (13 %). Two species (*Sporobolus fimbriatus* (Trin.) Nees and *Trichoneura grandiglumis* (Nees) Ekman.) occurred only on this site, but in low numbers (1 %). Seven grass species occurring on the other two sampling sites were absent from this site with *Anthephora pubescens, Aristida canenscens* (Roem. & Schult.) and *Eragrostis racemosa* (Thumb.)

Steud. absent on both this site and the Woodland site. Eleven herb and shrub species also occurred on the site (Table 3).

2.4 Comparison of vegetation of sampling sites

Twenty six grass species were encountered on all three sampling sites (Table 2). A cluster diagram of the calculated Bray-Curtis similarities of the dominance percentages of grass species, occurring on the different sites (Table 2) showed that the Woodland and the Open Savanna sites are 48 % similar in terms of grass coverage, while the Grassland is 42 % similar to the previous two sites (Fig. 2).

The Woodland and Open Savanna sites were both dominated by *Themeda triandra* grass with 25 % and 33 % respectively, while on the Grassland site *Themeda triandra* only showed a 2 % occurrence with *Elionurus muticus* (16 %) the dominant species. Of the three sites, the Grassland site had the higher variety of grass species (19) with five species occurring only on this site. The Open Savanna site had fewer different grass species (16) with four species occurring only on this sampling site. The Woodland site showed the least variety in terms of grass species (11), with only two species occurring uniquely on this site. The species *Chloris virgata* was encountered on both the Woodland and Open Savanna sampling sites, while three species (*Aristida congesta*, *Elionurus muticus* and *Eragrostis micrantha*) were found on the Open Savanna and the Grassland sampling sites. The Woodland and Grassland sites had no grass species in common (Tables 2 & 3).

Lycium sp. was the common herb/scrub species on both the Woodland and the Grassland sites (Table 3). *Gnidia* species was the common species in both the Open Savanna and the Grassland sites. There was no common herb/scrub species in the Woodland and Open Savanna sites. The Grassland and Open Savanna sites both had high numbers of herbs and shrubs species (11) while the Woodland site had only eight species. Six herb and shrub species occurred only on the Woodland site. Ten herb and shrub species were found only on the Open Savanna site while nine species only on the Grassland site (Table 3).

From this, the common appearance of the herb and shrub species in the Open Savanna and Grassland sites does not confirm the previous higher similarity value (48 %) for the calculated dominance percentages of grass species between these two sites. In terms of tree cover, the Open Savanna and the Grassland sites seem to be more similar, both with 0-25 % tree cover. However, the Open Savanna had about 25 % tree cover while the Grassland had 0 % tree cover. Therefore, even with different values of 0-25 % and 50-75 % for Open Savanna and Woodland respectively, they were more similar due to the presence of trees versus the absence of trees from the Grassland site. Since a more diverse spider community can be supported by structurally more complex shrubs (Uetz 1991), it is expected that the Woodland and the Open Savanna sites will have a more diverse spider composition than the Grassland site due to the presence of trees and shrubs. Spiders that prefer to dwell on the bark and leaves of a tree will have habitats to occupy. Furthermore, the higher number of field layers available in the Woodland site may result in an increased availability of more different habitats for spiders to occupy which can lead to increased numbers of spiders caught in the Woodland site compared to the Open Savanna and Grassland sites.

2.5 Rain fall

Rain fall in the reserve is measured with three rain gauges spread out through the reserve and readings were checked and recorded after each rainfall. The average rainfall was determined from the three readings. During the year of sampling rain fell during six of the 12 months with the highest rainfall measured during December 2005 (138 mm), followed by November 2005 (130 mm), February 2006 (112 mm), January 2006 (51 mm), April 2005 (41 mm) and March 2005 (15 mm). The seasonal average for the year during which sampling was conducted was 100 mm in summer, 43.3 mm in spring, 18.6 mm in autumn and 0 mm in winter. The annual rain fall was 487 mm.

2.6 Collecting methods

Sampling was conducted for the period of one year, using the following methods as described by Eardley & Dippenaar-Schoeman (1996): pitfall trapping, tree beating, sweep netting, leaf litter sifting and active searching.

Sampling on a site was conducted one week each month over a 12-month period (n=12). During the week of sampling on a specific site, a day was spent per method, except for the pitfall traps which were open for five consecutive days of that week.

Pitfall trapping: Plastic containers with a diameter of 10 cm and a length of 20 cm were placed in a hole in the ground with the upper rim level with the ground surface and a smaller container (diameter of 6 cm) with 70 % ethanol was placed inside to immobilize and preserve caught specimens. A funnel was placed over the opening of the trap to prevent caught organisms from escaping. Ten pitfall traps were used per site, placed 10 m apart in three directions from a central trap with the furthest ones being 30 m from the central trap (Fig. 3). The traps remained at the same locations throughout the sampling period. The traps were opened for five consecutive days only during the week of sampling on a specific site and checked daily. All caught specimens were transferred from the traps to bottles containing 70 % ethanol and the containers inside the traps were refilled with 70 % ethanol. Samples collected from all 10 traps during the sampling week on a site were combined to form one sample. From a site, 5 trap days were sampled per week, giving a total of 60 trap days during the 12 months, giving a total of 12 samples per sampling site. A total of 180 trap days were sampled for all three sites during the study period.

Active searching: Active searching was undertaken for two hours at a site per month. Searching started in the morning at the central pitfall trap and extended beyond the last trap and included searching under stones, on plants and bark to include all vegetation layers. Collected specimens form a site were combined into a single sample and preserved in 70 % ethanol. A total of 2 hours per site per month were spent using this method resulting in 24 hours actively searching for spiders. In total 72 hours of active searching was done on all three sites during the study period, resulting in a total of 12 samples per sampling site.

Tree beating: Trees were beaten for two hours per site per month using a stick of 0.21 kg, 207.6 cm long. Specimens knocked from the vegetation were collected on a sheet of 180 x 230 cm. A tree of average height was beaten 20 times with bigger trees beaten more (up to 30 beats) and smaller ones beaten less (down to 10 beats). All the collected spiders were combined to form a single sample per site. All the trees among the pit traps, as well as some beyond the pit traps were sampled. This method was applied to the Woodland and the Open Savanna sites but due to the absence of trees in the Grassland site no samples were taken. A total of 2 hours per site per month were spent using this method resulting in 24 hours per site. For the two sites, a total of 48 hours were spent beating during the study period. A total of 12 samples were collected from each site during the study period.

Sweep netting: A sweep net (diameter of 31 cm) was used to sweep through the grass layer to dislodge specimens and to knock them off the plants into the net. Twenty sweeps were taken every 20 m. Sweep netting was carried out for 2 hours during the morning, per site per month and extended beyond the furthest pit traps. The contents from the sweep net were emptied into a marked plastic bag. The samples collected during the sampling day were combined to form one sample. Spiders and other organisms were separated from the vegetation in the laboratory. A total of 2 hours per site per month were spent sweep netting which resulted in 24 hours of sweep netting per site during the

12 months. Combined, a total of 72 hours of sweep netting was done on all three sites during the study period which resulted in 12 samples per sampling site.

Leaf litter sifting: A sample of litter was collected in a wooden box with a chicken wired bottom and specimens were sieved from the litter. This method was used once on the Woodland site (the only site that seemed to have leaf litter), but was ineffective as there was not enough litter to fill the box.

In the laboratory, a stereomicroscope was used to examine and sort specimens into families using the African spider family keys (Dippenaar-Schoeman & Jocqué 1997) and guild (Table 1). Family and morph-species identifications were confirmed by Prof A.S. Dippenaar-Schoeman where after she identified the specimens to genus and species level. Unfortunately, due to the lack of expertise within certain families and the absence of adult material, identification to species level in some instances was impossible. Voucher specimens were deposited in the National Collection of Arachnida at the ARC-Plant Protection Research Institute in Pretoria.

2.7 Analyses

The computer package, Primer v5 (Clarke & Warwick 2001) was used to do the following analyses: Bray-Curtis similarities, cluster analyses, accumulative curves, Shannon-Wiener diversity calculations and multidimensional scaling (MDS).

Bray-Curtis similarities: Bray-Curtis similarities examine whether similarities between groups of samples exists e.g. a comparison of two or more samples is done to find out which sites have similar species. All multivariate techniques are perfomed on similarity coefficients which are calculated between every pair of samples (Clarke & Warwick 2001). The similarity coefficient uses e.g. the abundance levels of each species as a measure of their similarity where 100 % represents total similarity while 0 % shows complete dissimilarity. Bray-Curtis values are not affected by a change of measurement unit and is furthermore unaffected by the inclusion or exclusion of a species that is jointly absent from the two samples compared. Additionally, it has the flexibility to register differences in total abundance when the relative abundances for all species are identical. The Bray-Curtis coefficient reflects differences between two samples due to differing community composition and differing total abundance (Clarke & Warwick 2001).

Bray-Curtis similarities were calculated for the dominance values of the grass species occurring on each of the three sites in an attempt to compare the similarities of the three sites. Bray-Curtis similarities were also calculated for the different species caught using different sampling methods in an attempt to compare the similarities of samples caught using different methods.

Cluster analysis: Clustering start from a triangular matrix of similarity coefficients computed between every pair of samples. Samples are fused into groups which are grouped into larger clusters, starting with the highest mutual similarities. Clusters are represented by a tree diagram or a dendogram (Clarke & Warwick 2001).

A dendogram was constructed from the similarities calculated for dominance values of the grass species occurring on each of the three sites in an attempt to compare how similar the three sites were. Additionally, a dendogram was constructed from the Bray-Curtis similarities of species caught using different methods.

Accumulation curves: These curves record the total number of sample units (species or families) revealed during the sampling process since additional sample units (species or families) are added to the pool of previously collected samples (species or families) (Gotelli & Colwell 2001). It illustrates how the number of families and species collected increases as samples are added every month. The slope of the curve indicates when saturation in the number of families and species is reached since it will plateau out. Raw species richness or higher taxon counts can only be validly compared once the accumulation curves have reached a clear asymptote (Gotelli & Colwell 2001).

Accumulation curves were plotted for the families and species caught during each month of sampling from all sampling sites in an attempt to estimate family and species diversity.

Shannon-Wiener diversity: The Shannon-Wiener diversity calculations determine how diverse the caught specimens are in terms of species diversity. The total number of species depends on the sample site (the bigger the sample site, the more species are likely to be sampled). Additionally, when there are more specimens in an area, species are expected to be more diverse (Clarke & Warwick 2001). From the total number of specimens (N) captured, the total number of species captured (S) per month is computed. It combines two components of diversity: i) the number of species ii) equitability or evenness of allotment of individuals among the species. Shannon-Wiener diversity for two studies done at different areas cannot be compared as the time for sampling and methods used might have an effect on the species sampled. The sampling effort must be the same. Therefore, for the three sampling sites Shannon-Wiener diversity can be compared as sampling was conducted by the same person at the same time of the day. The higher the calculated Shannon-Wiener values the more diverse the species are.

Shannon-Wiener diversity calculations were calculated for the species caught in the three sampling sites as well as the species caught per month in an attempt to compare their diversity.

Multidimensional scaling (MDS): A similarity matrix is used to construct a map of the samples in a specified number of dimensions. Multidimensional scaling places similar species from different samples close to each other (Clarke & Warwick 2001). Multidimensional scaling was done for species caught with different sampling methods to investigate how similar species are caught with different methods.

Additional analyses done by hand include:

Species evenness diversity: The species evenness diversity index is a measure of the distribution of species in a community which quantifies how equal the communities are numerically (Begon *et al.* 1996). The evenness of species caught from the three different sampling sites was compared using the species evenness diversity index ($E_H = H / \ln(S)$).

Beta-diversity: Beta-diversity measures diversity between two ecosystems by comparing their species (http://en.wikipedia.org/wiki/Beta_diversity, DOA 19/02/08). Sørensen's similarity indices ($\beta = 2c/S_1 + S_2$) were calculated for species found in the three studied sampling sites and for other studies done in the Savanna Biome including Roodeplaat Dam Nature Reserve, Sovenga Hill, Kruger Park, Makalali Nature Reserve and the Western Soutpansberg.

Table 1. Guild classification of spiders collected at the Polokwane Nature Reserve during March 2005-February 2006 (adapted from Dippenaar-Schoeman & Leroy 2003).

Guilds	Abbreviation	Guild explanation
WANDERING SPIDERS (W)		
Ground wandering spiders (GW)		
Free living	FGW	free-living spiders running on the soil surface when active
Burrow living	BGW	living in burrows
Plant wandering spiders (PW)		
Free living	FPW	free-living spiders running on the plant surface when active
WEB-BUILDING SPIDERS (WB)		
Orb-web	OWB	webs consisting of a frame with mooring and bridge lines that anchors the web and radial signal threads arranged like the ribs of a umbrella converging onto the centre of the web with circular spiral threads
Funnel-web	FWB	webs made over soil surface with a funnel-shaped retreat on one side
Gumfoot-web	GWB	three-dimensional webs consisting of a central area with or without a retreat. The upper part comprises mooring, signal and catch threads and a lower part with mooring and catch threads. The lower catch threads studded with sticky droplets are attached to the substrate
Retreat-web	RWB	Web consisting of silk radiating from retreat used to catch prey
Sheet-web	SHWB	webs which, usually consists of an upper sheet with mooring, signal and catch threads
Space-web	SPWB	webs which, fill open space.

Table 2. Vegetation structure of the three sampling sites at the Polokwane Nature Reserve, indicating tree cover, grass cover, grass height and the grass species occurring on each site as well as their percentage dominance values.

Vegetation	Woodland	Open Savanna	False Grassland
Tree cover	50-75 %	0-25 %	0-25 %
Grass cover	50-75 %	25-50 %	25-50 %
Grass height	250-500 mm	250-500 mm	50-250 mm
Anthephora pubescens (Nees)	0	5	0
Aristida canenscens (Roem. & Schult.)	0	2	0
Aristida congesta (Roem. & Schult.)	0	17	6
Bothriochloa insculpta (A. Rich.) A. Camus	11	0	0
Brachiaria nigropedata (Ficalho & Hiern) Stapf	1	19	3
Brachiaria subuliforia (Mez) Clayton	0	0	10
Chloris virgata Sw.	1	2	0
Cymbopogon excavates Spreng.	20	0	0
Digitaria eriantha Steud.	3	1	3
Elionurus muticus (Spreng.) Kuntze	0	1	16
Eragrostis gummiflua Nees	0	2	0
Eragrostis lehmanniana Nees var.	0	0	8
Eragrostis micrantha Hack.	0	1	2
Eragrostis racemosa (Thunb.) Steud.	0	2	0
Eragrostis rigidior Pilg.	0	0	6
Eragrostis superba Peyr	5	3	4
Eustachys paspaloides (Vahl) Lanza & Matte	0	0	2
Heteropogon contortus (L.) Roem. & Schult.	11	1	10
Hyparrhenia fillipendula (Hochst.) Stapf var.	0	0	2
Melinis repens (Willd.) Zizka	3	1	13
Sporobolus fimbriatus (Trin.) Nees	0	0	1
Sporobolus nitens Stent	0	0	3
Themeda triandra Forssk	25	33	2
Tragus berteronianus Schult	1	8	5
Trichoneura grandiglumis (Nees) Ekman.	0	0	1
Urochloa mosambisensis (Hack.) Dandy	19	2	3
Total number of species	11	16	19

Table 3. Herb and shrub species occurring on the three sampling sites as recorded during a study in the Polokwane Nature Reserve (March 2005-February 2006).

Woodland	Open Savanna	Grassland
Asparagus sp.		
	Bidens pilosa L.	
		Convolvulus sagittatus Thumb.
Dichrostachys cinerea (L.) Wright & Arn.		
	Cassia mimosoides (L.) Greene	
		Crabbea angustifolia Nees
Gymnosporia senegalensis (Lam.) Loes.		
	Chloris virgata Sw	
		Crotalaria sp.
Lippia javanica (Burm.F.) Spreng.		
	Cleome rubella Burch	
		Clerodendram glabrum E. Mey.
	Commelina africana	
		Dicerium
Sanseveria sp.		
	Gnidia sp	*Gnidia* sp
	Gladiolus sp.	
Trianthema sp.		
		Gymnosporia buxifolia (L.)Szyszyl.
	Hypoxis obtusa Burch. Ex Ker Gawl.	
	Indigofera sp.	
Lycium sp.		*Lycium* sp.
	Pentarrhinum insipidum E. Mey.	
		Solanum sp.
		Striga elegans Benth.
	Tagetes minuta L.	
		Tephrosia longipes Meisn.

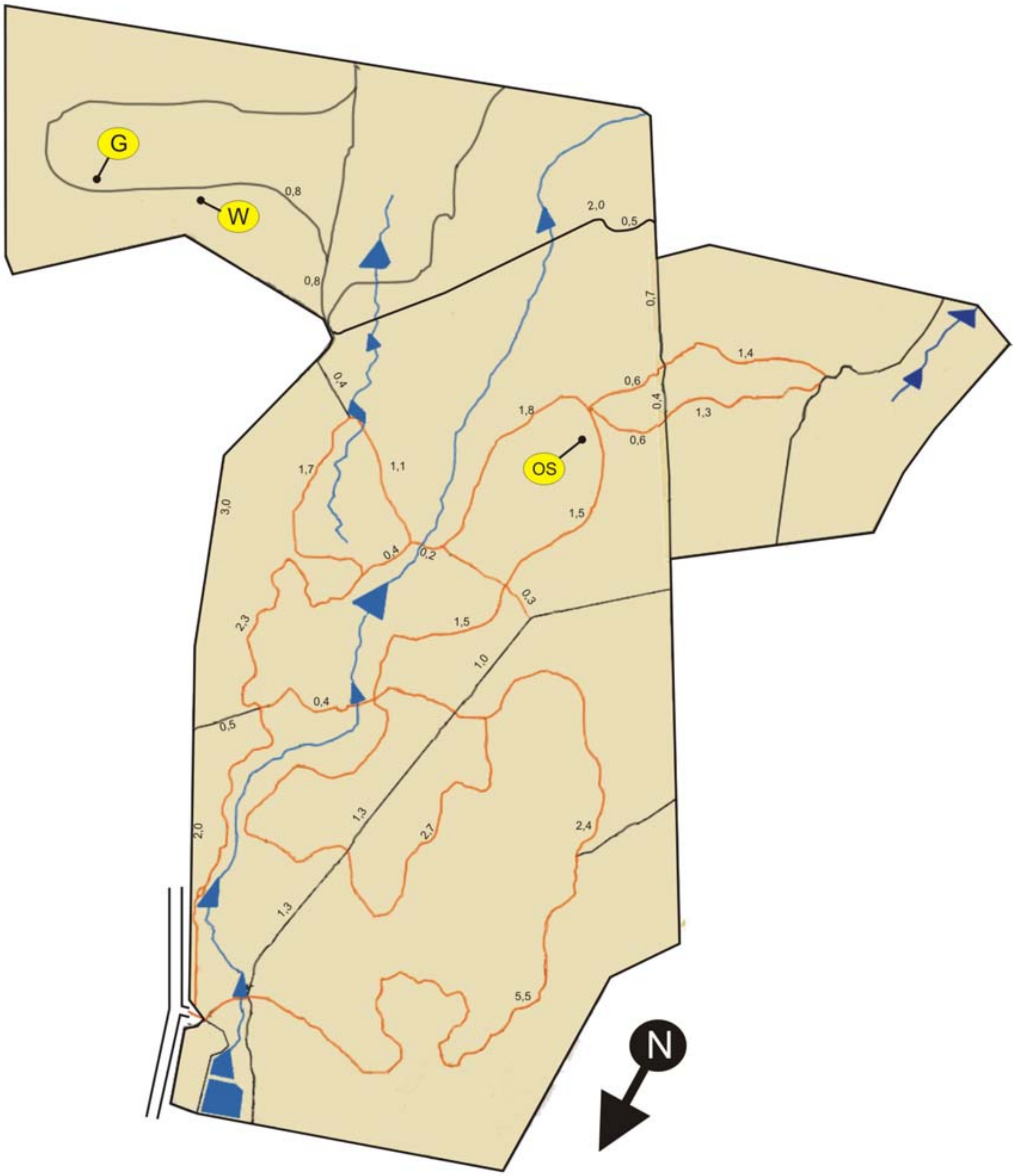

Fig. 1 A map of the Polokwane Nature Reserve, Limpopo Province indicating the distances in km of the roads as well as the location of the three sampling sites (OS = *Acacia tortillis* Open Savanna, W = *Acacia rehmanniana* Woodland, G = Pietersburg Plateau False Grassland)

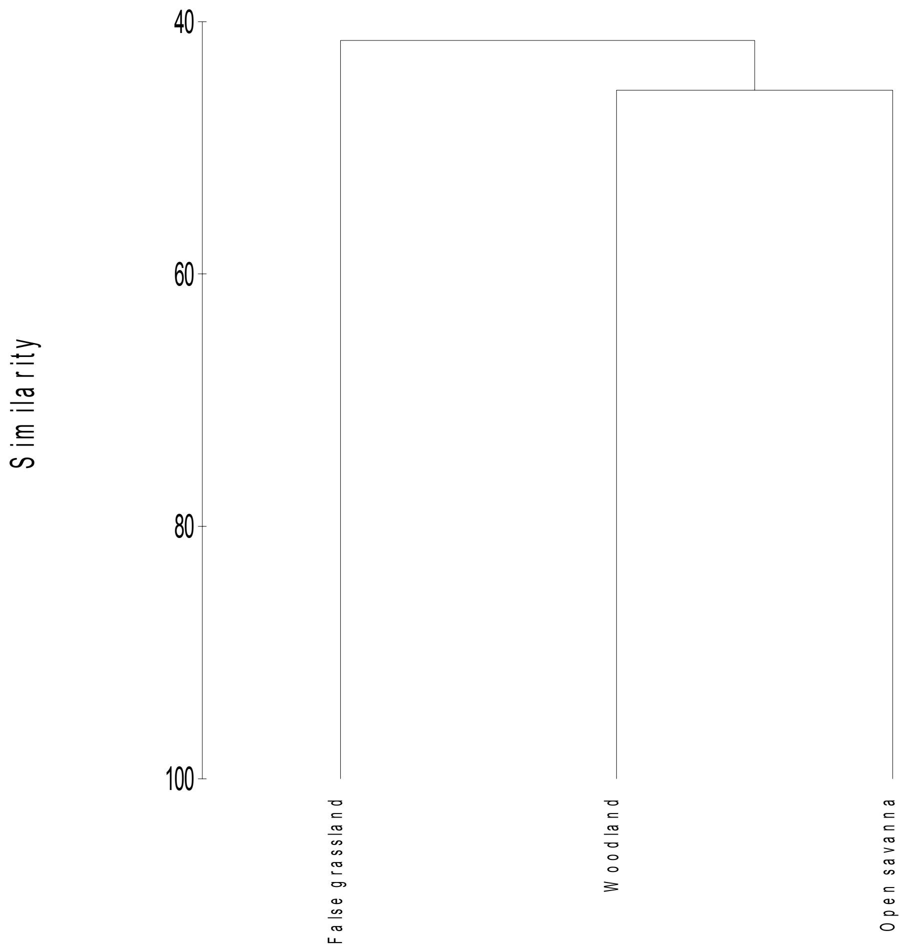

Fig 2. A cluster analysis of Bray-Curtis similaries of the percentage dominance values of the grass species occurring on each site during a study in the Polokwane Nature Reserve (March 2005- February 2006).

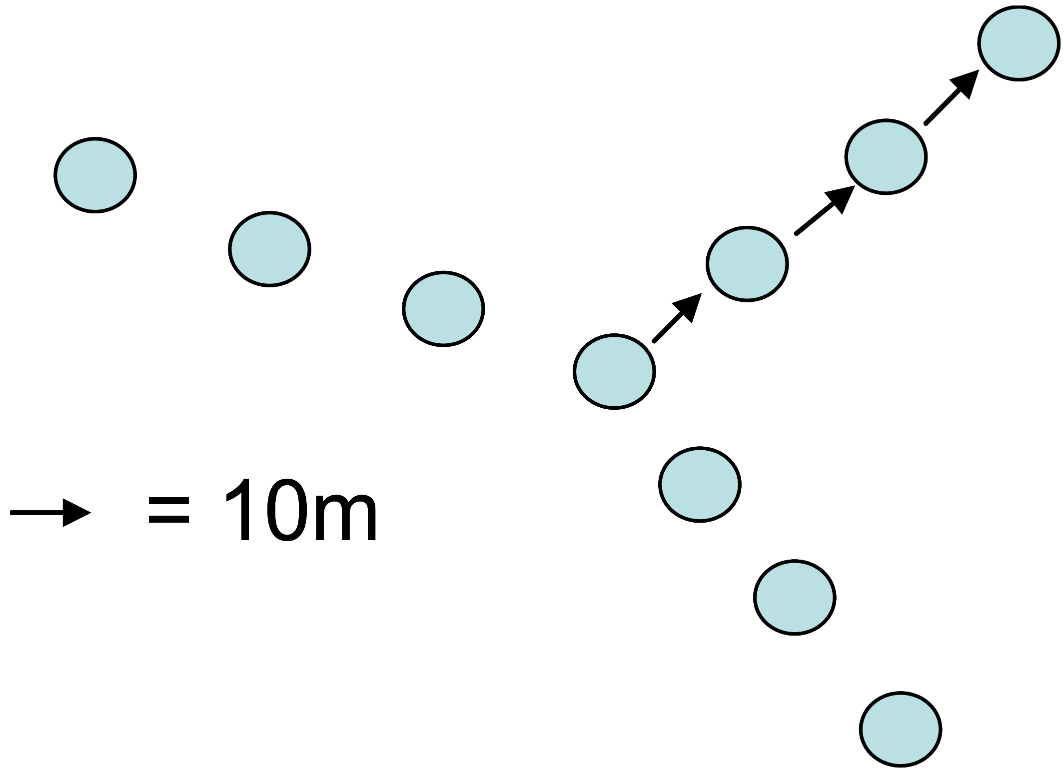

Figure 3. A diagram showing the ten pitfall traps per site, placed 10 m apart in three directions from a central trap with the furthest ones being 30 m from the central trap.

CHAPTER 3

RESULTS AND DISCUSSION

3.1 An inventory of spiders from three studied sampling sites and a comparison with other areas

3.1.1 Spider composition

A total of 7 776 spiders were sampled belonging to 33 families, 131 genera and 219 species (Appendix 2). As a total of all species recorded from Southern Africa (Dippenaar-Schoeman 2002b), 11 % of the species is presently protected in this reserve. Results from other studies done in the Savanna Biome include:

> A study done at Makalali Private Game Reserve was conducted during four summer periods (preliminary survey (February), late summer (March), early summer (October) and mid-summer (December)) using the same collecting methods as in the current study. During this study five different vegetation types were sampled. A total of 4832 specimens were collected which included 38 families, 268 species and 147 genera (Whitmore *et al*. 2002), representing 57% of the currently known families of southern Africa.
>
> During an *ad hoc* survey in the Kruger National Park conducted over a period of 16 years using three collecting methods, a total of 40 families including 152 species and 116 genera were collected (Dippenaar-Schoeman & Leroy 2003). These represent 60% of the currently known families of southern Africa.
>
> A survey at Sovenga Hill used five collecting methods and the study was conducted for a period of two months. A total of 29 families, including 62 genera and 76 species, were collected (Modiba *et al.* 2005*)* representing 43% of the currently known families of southern Africa.
>
> At Lajuma on the Western Soutpansberg five years of sporadic *ad hoc* sampling was done. A total of 46 families, including 109 genera and 127 species, were collected (Foord *et al.* 2002) representing 69% of the currently known families of southern Africa.

During a survey done at Ndumo Game Reserve that extended over a period of six years of *ad hoc* sampling during 11 trips using five collecting methods, a total of 46 families including 222 genera and 431 species were collected (Haddad *et al*. 2006). These represent 69% of the currently known families of southern Africa.

At the Springbok Flats, three collection methods were used over a period of two years resulting in a total of 3139 spiders collected from 35 families (Van den Berg *et al.* 2003), representing 52% of the currently known families of southern Africa.

The total number of spiders, families and species collected during the current study compare well with the above mentioned studies done in the Savanna Biome. From these studies it seems like more diversity and numbers of species and families are collected during *ad hoc* sampling over extended periods using a variety of sampling methods.

3.1.2 Family abundance and diversity

The family Oxyopidae was the most abundant family representing 20.3 % of the number of collected specimens, followed by the Eresidae with 19.9 %, the Thomisidae with 18.1 %, the Araneidae with 7.4 %, the Lycosidae with 7.3 %, the Salticidae with 6.7 % and Theridiidae with 6.1 % (Table 4). The rest of the families recorded were below 6.0 % of the total collected.

Oxyopidae: A total of 1 575 (20.3 %) oxyopids represented by 11 species were collected (Table 4). Oxyopids are plant dwellers commonly found on grass, shrubs and trees and they form an important component of the Savanna Biome. Their good vision enables their quick detection of prey as they move around on plants, leaping from leaf to leaf. Prey is caught with their legs, and they often jump a few centimeters into the air to seize an insect passing in flight hence their common name lynx spiders (Dippenaar-Schoeman & Jocqué 1997). This is the first survey in Southern Africa where the family Oxyopidae was recorded as the most abundant group present.

Eresidae: A total of 1 554 (19.9 %) specimens of eresids represented by three species were collected from retreat-webs (Table 4). However, it was mainly the species *Stegodyphus dumicola* Pocock, 1898 (1 549) who contributed to their high numbers. This species is one of two *Stegodyphus* species that lives socially in community nests (Dippenaar-Schoeman & Jocqué 1997) and is a common inhabitant of the Savanna

Biome. Nests collected during this study host on average about 60 individuals, some nests had more than a hundred and they were mainly collected during active searching on shrubs and *Acacia* trees. Members of Eresidae have diverse life styles. These spiders build sheet-webs provided with retreat, regular arrays of radiating threads covered with zigzag bands of cribellated silk. The other two genera, *Dresserus* that build their messy, shroud-like retreat on loosely woven silk are commonly found under stones and *Gandanameno* that is found under loose bark on trees (Dippenaar-Schoeman & Jocqué 1997), were present in low numbers.

Thomisidae: During this study 1 411 (18.1 %) thomisids represented by 31 species (14.1 %) were collected (Table 4). They are wandering spiders found on plants. They usually have strong bodies and robust front legs which enable them to attack prey of a larger size than themselves. They are well camouflaged and ambush their prey on plants or soil surface (Dippenaar-Schoeman & Jocqué 1997). Thomisids are very abundant and present in high numbers in most surveys so far undertaken in South Africa. Two studies undertaken in the Limpopo Province at the Western Soutpansberg and Sovenga Hill, recorded the Thomisidae as being the most diverse with 15 and 12 species respectively (Foord *et al*. 2002; Modiba *et al.* 2005). The genus *Ozyptila* sp. 1 is a new record for South Africa (Appendix 2).

Araneidae: The araneids are orb-web builders and commonly found in the Grassland and Savanna Biomes. A total of 582 (7.4 %) specimens represented by 33 species (15.1 %) were collected (Table 4). Most of the species are nocturnal making their webs in the grass or between shrubs to be removed early in the morning. In another study in the Savanna Biome at Makalali Nature Reserve (Whitmore *et al*. 2001) a total of 31 araneid species were recorded.

Lycosidae: The lycosids (568; 7.3 %) (Table 4) are ground dwellers and commonly found in the Savanna Biome. In this family, taxonomy is still unstable and of the 16 species (7.3 %) collected only three could be identified to species level (Appendix 2). Most species are diurnal and seen running on the soil surface. They have good vision with highly developed sense of touch. Before their prey can be bitten, they grab it with their legs and form a basket around it. The female lycosid attaches the egg sac on the spinneret. The young spiderlings climb onto the mother’s back after emerging from the egg sac and remain there until the second moult. In the study undertaken at the Makalali

Nature Reserve only 71 lycosids were recorded (Whitmore *et al*. 2002). In a study done by Modiba *et al*. (2005), Lycosidae was the third most abundant family (77) representing 9.7 % of the total number of specimens collected.

Salticidae: The Salticidae is another family of spiders that are very abundant on vegetation and the soil surface. A total of 527 (6.7 %) specimens representing 25 species (11.4 %) were collected (Table 4). They have well developed vision. They detect and persue their prey by stalking, chasing and leaping. Most salticids do not use silk to catch their prey. They use silk to build sac-like retreats for moulting, mating and to occupy during inactive periods. In three Savanna Biome surveys salticids were among the three most abundant families. At a study on the Western Soutpansberg, the Salticidae and Araneidae were the second most abundant, both represented by 10 species (Foord *et al*. 2002), while in the Makalali Nature Reserve survey, the salticids were the most species rich family (32). In the study done at the Roodeplaat Dam Nature Reserve, Salticidae was the third most abundant family collected from vegetation (Dippenaar-Schoeman *et al*. 1989).

Theridiidae: Theridiids occur in a variety of habitats and constitute a diverse group of spiders. A total of 471 (6.1 %) specimens represented by 18 species (8.2 %) were collected (Table 4). Some theridiids construct regular webs while others have webs that are reduced or absent. Some of the theridiid webs are able to catch flying insects. Five of the species collected belong to the genus *Theridion* one of the most diverse genera in the world. In the Makalali Nature Reserve survey, 248 specimens of Theridiidae were collected (Whitmore *et al*. 2002).

3.1.3 Species abundance and richness

The seven most abundant species collected were: (1) *Stegodyphus dumicola* (Eresidae) (1 549); (2) an undescribed oxyopid *Oxyopes* sp. 3 (535); (3) *Oxyopes russoi* Caporiacco, 1940 (476); (4) *Runcinia flavida* (Simon, 1881) a thomisid *(*437); (5) another oxyopid, *Oxyopes pallidecoloratus* Strand, 1906 (384); (6) a lycosid *Evippomma squamulatum* (Simon, 1898) (282) and (7) a thomisid *Monaeses austrinus* Simon, 1910 *(*201) (Appendix 2). Abundance differs among each of the surveys undertaken in South Africa so far. In the Nama Karoo grassland the dominant ground spiders were gnaphosid species (*Asemesthes lineatus* Simon, 1887) and a philodromid (*Hirriusa arenacea* Strand, 1932) (Haddad & Dippenaar-Schoeman 2005) while the dominant ground spiders at Richards Bay were an undescribed lycosid and the ctenid *Ctenus gulosus* (Dippenaar-

Schoeman & Wassenaar 2002). The most abundant species on Sovenga Hill were a thomisid *Tmarus comellini* Garcia-Neto, 1989 and a clubionid *Clubiona godfreyi* Lessert, 1921 (Modiba *et al*. 2005).

The seven families with the highest number of species caught during this study were the Araneidae (33), the Thomisidae (31), the Salticidae (25), the Gnaphosidae (20), the Theridiidae (18), the Lycosidae (16) and the Philodromidae (12) (Table 4).

Araneidae: The seven most abundant araneid species recorded were an undescribed species of *Araneilla* (86); four *Neoscona* species namely *N. quincasea* Roberts, 1983 (83); *N. blondeli* (Simon, 1881) (51); *N. subfusc*a (C.L. Koch, 1837) (34) and *N. moreli* Vinson, 1863 (32) (Appendix 2). Most of the *Neoscona* species inhabit grass where they built their orb-webs at night removing it early in the morning. *Hypsosinga lithyphantoides* Caporiacco, 1947 (56) a small araneid, makes very small webs in the grass close to the soil surface. Five *Argiope* species were collected from the study area with A*rgiope trifasciata* (Forskal, 1775) (42) the most abundant (Appendix 2). They construct large orb-webs between plants and are found in the hub of the web during the day.

Thomisidae: The seven most abundant thomisid species recorded included two species of the genus *Runcinia* namely *R. flavida* (437) and *R. erythrina* Jézéquel, 1964 (70) (Appendix 2). *Runcinia* species are mainly diurnal grass dwellers that blend in with their surroundings with their cream elongated bodies (Dippenaar-Schoeman 1980). Three other long-bodied grass dwelling species collected were *Monaeses austrinus* Simon, 1910 (201); *M. gibbus* Dippenaar-Schoeman, 1984 (103) and *M. quadrituberculatus* Lawrence, 1927 (89) (Appendix 2). All three species are common inhabitants of grass (Dippenaar-Schoeman 1983). The two species *Misumenops rubrodecoratus* Millot, 1942 (181) and *Synema imitator* (Pavesi, 1883) (58) (Appendix 2) are abundantly found not only on grass but also on shrubs and trees.

Salticidae: The third most diverse family was Salticidae represented by 25 species (11.4 %) (Table 4). They are known to occur in a wide variety of habitats (Dippenaar-Schoeman & Jocqué 1997). The most abundant species were: *Euophrys* sp.1 (125); *Thyene inflata* (Gerstäcker, 1873) (87); *Brancus bevisi* Lessert, 1925 (53); *Stenaelurillus* sp. 2 (49); *Heliophanus debilis* Simon, 1901 (39); *Rhene machadoi* Berland & Millot, 1941 (38) and *Pellenes* sp.1 (27) (Appendix 2).

Gnaphosidae: The fourth most diverse family was Gnaphosidae, a ground dweller consisting of 20 species, representing 9.1 % of the total species collected (Table 4). They are nocturnal free living spiders, found mainly on the soil surface (Dippenaar-Schoeman & Jocqué 1997). The four most abundant species were: *Asemesthes ceresicola* Tucker, 1923 (124); *Drassodes splendens* Tucker, 1923 (49); *Xerophaeus bicavus* Tucker, 1923 (38) and *Setaphis arcus* Tucker, 1923 (7) (Appendix 2).

Theridiidae: The gumfoot-web spiders of the family Theridiidae were represented by 18 species (8.2 %) (Table 4). They constitute a diverse group of spiders occurring in a variety of habitats, with diverse life styles and webs. They usually construct irregular space webs with threads radiating in different directions (Dippenaar-Schoeman & Jocqué 1997). The five most abundant species were *Theridion* sp.13 (189); *Enoplognatha molesta* O.P.-Cambridge, 1904 (56); *Latrodectus renivulvatus* Dahl, 1902 (36); *L. geometricus* C.L.Koch, 1841 (24) and *Theridion* sp.19 (14) (Appendix 2).

Lycosidae: The Lycosidae were represented by 16 species (7.3 %) (Table 4) that are free-living, ground dwelling hunters occurring in a variety of habitats and are commonly found in Savanna and Grassland Biomes (Dippenaar-Schoeman & Jocqué 1997). The most abundant lycosids were *Evippomma squamulatum* Alderweireldt, 1992 (282) followed by *Lycosa* spp. 1 & 2 (79; 89 respectively); *Proevippa* sp.1 (37); *Lycosidae* sp. 2 (21) and *Pardosa* sp.10 (20) (Appendix 2).

Philodromidae: The philodromids were represented by 12 species (5.4 %) (Table 4) that are free-living plant dwellers with some species recorded from the soil surface. The more abundant species recorded were three species belonging to the genus *Philodromus* commonly found on grass and trees namely *P. grosi* (65) Lessert, 1943; *P. guineensis* Millot, 1942 (64) and *P. browningi* (34). Other abundant species included *Tibellus hollidayi* Lawrence, 1952 (43) another commonly found long bodied grass dweller (Dippenaar-Schoeman & Jocqué 1997); *Tibellus minor* Lessert, 1919 (30) is commonly found on bushes and tall grass as well as *Suemus punctatus* Lawrence, 1938 (23) (Appendix 2).

This survey compares well with four other studies undertaken in the Savanna Biome in South Africa. In a study undertaken in the Western Soutpansberg, covered by a very diverse floral environment, the Thomisidae had the highest number of species (15), followed by the Araneidae and the Salticidae with 10 species each (Foord *et al*. 2002). In a study done on Sovenga Hill, a closed woodland, the Thomisidae was also the most diverse with 12 species, followed by the Gnaphosidae with 11 species and the Araneidae with 10 species (Modiba *et al.* 2005). A study in the Makalali Nature Reserve covered by broad-leafed savanna, recorded the highest number of species for the Salticidae (32), followed by Araneidae (31) and the Theridiidae with 28 species (Whitmore *et al*. 2002). In Ndumo Game Reserve, within the Bushveld Savanna ecozone, the most diverse families were the Salticidae (82 species) followed by the Thomisidae (56 species) and the Araneidae (38 species) (Haddad *et al*. 2006c).

Spiders belonging to the Araneidae occur in a wide variety of habitats (Dippenaar-Schoeman & Jocqué 1997) and are therefore more frequently encountered and caught. Additionally members of Araneidae, Thomisidae and Salticidae are mostly plant-dwelling spiders and areas with a variety of plant layers have a high number of species belonging to these families. Therefore the vegetation cover in an area may explain the abundance of spiders of certain guilds (Marc *et al*. 1999).

Families represented by only a single species during this study were the Amaurobiidae (11), Ammoxeniidae (3), Caponidae (5), Ctenidae (3), Cyrtaucheniidae (6), Dictynidae (5), Hersiliidae (9), Linyphiidae (1), Mimetidae (1), Nephilidae (17), Pholcidae (4), Prodidomidae (7), Selenopdae (1) and Theraphosidae (1) (Appendix 2). Some of these species have specific habitat and microclimatic requirements that result in their restricted distribution patterns (e.g. Ammoxeniidae (Dippenaar-Schoeman *et al*. 1996a).

3.1.4 Spider guild diversity

From the species caught, 69.8 % (153) were wanderers and 30.2 % (66) were web-builders. Most of the wanderers caught are free living, found on the vegetation and the soil (96.7 %; 148) with only few (3.3 %; 5) living in burrows. Most of the web-builders collected were orb-web spiders (57.5 %; 38), followed by gumfoot-web spiders (27.3 %; 18). The remaining (15.2 %; 10) of the web-builders built retreat-webs (9.1 %; 6), funnel-webs (3.1 %; 2), space-webs (1.5 %; 1) and sheet-webs (1.5 %; 1).

3.2. Comparison of the differences among spider communities of the three sampled vegetation types

3.2.1 Spider composition from the three sampling sites

During the study period, the highest number of spiders was caught in the Woodland site (3 520) representing 45.3 % of the total number of spiders collected, followed by the Open Savanna with (2 823) 36.3 % and the Grassland (1 433) representing only 18.4 % of the total number sampled (Table 4). The decrease in numbers of specimens caught from the Woodland to Open Savanna to Grassland was expected, due to the decrease in tree cover from Woodland (50-75 %), to Open Savanna (0-25 %) and the absence of trees in the Grassland site (0-25 %) (Table 2).

3.2.2 Family diversity caught from the three sampling sites

The highest number of spider families was recorded from the Open Savanna site (28) followed by the Woodland site (27) and the Grassland site (21) (Table 4). The total number of families collected per site does not follow the above mentioned expected pattern for the different sampling sites. The familes with the highest number of individuals caught in all three sampling sites were the Oxyopidae (Woodland 780 specimens; Open Savanna 736 specimens; Grassland 59 specimens), Eresidae (Woodland 836 specimens; Open Savanna 289 specimens; Grassland 429 specimens) and Thomisidae (Woodland 409 specimens; Open Savanna 289 specimens; Grassland 429 specimens) (Table 4).

Woodland site: Of the 27 families collected from the Woodland site the Eresidae (836; 23.8 %) was the most abundant of the total caught in the Woodland site, followed by the Oxyopidae (780; 22.1 %), the Thomisidae (409; 11.6 %), Salticidae (7.4 %) and Theridiidae (6.4 %) (Table 4). The denser vegetation provided better coverage and attachment sites for several plant and web dwelling families. The following web-builders were found in the Woodland site: Araneidae (7.7 %); Pisauridae (2.1 %); Nephilidae (0.3 %); Uloboridae (0.25 %) and Pholcidae (0.08 %). Of the wandering spiders the Miturgidae was the most abundant (61; 1.7 %), followed by Sparassidae (10; 0.28 %) and Prodidomidae (5; 0.14 %). Three families (Amaurobiidae, Ctenidae and Linyphiidae) were present only in the Woodland site while the families Ammoxenidae, Hersiliidae, Mimetidae, Selenopidae and Theraphosidae were absent (Table 4).

Open Savanna: Twenty-eight families were recorded from this site (Table 4). Most individuals caught from the Open Savanna belonged to the family Oxyopidae (736; 26.1 %), followed by the Thomisidae (685; 24.2 %) and the Eresidae (289; 10.2 %). The family Ammoxenidae was caught only in the Open Savanna site. Members of this family are unique, free-living termitophagous hunters with a special ability to dive into soil and they usually occur in areas heavily infested with harvester termites (Dippenaar-Schoeman *et al*. 1996b). The Open Savanna site had some termite hills which made this site a suitable habitat for the Ammoxenids to inhabit. Five families were absent from the Open Savanna (Amaurobiidae, Ctenidae, Cyrtaucheniidae, Linyphiidae and Theraphosidae) (Table 4).

Grassland: The Grassland site was poorer in numbers (1 433) and the number of families (21) (Table 4). In the Grassland, the family Eresidae (429; 29.9 %) was again the most abundant (but in lower numbers than the Woodland site), followed by Thomisidae (317; 22.1 %) and Lycosidae (146; 10.2 %). Nine families were absent from this site and only a single specimen of Theraposidae was sampled in the Grassland while 50 % of the agelenids were collected here (Table 4).

Similar results were observed in other Savanna Biome surveys. In a study done on the Roodeplaat Dam Nature Reserve, 27 families were recorded with most spiders belonging to Tetragnathidae (29.3 %), followed by 21.4 % of Araneidae and 21.4 % of Salticidae (Dippenaar-Schoeman *et al*.1989). In a study done on a Savanna Biome in Namibia and Kenya, 34 and 40 families were recorded respectively (Warui 2004 & Warui *et al*. 2005). Salticidae accounted for 17 % (Mkomazi) and 14 % (Etosha) while Gnaphosidae accounted for 16 % (Mkomazi) and 14 % (Etosha) of the total. Other families included Lycosidae with 6-7 % and Zodaridae with 6-7.5 % (Russell-Smith 2002).

Shannon-Wiener diversity index values calculated for species caught in the three different sampling sites were the highest for the Open Savanna site (H'=3.777), followed by the Woodland site (H'=3.569) and the Grassland site (H'=3.273). Although the Woodland site had the highest number of specimens caught and the highest number of species, the calculated Shannon-Weiner diversity index for this site does not correspond to these values. Evenness values for the Open Savanna (H_E=0.748), the Woodland (H_E=0.692) and the Grassland sites (H_E=0.689) were reasonably high indicating a relative even distribution of species across sites. Sørensen's similarity index calculated to compare the species diversity between the woodland and open savanna (β=0.716) indicates that there is a reasonable amount of species overlap between the two sites. A slightly lower overlap was found in a comparison between the woodland and grassland sites (β=0.64) as well as between the open savanna and grassland sites (β=0.56).

Thus a relative equal distribution of species exists across sites (H_E=0.6 – 0.7) with reasonable amount of overlap (β=0.5 – 0.7) and a slightly higher diversity of species in one site (Open Savanna) (H'=3.7) compared to the other sites.

3.2.3 Comparison of species caught in the three sampling sites

The highest number of species was found in the Woodland (173), followed by Open Savanna (159) and the Grassland sites (115) (Appendix 2). Some species were encountered both in the Woodland and Open Savanna (*Cheiracanthium vansoni* Lawrence, 1936; *Diores* sp. 2; *Gephyrota* sp.; *Hypsosinga* sp. 2; *Miagrammopes longicaudus* O.P.-Cambridge, 1882; *Oxyopes bothai* Lessert, 1915; *Pardosa* sp. 10 and *Philodromus grosi*). The presence of trees on these sites played a role in providing habitat for most of the above mentioned species. Specimens of seven species (i.e. *Hirriusa variegata* (Simon, 1895); *Monaeses paradoxus* (Lucas, 1846); *Zelotes* sp.1; *Olios* sp. 2; *Psammoduon* sp. 1; *Langelurillus* sp. 1 and *Lycosidae* sp. 4) co-occurred in the Grassland and Open Savanna sites. Some species (*Argyrodes convivans* Lawrence, 1937; *Capheris decorata* Simon, 1904; *Cosmophasis* sp. 2; *Oxyopes schenkeli* Lessert, 1927; *Pseudomicrommata longipes* (Bösenberg & Lenz, 1895) and *Thyenula aurantiaca* (Simon, 1902)) were found only on the Woodland site while others were found only on the Open Savanna (*Ebo* sp. 1; *Monaeses fuscus* Dippenaar-Schoeman, 1984; *Phlegra* sp. 1 and *Tmarus longicaudatus* Millot, 1941) and Grassland (*Singa lawrencei* (Lessert, 1930); *Thomisops sulcatus* Simon, 1895 and *Zelotes ungulus* Tucker, 1923) sites.

Most individuals caught from the total number of eresids belonged to *Stegodyphus dumicola* (1 549, 99.6 %), with 836 (53.7 %) specimens caught in the Woodland, 427 (27.4 %) in the Grassland and 287 (18.4 %) in the Open Savanna site (Appendix 2). The second most abundant species caught was *Oxyopes* sp. 3 (535, 33.9 %) with 336 (62.8 %) individuals caught in the Woodland, followed by 196 (36.6 %) caught in Open Savanna and only 3 species found in the Grassland site. The third abundant species is *Oxyopes russoi* (476, 30.2 %) which had 266 (55.8 %) in the Woodland site, 206 in the Open Savanna and only four specimens in the Grassland site. *Oxyopes pallidecoloratus* (384, 24.3 %) had the highest numbers in the Open Savanna where 268 (69.7 %) specimens were caught, followed by 83 (21.6 %) specimens caught on the Woodland and 33 (8.5 %) on the Grassland sites. These three species contributed mainly to the high oxyopid numbers (Appendix 2).

The next most abundant species belong to the Thomisidae. Members of Thomisidae are typical plant dwellers. From the total number (1 411) of thomisids caught, the most abundant were in the Open Savanna (685; 48.5 %), followed by the Woodland (409; 28.9 %) and the Grassland (317; 22.4 %) (Appendix 2). The two most abundant genera were *Runcinia* (536; 37.9 %) and *Monaeses* (415; 29.4 %). *Runcinia* were represented by four species of which *Runcinia flavida* was the most abundant thomisid caught (437; 30.9 %). Members of *Runcinia* are typical grass dwellers (Dippenaar-Schoeman & Jocqué 1997), they were the most abundant in the Woodland (196; 13.8 %) followed by slightly lower numbers from the Open Savanna (190; 13.4 %) and the Grassland (150; 10.6 %). Members of the genus *Monaeses* were represented by six species with *Monaeses austrinus* the most abundant (201; 14.2 %). This genus was scarce in the Woodland (4; 0.2 %) but more abundant in the Open Savanna (138; 9.7 %) and Grassland (59; 4.1 %).

Vegetation type affects spider assemblages as some prefer specific habitats and microclimatic conditions (Marc *et al.* 1999, Whitmore *et al.* 2002). Families show varying degrees of habitat fidelity with some being widespread and abundant while others are restricted to one site and are locally rare (Whitmore *et al*. 2002). Habitat preference was observed during this study, since some species were collected from a specific site but were absent from the others. During the current study it was expected that a higher number of species will be collected from the Woodland site since it is structurally more complex (Table 2) and indeed more species were caught on the Woodland site (173) followed by the Open Savanna (159) and the Grassland (115) sites. Therefore the results from the current study confirm that vegetation type affect spider assemblages and richness.

3.3 Comparison of sampling methods used during the survey

During this study the highest number of specimens and species were caught by sweep netting (2 972; 126), followed by active searching (2 572; 121), tree beating (1 895; 76), pitfall trapping (323; 71) and only a few (14; 9) were caught by leaf litter sifting (Table 5). The presence of grass cover of between 25-75 % in all the sites (Table 2) resulted in the high number of specimens caught by sweep netting as it sample specimens inhabiting the grass and herb layer. Due to the scarcity or absence of leaf litter in all sites, leaf litter sifting was used only once in the Woodland site and only 14 specimens represented by 9 species were collected (Table 5). Even in this site there was not enough litter to fill the box, since the site was dominated by *Acacia rehmanniana* trees with very thin leaves.

A dendrogram constructed from Bray-Curtis similarities calculated for the species caught using different sampling methods (Fig. 4) indicated that sweep netting and tree beating were 48 % similar. This is due to 54 species caught using both methods (Table 5). Both these methods target plant dwelling species and will therefore overlap in the species caught. Species caught by active searching and pitfall traps were 44 % similar due to 50 species shared by these two methods. This is probably because all kinds of spiders are caught during active searching and will include wanderers caught specifically by pitfall trapping. Species caught by leaf litter sifting were 8 % similar to the other methods (Fig. 4). This method is mainly used to catch spiders living in leaf litter, but since it was used only once, the results may not reflect the total composition of families that maybe encountered in leaf litter.

Active searching: Active searching contributed 33.1 % of all spiders collected. The Eresidae (54.8 %) was the most abundant family collected and it represented 90.7 % of all eresids collected during the study period, using all collection methods (Table 5). The eresids collected were represented mainly by *Stegodyphus dumicola* the community nest spider. These spiders were abundantly found in the reserve and their webs and nests are easily seen on the vegetation. Some nests can house on average 60 or even more specimens. The Lycosidae (19.6 %) and Salticidae (4.7 %) were the other abundant families collected during active searching. Most of the species of these families are diurnal and commonly found running on the soil surface or vegetation during the day. Three families (Hersiliidae, Theraphosidae and Corinnidae) were caught only during active searching. The Hersiliidae were represented by *Tyrotama soutpansbergensis* Foord & Dippenaar-Schoeman 2005, it is a sedentary ground-dwelling web-builder and not easily caught in pittraps (Foord & Dippenaar-Schoeman 2005). The Theraphosidae species *Augacephalus junodi* (Simon, 1904) is a burrow dweller and especially the females are not collected in pittraps. The two ground-dwelling corinnids specimens were also collected during active searching.

Sweep netting: Sweep netting contributed 38.2 % of all spiders collected (Table 5). The Thomisidae (42.1 % of all thomisids) was the most abundant family collected with this method. The thomisids are one of the most common families found in the grass layer. *Runcinia flavida* was caught in higher numbers using this method as these are plant dwelling species. They were followed by the Oxyopidae (16.7 %), the Araneidae (13 %) and the Theridiidae (9.3 %). The Linyphiidae was the only family collected only with this method.

Tree beating: Tree beating contributed 24.4 % of all spiders collected (Table 5). The *Oxyopes russoi* and *Oxyopes* sp. 3 were the most abundant species caught using this method both with 464. In total 52.3 % of all oxyopids were collected from trees. Other abundant families were Philodromidae and Salticidae both with 8.4 % followed by the Araneidae with 7.4 %.

Pitfall trapping: Only 4.2 % of all the spiders collected were sampled with pittraps (Table 5). This method targets mostly wanderers. Gnaphosidae (92; 28.4 %) was the most abundant family caught with pitfall traps, followed by Zodariidae with 22.9 %. *Diores* sp. had the highest numbers caught using this method (45) followed by *Asemethes ceresicola* (24). Three families (Amaurobiidae, Ctenidae and Selenopidae) were caught by pitfall trapping only. The Ctenidae are nocturnal, wandering spiders which hunt their prey on foliage and on the soil surface. They are commonly found under fallen logs on the ground (Dippenaar-Schoeman & Jocqué 1997). Selenopids are free living wandering spiders with some species found under stones, rocks while other live on tree trunks and on walls (Dippenaar-Schoeman & Jocqué 1997).

3.4 Comparison of spiders caught in different months and seasons

3.4.1 Total numbers and abundance per month

Spiders were present throughout the year in all three sites. The annual phenological pattern of all the spiders collected showed a peak in May (859) with a small decline to June (805) while the lowest number was recorded in August (426) (Table 6). During the present study most spiders were caught during autumn (March, April and May) (2 238), followed by summer (December, January and February) (1 892), spring (September, October and November) (1 844) and winter (June, July and August) (1 802) (Table 6).

The reason for the increased numbers of spiders captured in autumn might be due to the increased availability of resources needed by the spiders for survival which were produced in summer. During the summer months, the study area had 100 mm of rain, while during the autumn months there was 18.6 mm of rain. Increased precipitation may lead to germination of seeds, growth of plants, development of new leaves, flowering and seed production. Flowers with their nectar attract an increased number of insects which will attract an increased number of predatory organisms. Since spiders are predacious arthropods (Dippenaar-Schoeman *et al*. 1999b), their numbers may be expected to increase as a result of increased insect numbers as well as an increase in female fecundity and juvenile survival (Langlands *et al*. 2006). New foliage results in more available habitats for the spiders to dwell on, to ambush their prey and to lay and camouflage their eggs. Additionally, increased rainfall reduce desiccation risk for males searching for mates because spiders are sensitive to water loss as they are soft bodied organisms (Langlands *et al*. 2006). During winter, organisms compete for the available resources as resources are becoming scarce. In this case, prey also become scarce, some plant dwelling spiders will start to compete for habitats as most plants become dry, trees loose their leaves and flowers wither. Many spiders overwinter as immatures and they will frequently go for long periods without food. Reduced food sources might be the reason why lower numbers of spiders were collected during winter. According to Wise (1993) food often limits spider populations, while competition among species for the same limiting resources, will drive some species to extinction (Begon *et al*. 1996). In a study done in ground covers of pistachio orchards seasonal fluctuations were observed and spider numbers were also low in winter with an increase in spring (Haddad *et al*. 2004a). Russell-Smith (1981) found that 76 % of species recorded had major peaks in spider numbers during summer while during winter only 12 % peaked.

For the three most abundant families the following seasonal patterns were observed:

Eresidae: The numbers of the eresids, represented mainly by *Stegodyphus dumicola*, peak in December (322) (Fig. 5). The lowest numbers were recorded in August (7). The seasonal pattern of this species differs slightly from that of the total number of spiders. During autumn, 282 eresids were recorded which increased to 301 in the winter and to 339 in spring with the highest number recorded during summer (632).

Oxyopidae: The numbers of the oxyopids peaked in May (216), with a second peak in June (256). The lowest number was recorded in January (44). The seasonal pattern differs slightly from that of the eresids with 460 oxyopids recorded during autumn, while the number increased to 481 in winter, but decreased to 397 in spring and 217 in summer (Table 6). Three oxyopid species were recorded in fairly high numbers. *Oxyopes* sp. 3 (535) was more abundant in the winter (210) while the number declined to 147 in spring with a low of 70 in summer but increased again in autumn (108) (Table 6). In *O. russoi* the highest numbers were recorded in spring (170) which declined to 76 in summer but increased again to 80 in autumn and reached a high of 150 in winter. In the third species, *O. pallidecoloratus* the highest number was recorded in autumn (233) which declined to 94 in winter and even further to only 19 in spring, but increased again to 38 in summer (Table 6).

Thomisidae: The numbers of the thomisids peaked in March (274), declined to 204 in April with the lowest numbers recorded in November (33). The seasonal pattern differs slightly from that of the previous two families. The highest numbers were recorded during autumn (605=March=274+ Aril= 204+ May= 127)(May) followed by winter to 372 a decline in summer (160), in spring (212) (Table 6). One of the two commonly found thomisid species, *Runcinia flavida* was the most abundant in autumn (300) while their numbers declined to 26 in winter and increased again to 40 in spring and 71 in summer. Specimens of *Monaeases austrinus* were mostly recorded in winter (118), with numbers decreasing to 49 in spring, 2 in summer and increased again to 32 in autumn (Figure. 5).

3.4.2 Comparison of numbers of specimens caught per month per site

The highest number of specimens were caught during May (859), followed by June (805) and December (721) with the lowest numbers collected during August (426) and July (571) (Table 6). The peaks in May, June and December coincided with high numbers of *Stegodyphus dumicola* (186, 166 and 322 respectively), while the lowest number of *S. dumicola* was caught during August (7) (Fig.5). From these results it seems like the number of spiders caught per month was mostly influenced by numbers of *S. dumicola* caught.

During May the highest numbers of specimens were caught in the Woodland site, while in June most specimens were caught in the Open Savanna (453) (Fig. 6). Although the Woodland site had the highest numbers of spiders caught during the study period (3 520) (n=12; $\overline{x}$ = 293.3; s= 73.4), it did not have the highest numbers of specimens caught during each month.However, for nine months (April, May, July, August, September, October, November, December and February) of the study period most spiders were caught in the Woodland site. This might be due to the availability of more trees (50-75 % tree cover) (Table 2) on this site that increased habitat availability for spiders that dwell on vegetation. During the remaining three months (January, March, June) the highest numbers were collected in the Open Savanna. The lowest numbers of spiders were almost always collected from the Grassland site except during November when the least spiders were caught in the Open Savanna (Fig. 6). The absence of trees from the Grassland site may have played a role in reducing habitat availability for spiders and therefore resulted in lower numbers collected.

The Grassland site was burnt on the 18^{th} of September after the September sampling. The October sampling was conducted three weeks after the burn (on the 12^{th} of October). Since August a gradual increase in collected spiders was observed. Therefore, it seems like the number of collected spiders was not influenced by the burn. The first appearance of two specimens of

Cyrtaucheniidae was observed during November in the Grassland site. Members of Cyrtaucheniidae are ground-dwelling trapdoor spiders (Dippenaar-Schoeman 2002c) and were caught by active searching and pitfall trapping. Their appearance might be a result of easier detection resulting from ground exposure as fire removed the grass layer.

The highest number of spiders caught during autumn (n=3; $\bar{x}$ = 379.3 ;s= 78.35); spring (n=3; $\bar{x}$ = 279.3; s= 51.03) and summer (n=3; $\bar{x}$ = 269.3; s= 47.24) were in the Woodland site whereas the highest number during winter (n=3; $\bar{x}$ = 256.6;s= 88.44) was collected in the Open Savanna site (Fig. 7). During the study period, lower spider numbers were always caught in the Grassland site.

3.4.3. Comparison of families caught per month

Members of 11 families (Araneidae, Eresidae, Gnaphosidae, Lycosidae, Miturgidae, Oxyopidae, Philodromidae, Salticidae, Theridiidae, Thomisidae and Zodaridae) were caught during all months of sampling (Table 6). These families have generally more representatives that occupy a wide range of habitats and are therefore found more commonly. On the contrary, specimens of some families (Amaurobiidae, Linyphiidae, Mimetidae, Selenopidae and Theraphosidae) were caught only in one month. Members of Amaurobiidae are represented by 69 genera which occur worldwide. They are ground dwelling spiders commonly found in dark and damp places (Dippenaar-Schoeman & Jocqué 2006c). *Pseudauximus* sp. 1 was caught by pitfall trapping in the Woodland site during June. The site may have provided suitable habitat during this time because it has 50-75 % tree and grass cover (Table 2) which supplied dead and dry material to hide in. Since active sampling was conducted only during the day and these spiders are nocturnal hunters (Dippenaar-Schoeman & Jocqué 2006c), it may explain the capture of the specimen by pitfall trapping. Members of Linyphiidae comprise of 562 genera, a very large family, which spin delicate sheet webs between branches of trees and shrubs, in tall grass and sometimes close to the ground. Members of the family occur worldwide but are specifically well represented in temperate and cooler regions of the Northern Hemisphere (Dippenaar-Schoeman & Jocqué 2006c). *Mircolinyphia sterilis* (Pavesi, 1883) was caught on the Woodland site during March using sweep netting. The absence of members of Linyphiidae from other sites is unexplainable. Members of Mimetidae are represented by 12 genera. Most mimetids lack webs and are encountered in low vegetation where they prey on other spiders (Dippenaar-Schoeman & Jocqué 2006c). *Ero* sp. was caught by tree beating during August on the Open Savanna site. This species are found in humid habitats spiders (Dippenaar-Schoeman & Jocqué 1997). Members of Selenopidae are represented by four genera. These spiders are free living, wandering under stones, rocks, tree trunks and even on walls. Of the four genera, three are known only from Africa

(Dippenaar-Schoeman & Jocqué 2006c). *Anyphops* sp. was caught in the Open Savanna site in a pitfall trap during March. Members of Theraphosidae are free living spiders inhabiting terrestrial, silk lined burrows made under rocks and in holes under bark (Dippenaar-Schoeman & Jocqué 1997). *Augacephalus junodi* (Simon, 1904) was found by actively searching on the Grassland site during January. Theraphosids are predominantly nocturnal hunters, which hide in burrows with silked over entrances during the day (Dippenaar-Schoeman 2002c). Due to an escalating trade in baboon spiders as pets, specifically members of the Theraphosidae, many species are endangered. These spiders usually lay eggs once a year and if the female is excavated, the eggs do not survive, or spiderlings die as they depend on the female for care (De Wet & Schoombee 1991). The reported species, *A. junodi*, are one of the more commonly occurring theraphosids in the Limpopo and Gauteng Provinces (Dippenaar-Schoeman 2002c).

3.4.4. Comparison of species caught per month

The highest species numbers were caught during the months of April (91), March (89) and May (84) with the lowest in August (65) and December (66) (Table 6). Resources resulting from the summer rains may lead to flowering and growth of plants, allowed spiders to have more habitats to occupy as a result, increasing numbers of spiders in autumn. *Stegodyphus dumicola* (1549) was the most abundant species caught (Fig. 5). These species belong to the family Eresidae which are web-builders which are found in nests which can host on average 60 spiders. The *Oxyopes* sp. 3 (535) was the second most abundant species caught and are plant dwellers. The presence of more plant material may have increased habitat for them.

No distinct clustering of species collected during different months occurs on the MDS ordination (Fig. 8). However, species collected during November, December, January and February grouped further from those collected during the other eight months.

During the study period, the Woodland site had the highest number of species caught in almost all months except in June were the highest species numbers (50) were caught in the Open Savanna site (Fig. 6). The total number of species collected from the Woodland site was 173 followed by the Open Savanna with 159 species and the Grassland site had 115 species (Appendix 2). During July and August equal numbers of species were caught in the Woodland site. The lowest numbers of species were always caught on the Grassland site.

In a comparison between the number of families caught per month per site (Appendix 2) and the number of species caught per month per site, it is clear that an increase in the number of families correlates with a higher number of species. During March and April higher family numbers were caught (21 each), that corresponded with higher numbers of species (89 and 91 respectively) (Table 6). Furthermore, the number of species was the highest in the Woodland site (173) which agrees with the higher number of specimens caught in the Woodland site (3 520). Lower number of species occurred in the Open Savanna (159) where fewer specimens (2 823) were caught, followed by the Grassland with the lowest number of species (115) where the fewest specimens (1 433) were caught (Appendix 2).

3.4.5 Age of the caught spiders

During this study the total number of spiders caught (7 776) consisted of 716 females, 596 males and 6 464 immatures (Table 7). Therefore, 83.1 % of the caught spiders were immature while only 16.8 % were adults. From the spiders caught, higher numbers of immature spiders were recorder in May (787) and June (751) and the lowest numbers were in January (415) and February (396). The adult males comprise 7.7 % of total and they peaked in January (106) and in March (88) with low numbers from June to September. The females (9.17 %) peaked from December to March with low numbers in July and October. The best time for sampling in the studied sites were from December to March because spiders caught during those months were mature and could be identified.

3.4.6 Accumulative curves for the numbers of families and species caught in different months

A total of 21 families were caught during the first sampling month (March). The accumulative number of families increased with 15.15 % in April (see Fig 9). The increases observed during the first months of sampling are higher than towards the end of sampling. This indicates that families occurring in the studied area are probably approaching saturation because only a few new families are added. The slope of the curve is approaching an asymptote where it starts to plateau out. According to Clarke & Warwick (2001) the slope of the curve indicates when saturation in the number of taxa is reached since it will plateau out. At this point representatives of all the families occurring in a specific area are sampled. The accumulation curve for families collected has not reached a clear asymptote yet and therefore more families may be added. The use of the cumulative number of families as the total number of families currently present in the three sites sampled for comparative purposes is thus not recommended.

A total number of 89 species were collected during the first sampling month. The accumulative number of species increased with 13.24 % to 118 species in April (Fig 10). From this curve it becomes clear that the accumulative number of species is still increasing towards the end of the study period of one year and an asymptote has not been reached. This implies that not all species occurring in the studied area were caught. Therefore, new species will still be collected if additional sampling should be carried out and the current number of collected species is not a representative of the total species richness of the studied area.

3.5 Comparison of species diversity using the Shannon-Wiener index

The Shannon diversity index value was the highest in April (H'=3.561) followed by August (H'=3.54) and October (H'=3.455). The lowest value was in December (H'=2.546) (Fig. 11). The higher the Shannon diversity index value the more diverse the species (Clarke & Warwick 2001). The Shannon diversity calculations indicate that a higher diversity of species was caught during April than during other months of the sampling period. The higher diversity of species in April does not correspond to a high number of collected specimens since the highest numbers of specimens were collected during May and June. However, this may have been influenced by the high numbers of juveniles caught during May and June which could not be identified to species level. When considering identifiable males and females, the highest numbers of specimens were caught during December to March, which still does not correspond to the high value of Shannon-Weiner diversity index in April. Therefore, higher specimen numbers does not necessarily result in more diverse species. The highest number of species was found in the Woodland site (173) followed by the Open Savanna (159) and the Grassland site (115). The Shannon- Wiener diversity index value calculated for species caught in the three different sampling sites was the highest for the Open Savanna site (H'=3.777), followed by the Woodland site (H'=3.569) and the Grassland site (H'=3.273). Although the Woodland site had the highest number of specimens caught and the highest species richness, the calculated Shannon diversity index for this site does not correspond to the higher species richness of the site.

Table 4. List of families with the total number of individuals and species collected for each family per sampling site expressed as a percentage of total number of specimens and species collected during a study at the Polokwane Nature Reserve (March 2005-February 2006).

Families	Woodland	Open Savanna	Grassland	Total	% of total	No of species	% of total species
Agelenidae	0	4	4	8	0.1	2	0.91
Amaurobiidae	1	0	0	1	0.01	1	0.46
Ammoxenidae	0	3	0	3	0.03	1	0.46
Araneidae	274	183	125	582	7.4	33	15.07
Caponiidae	4	1	0	5	0.06	1	0.46
Clubionidae	6	6	1	13	0.16	2	0.91
Corinnidae	1	1	0	2	0.025	2	1.37
Ctenidae	3	0	0	3	0.03	1	0.46
Cyrtaucheniidae	4	0	2	6	0.07	1	0.46
Dictynidae	2	2	1	5	0.06	1	0.46
Eresidae	836	289	429	1554	19.9	3	1.37
Gnaphosidae	81	116	70	267	3.4	20	9.13
Hersiliidae	0	9	0	9	0.11	1	0.46
Idiopidae	4	3	0	7	0.09	3	1.37
Linyphiidae	1	0	0	1	0.01	1	0.46
Lycosidae	218	204	146	568	7.3	16	7.31
Mimetidae	0	1	0	1	0.01	1	0.46
Miturgidae	61	48	12	121	1.5	3	1.37
Nephilidae	12	4	1	17	0.2	1	0.46
Oxyopidae	780	736	59	1575	20.3	11	5.02
Palpimanidae	26	2	3	31	0.3	3	1.37
Philodromidae	143	193	38	374	4.8	12	5.48
Pholcidae	3	1	0	4	0.05	1	0.46
Pisauridae	71	5	9	85	1.1	5	2.28
Prodidomidae	5	1	1	7	0.09	1	0.46
Salticidae	259	170	98	527	6.7	25	11.42
Selenopidae	0	1	0	1	0.01	1	0.46
Sparassidae	10	2	1	13	0.16	5	2.28
Theraphosidae	0	0	1	1	0.01	1	0.46
Theridiidae	225	143	103	471	6.05	18	8.22
Thomisidae	409	685	317	1411	18.1	31	14.16
Uloboridae	9	4	0	13	0.16	3	1.37
Zodariidae	72	6	12	90	1.1	7	3.2
Total no of families	27	28	21				100.00
Total no of spp.						219	
Total no of spiders	3520	2823	1433	7776			

Table 5. Species caught using the different collecting methods during a study at the Polokwane Nature Reserve (March 2005-February 2006).

Species	Active searching	Sweep netting	Tree beating	Leaf litter	Pitfall trapping	Total
Acanthepeira sp.1	0	3	0	0	0	3
Aelurillus sp.1	0	2	0	0	0	2
Afropisaura sp.1	0	16	0	0	0	16
Agelena sp.1	2	0	0	0	2	4
Ammoxenus amphalodes	2	0	0	0	1	3
Ancylotrypha brevipalpis	1	0	0	0	5	6
Aneplasa sp.1	1	0	0	0	0	1
Anyphops sp.1	0	0	0	0	1	1
Araneidae sp.1	1	18	0	0	0	19
Araneilla sp.1	0	73	13	0	0	86
Araneilla sp.2	2	4	0	0	0	6
Araneilla sp.3	0	14	1	0	0	15
Araneus apricus	10	0	0	0	0	10
Araneus coccinella	0	1	0	0	0	1
Araneus nigroquadratus	0	1	0	0	0	1
Archaeodictyna sp.1	0	3	2	0	0	5
Argiope aurocincta	0	10	0	0	0	10
Argiope lobata	1	11	0	0	0	12
Argiope sp.5	0	2	0	0	0	2
Argiope trifasciata	6	35	0	0	0	41
Argyrodes convivans	5	0	0	0	0	5
Argyrodes zonatus	0	3	4	0	0	7
Asemesthes ceresicola	97	3	0	0	24	124
Asemesthes decoratus	3	0	0	0	0	3
Augacephalus junodi	1	0	0	0	0	1
Baryphas ahenus	0	2	1	0	0	3
Brancus bevisi	3	50	0	0	0	53
Caerostris sexcuspidata	0	1	2	0	0	3
Camillina aestus	4	0	0	0	0	4
Camillina maun	2	0	0	0	0	2
Capheris decorata	1	0	0	0	4	5
Caponia chelifera	2	0	0	0	3	5
Cetonana simoni	1	0	0	0	0	1
Chariobas cylindraceus	0	2	0	0	0	2
Cheiracanthium furculatum	2	13	45	0	1	61
Cheiracanthium inclusum	1	26	16	0	0	43
Cheiracanthium vansoni	0	4	13	0	0	17
Clubiona abbajensis	2	2	1	0	0	5
Clubiona sp.1	1	2	5	0	0	8
Cosmophasis sp.2	1	0	0	3	0	4
Ctenolophus fenoulheti	1	0	0	0	0	1
Ctenus sp.1	0	0	0	0	3	3
Cyclosa insulana	0	30	1	0	0	31
Cydrela sp.	9	0	0	0	14	23
Cyphalonotus larvatus	0	1	0	0	0	1
Cyrtophora citricola	3	1	2	0	0	6

Dendryphantes sp.1	3	0	2	0	0	5
Dendryphantes sp.2	3	1	0	0	0	4
Diaphorocellus biplagiatus	3	0	0	0	2	5
Diores auricula	0	0	0	0	11	11
Diores sp.2	0	0	0	0	45	45
Dipoena sp.4	0	2	1	0	0	3
Drassodes bechuanicus	0	0	0	0	2	2
Drassodes solitarius	5	0	0	0	6	11
Drassodes splendens	20	0	0	0	29	49
Drassodes stationis	0	0	0	0	1	1
Dresserus colsoni	2	0	1	0	0	3
Ebo sp.1	0	0	11	0	0	11
Echemus sp.8	1	0	0	0	3	4
Enoplognatha molesta	6	48	2	0	0	56
Ero sp.1	0	0	1	0	0	1
Euophrys sp.1	7	22	96	0	0	125
Euprosthenopsis vuattouxi	40	17	1	1	2	61
Evippomma squamulatum	273	0	0	0	9	282
Gandanameno fumosus	2	0	0	0	0	2
Gasteracantha sanguinolenta	0	4	0	0	0	4
Gea infuscata	0	0	1	0	0	1
Gephyrota sp.1	1	7	14	0	0	22
Graptartia mutillica	1	0	0	0	0	1
Hamataliwa fronticornis	1	0	1	0	0	2
Heliophanus debilis	8	22	8	0	1	39
Heliophanus demonstrativus	0	0	1	0	0	1
Heliophanus insperatus	0	6	1	0	0	7
Heliophanus transvaalicus	0	0	1	0	0	1
Heriaeus crassispinus	2	8	0	0	0	10
Heriaeus transvaalicus	4	28	0	0	2	34
Hewittia gracilis	0	2	0	0	0	2
Hirriusa variegata	12	0	0	0	0	12
Hyllus sp.5	0	0	0	1	1	2
Hyllus treleaveni	2	3	4	0	0	9
Hypsosinga lithyphantoides	2	52	1	1	0	56
Hypsosinga sp.2	1	15	0	0	0	16
Idiops sp.1	0	0	0	0	3	3
Langelurillus sp.1	3	1	0	0	0	4
Larinia natalensis	0	7	0	0	0	7
Latrodectus geometricus	12	10	2	0	0	24
Latrodectus renivulvatus	20	15	0	0	1	36
Lipocrea longissima	1	5	0	0	0	6
Lycosa sp.1	76	0	0	0	3	79
Lycosa sp.2	87	0	0	1	1	89
Lycosidae sp.1	3	0	0	0	3	6
Lycosidae sp.10	2	0	0	0	0	2
Lycosidae sp.2	5	2	1	0	13	21
Lycosidae sp.3	0	0	0	0	2	2
Lycosidae sp.4	1	0	0	0	3	4

Lycosidae sp.6	0	0	0	0	2	2
Lycosidae sp.7	0	0	1	0	0	1
Maypacius bilineatus	0	1	0	0	6	7
Maypacius stuhlmanni	0	1	0	0	0	1
Miagrammopes longicaudus	1	9	0	0	0	10
Mircolinyphia sterilis	0	1	0	0	0	1
Misumenops rubrodecoratus	1	161	19	0	0	181
Mogrus sp.1	1	0	6	0	0	7
Monaeses austrinus	0	201	0	0	0	201
Monaeses fuscus	5	0	0	0	0	5
Monaeses gibbus	0	102	1	0	0	103
Monaeses paradoxus	0	11	0	0	0	11
Monaeses pustulosus	0	6	0	0	0	6
Monaeses quadrituberculatus	2	86	0	0	1	89
Natta horizontalis	1	0	0	1	1	3
Neoscona blondeli	1	27	25	0	1	54
Neoscona moreli	12	16	0	0	4	32
Neoscona quincasea	1	6	74	0	2	83
Neoscona subfusca	0	15	19	0	0	34
Nephila senegalensis	6	6	5	0	0	17
Olios sp.1	1	2	0	0	0	3
Olios sp.2	2	0	0	0	0	2
Olios sp.3	1	0	0	0	0	1
Olorunia sp.1	3	0	0	0	1	4
Oxyopes affinis	1	0	0	0	0	1
Oxyopes bedoti	0	24	0	0	0	24
Oxyopes bothai	1	8	0	0	0	9
Oxyopes hoggi	14	53	3	0	14	84
Oxyopes jacksoni	5	32	0	0	2	39
Oxyopes pallidecoloratus	42	283	53	4	2	384
Oxyopes russoi	0	12	464	0	0	476
Oxyopes schenkeli	0	0	6	0	0	6
Oxyopes sp.3	1	70	464	0	0	535
Ozyptila sp.1	0	1	0	0	2	3
Palpimanus armatus	1	0	0	0	0	1
Palpimanus transvaalicus	19	0	0	0	6	25
Palystes superciliosus	0	0	1	0	0	1
Paraplectana sp.1	0	1	0	0	0	1
Pararaneus cyrtoscapus	4	20	2	0	1	27
Pardosa sp.1	4	0	0	0	0	4
Pardosa sp.10	11	4	1	0	4	20
Pardosa sp.11	2	0	0	0	2	4
Pellenes sp.1	12	13	1	0	1	27
Peucetia viridis	1	14	1	0	0	16
Pherecydes tuberculatus	0	30	3	0	0	33
Philodromus browningi	0	4	30	0	0	34
Philodromus grosi	0	21	44	0	0	65
Philodromus guineensis	0	3	61	0	0	64

Phlegra sp.1	8	0	0	0	0	8
Phoroncidia eburnea	0	7	1	0	0	8
Poecilochroa sp.1	0	0	0	0	3	3
Prasonica sp.1	0	3	0	0	0	3
Proevippa sp.1	31	0	0	0	6	37
Psammoduon sp.1	4	0	0	0	0	4
Pseudauximus sp.1	0	0	0	0	1	1
Pseudicius sp.1	6	0	4	0	0	10
Pseudomicrommata longipes	1	5	0	0	0	6
Pycnacantha tribulus	0	5	0	0	0	5
Ranops sp.1	1	0	0	0	0	1
Rhene machadoi	0	5	32	0	1	38
Runcinia aethiops	0	4	0	0	0	4
Runcinia affinis	0	25	0	0	0	25
Runcinia erythrina	4	66	0	0	0	70
Runcinia flavida	1	435	0	1	0	437
Segregara monticola	1	0	0	0	2	3
Setaphis anchoralis	1	0	0	0	0	1
Setaphis arcus	5	0	0	0	2	7
Setaphis subtilis	1	0	0	0	1	2
Singa lawrencei	0	1	0	0	0	1
Singa sp.1	0	2	0	0	0	2
Singa sp.2	0	2	0	0	0	2
Smeringopus atomarius	3	0	0	1	0	4
Steatoda sp.1	5	0	0	0	0	5
Stegodyphus dumicola	1406	60	83	0	0	1549
Stenaelurillus nigricaudus	1	0	0	0	0	1
Stenaelurillus sp.1	17	4	0	0	4	25
Stenaelurillus sp.2	39	3	0	0	7	49
Stenaelurillus sp.3	4	0	0	0	4	8
Stiphropus affinis	0	5	0	0	0	5
Suemus punctatus	5	18	0	0	0	23
Synema diana	0	2	0	0	0	2
Synema imitator	0	13	45	0	0	58
Synema nigrotibiale	1	46	4	0	0	51
Thanatus dorsilineatus	20	5	0	0	2	27
Thanatus sp.1	13	3	0	0	0	16
Theridiidae sp.14	0	1	0	0	0	1
Theridiidae sp.21	3	1	1	0	0	5
Theridiidae sp.30	0	0	1	0	0	1
Theridiidae sp.33	0	4	0	0	0	4
Theridion sp.11	0	1	1	0	1	3
Theridion sp.13	5	183	101	0	0	289
Theridion sp.19	0	0	14	0	0	14
Theridion sp.23	0	1	5	0	0	6
Theridion sp.4	0	0	0	0	1	1
Theuma parva	4	0	0	0	3	7
Thomisops sulcatus	0	1	0	0	0	1
Thomisus blandus	0	1	0	0	0	1
Thomisus citrinellus	0	2	0	0	0	2

Thomisus congoensis	0	2	0	0	0	2
Thomisus granulatus	0	1	0	0	0	1
Thomisus kalaharinus	0	0	1	0	0	1
Thomisus stenningi	0	5	1	0	0	6
Thyene inflata	2	82	3	0	0	87
Thyenula aurantiaca	0	6	0	0	1	7
Tibellus gerhardi	0	27	0	0	0	27
Tibellus hollidayi	0	43	0	0	0	43
Tibellus minor	1	29	0	0	0	30
Tidarren sp.8	0	0	1	0	0	1
Tmarus africanus	0	3	0	0	0	3
Tmarus cameliformis	0	1	48	0	0	49
Tmarus foliatus	0	2	0	0	0	2
Tmarus longicaudatus	0	0	5	0	0	5
Trabea purcelli	5	0	0	0	2	7
Trachyzelotes jaxartensis	0	0	0	0	1	1
Tyrotama soutpansbergensis	9	0	0	0	0	9
Uloborus sp.1	0	0	2	0	0	2
Uloborus sp.2	0	0	1	0	0	1
Xerophaeus appendiculatus	4	0	0	0	1	5
Xerophaeus bicavus	22	2	1	0	13	38
Xysticus fagei	3	1	0	0	3	7
Zelotes reduncus	3	0	0	0	0	3
Zelotes sp.1	0	0	0	0	5	5
Zelotes ungulus	0	0	0	0	1	1
Zenonina albocaudata	3	0	0	0	5	8
Grand Total	2572	2972	1895	14	323	7776

Table 6. Numbers of spiders belonging to each family caught per month during a study at the Polokwane Nature Reserve (March 2005-February 2006).

	Autumn			Winter			Spring			Summer			
Family	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
Oxyopidae	105	149	216	256	109	126	156	121	120	97	44	76	1575
Eresidae	57	39	186	166	128	7	107	70	162	322	150	160	1554
Thomisidae	274	204	127	111	105	57	91	88	33	82	139	100	1411
Araneidae	67	55	54	54	37	59	46	30	20	30	73	57	582
Lycosidae	19	11	17	12	20	30	35	53	171	55	95	50	568
Salticidae	56	86	78	37	40	35	38	53	28	41	14	21	527
Theridiidae	41	38	93	62	54	19	38	18	18	16	25	49	471
Philodromidae	27	25	34	41	17	21	30	51	41	32	31	24	374
Gnaphosidae	2	16	18	27	36	40	20	20	43	32	7	6	267
Miturgidae	6	12	20	12	9	12	12	8	4	2	15	9	121
Zodariidae	1	3	1	5	1	7	1	42	25	2	1	1	90
Pisauridae	36	13	8	4	2	4	4	0	10	2	2	0	85
Palpimanidae	2	2	0	5	9	4	2	1	2	1	3	0	31
Nephilidae	13	1	0	0	0	0	0	1	0	1	1	0	17
Clubionidae	0	3	0	0	2	1	2	1	2	0	0	2	13
Sparassidae	1	1	0	0	1	1	1	0	0	3	1	4	13
Uloboridae	1	0	0	6	0	1	2	0	3	0	0	0	13
Hersiliidae	0	0	0	0	0	1	2	6	0	0	0	0	9
Agelenidae	0	1	0	3	0	0	2	0	0	1	1	0	8
Idiopidae	0	1	0	0	0	0	1	0	2	0	0	3	7
Prodidomidae	1	1	5	0	0	0	0	0	0	0	0	0	7
Cyrtaucheniidae	0	0	0	0	0	0	0	0	4	2	0	0	6
Caponiidae	1	0	0	1	1	0	0	1	0	0	1	0	5
Dictynidae	0	0	0	2	0	0	0	0	2	0	0	1	5
Pholcidae	2	0	0	0	0	0	0	0	0	0	0	2	4
Ammoxenidae	0	2	0	0	0	0	0	0	0	0	1	0	3
Ctenidae	0	2	1	0	0	0	0	0	0	0	0	0	3
Corinnidae	0	0	1	0	0	0	0	0	0	0	0	1	2
Amaurobiidae	0	0	0	1	0	0	0	0	0	0	0	0	1
Linyphiidae	1	0	0	0	0	0	0	0	0	0	0	0	1
Mimetidae	0	0	0	0	0	1	0	0	0	0	0	0	1
Selenopidae	1	0	0	0	0	0	0	0	0	0	0	0	1
Theraphosidae	0	0	0	0	0	0	0	0	0	0	1	0	1
Total no of families	21	21	15	18	16	18	19	16	18	17	19	17	33
Total	714	665	859	805	571	426	590	564	690	721	605	566	7776

Table 7. Numbers of female, male and immature spiders collected per month during a study at the Polokwane Nature Reserve (March 2005-February 2006).

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total	Mean	Standard deviation
Female	89	65	48	36	23	46	32	26	58	94	84	115	716	59.7	29.9
Male	88	37	24	18	21	20	17	34	92	84	106	55	596	50	33.7
Immature	537	563	787	751	527	360	541	504	540	543	415	396	6464	539	126.6
Total	714	665	859	805	571	426	590	564	690	721	605	566	7776	648	118.7

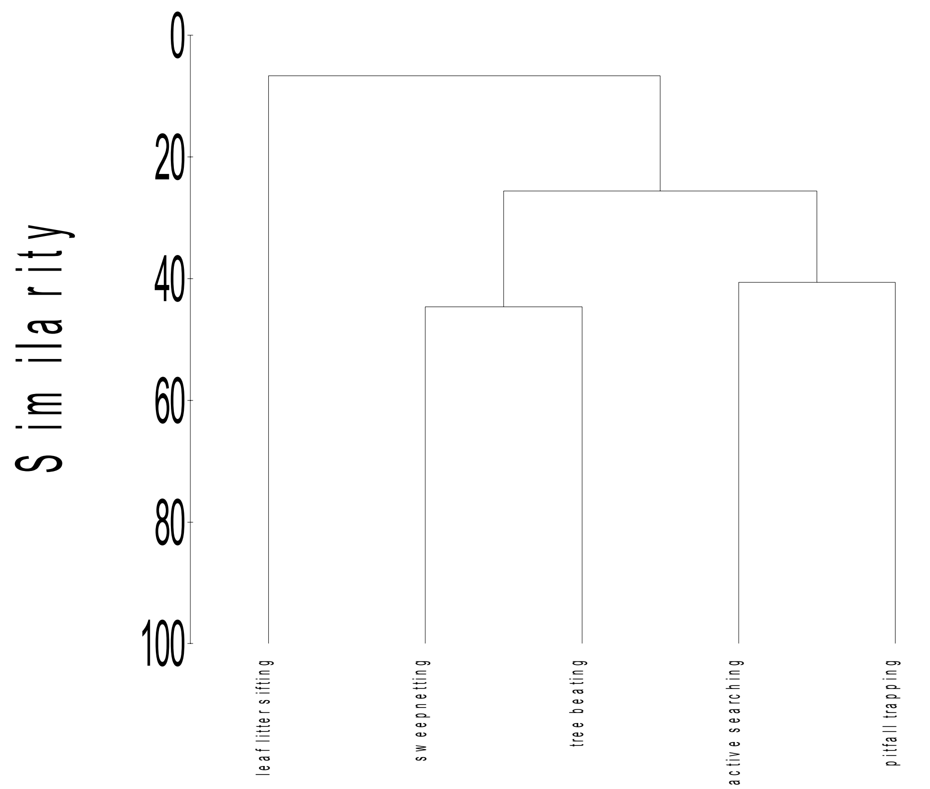

Figure 4. A cluster analysis of Bray-Curtis similarities of species caught using different sampling methods during a study at the Polokwane Nature Reserve (March 2005-February 2006).

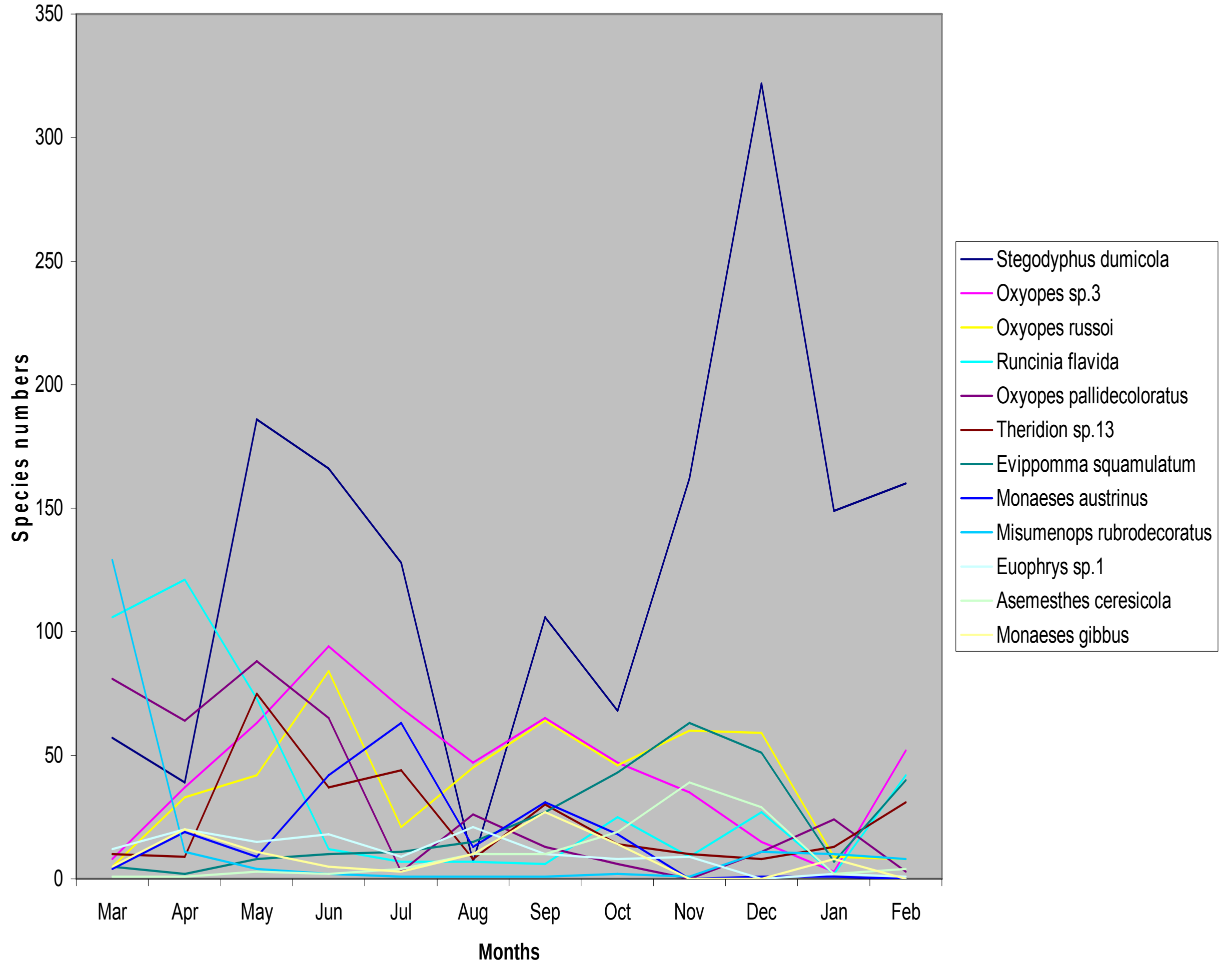

Figure 5. Numbers of dominant species caught in different months from three different sites during a study at the Polokwane Nature Reserve (March 2005-February 2006).

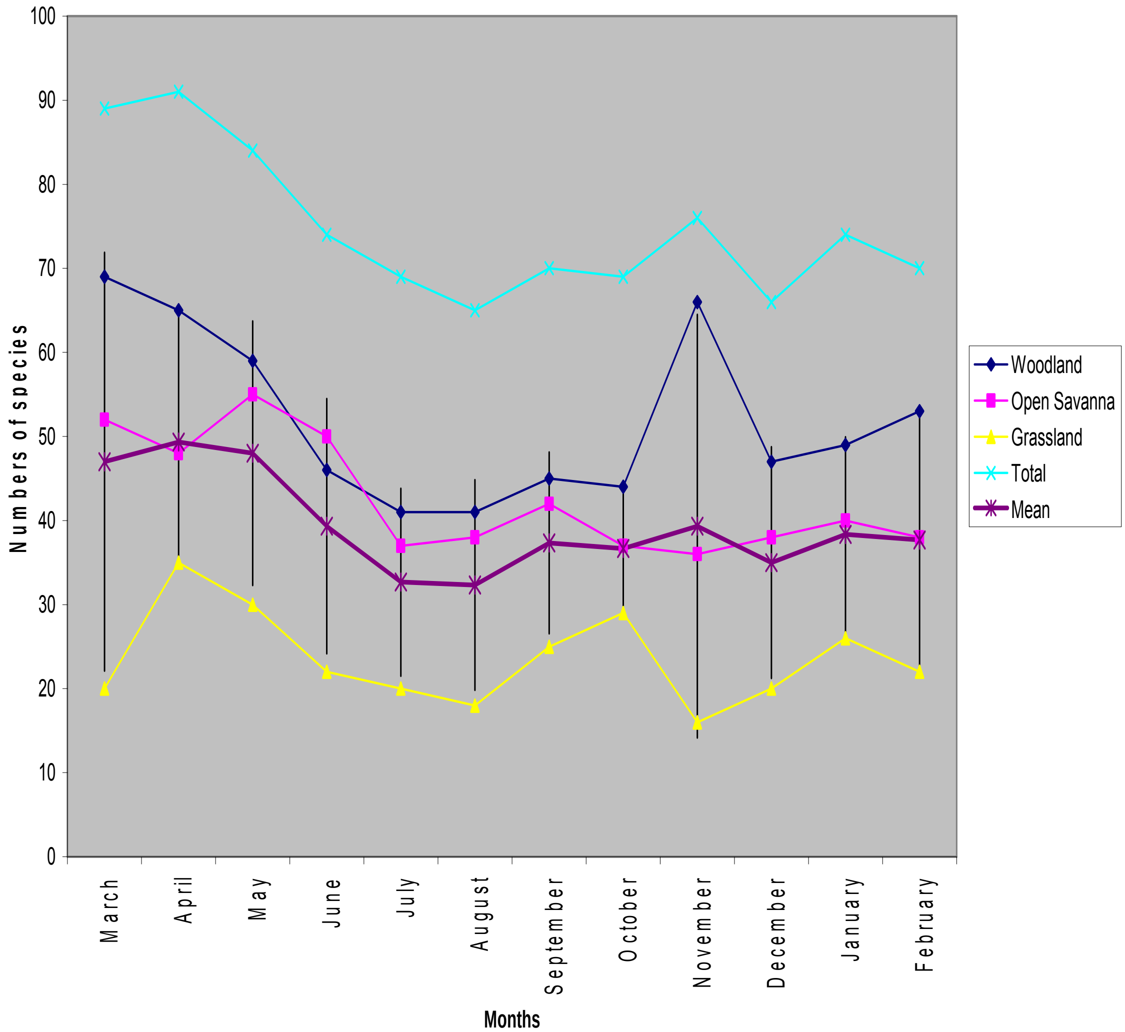

Figure 6. Numbers of species caught per site per month as well as total and mean number of species caught per month during a study at the Polokwane Nature Reserve (March 2005-February 2006) (bars indicate standard deviation).

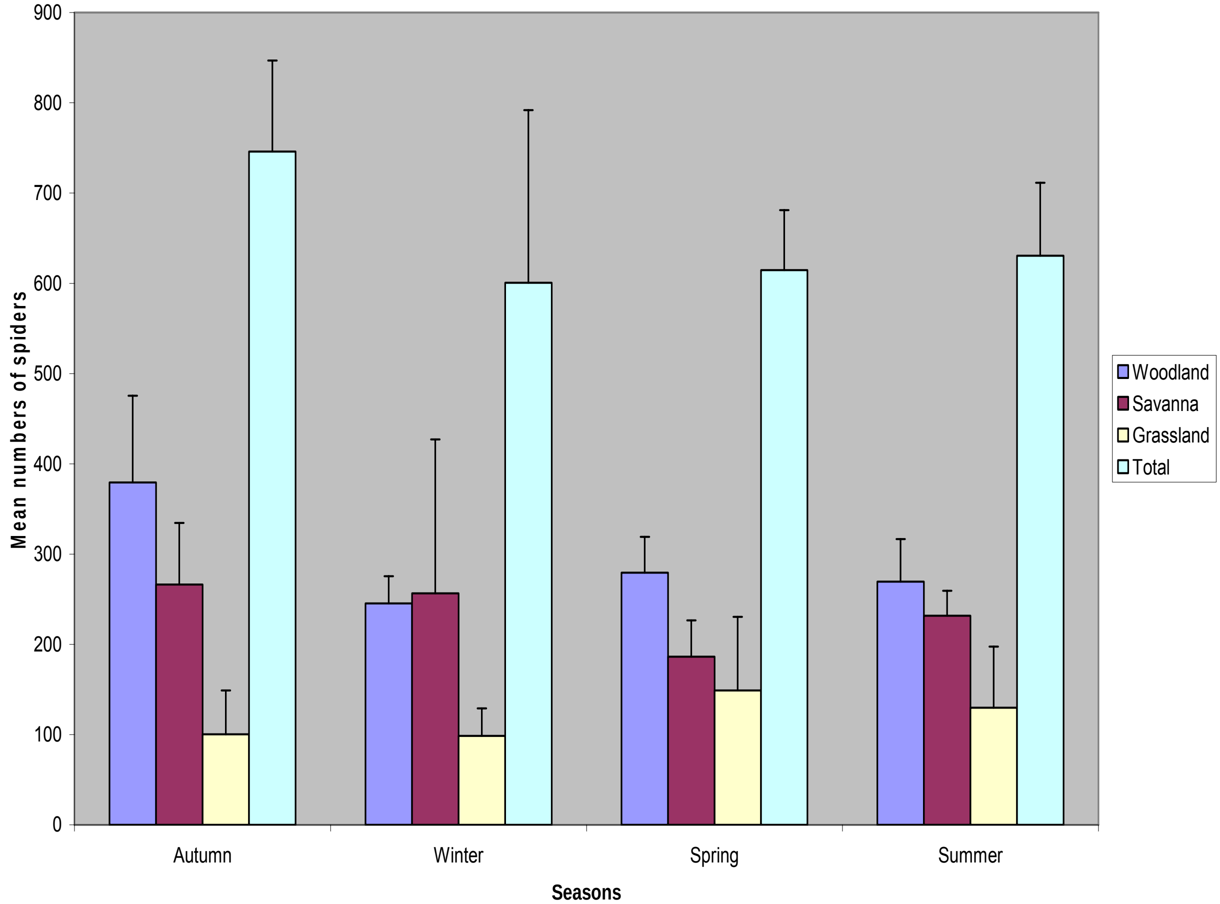

Figure 7. Comparison of the mean number of specimens caught over the four seasons on all sampling sites during a study at the Polokwane Nature Reserve (March 2005-February 2006) (bars indicate standard deviation).

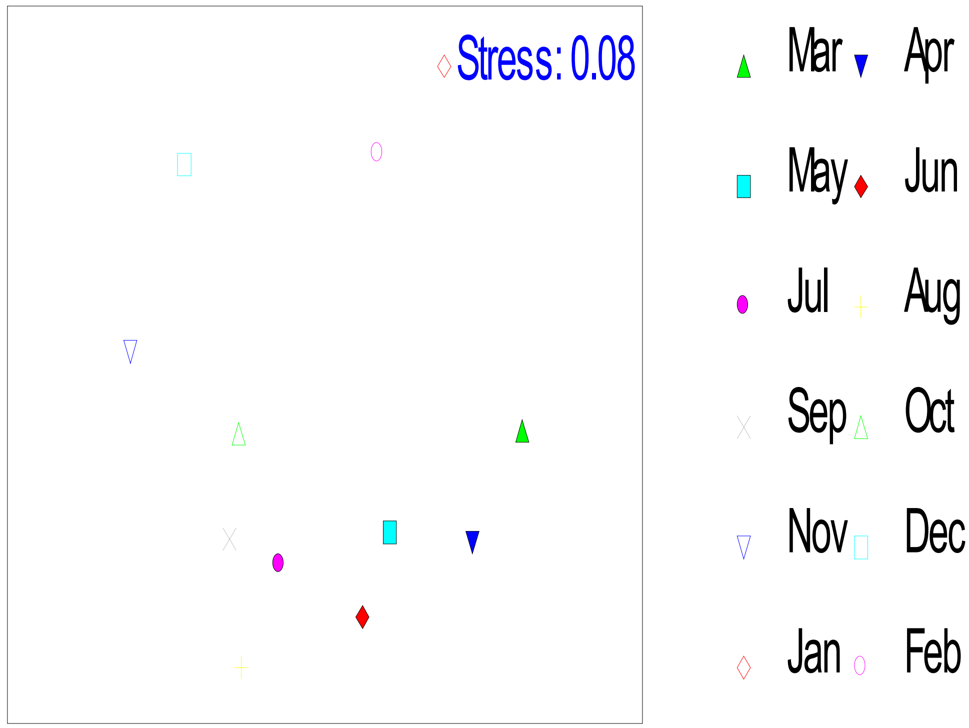

Figure 8. MDS ordination for species caught in different months in a study done at the Polokwane Nature Reserve (2005-February 2006).

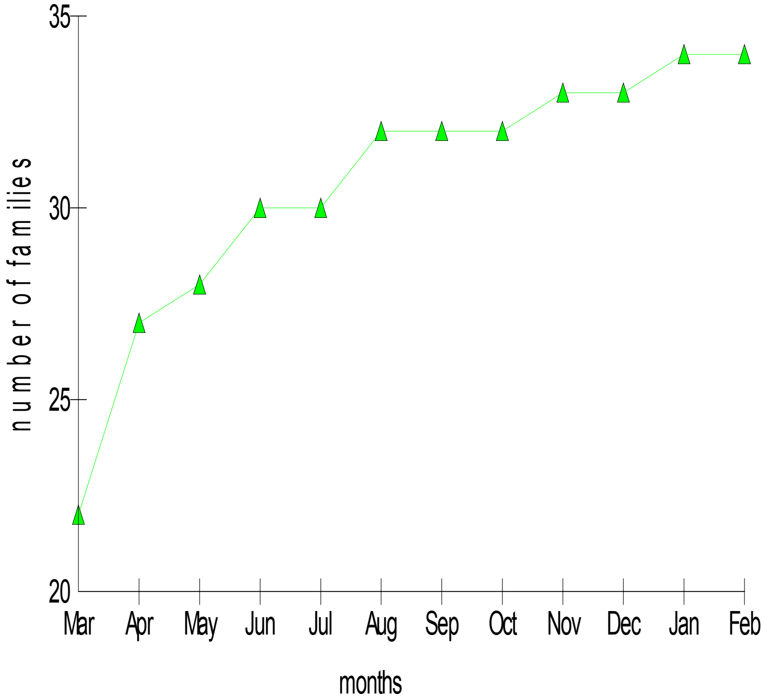

Figure 9. Species accumulation curve for the number of families sampled in consecutive months during a study at the Polokwane Nature Reserve (March 2005-February 2006).

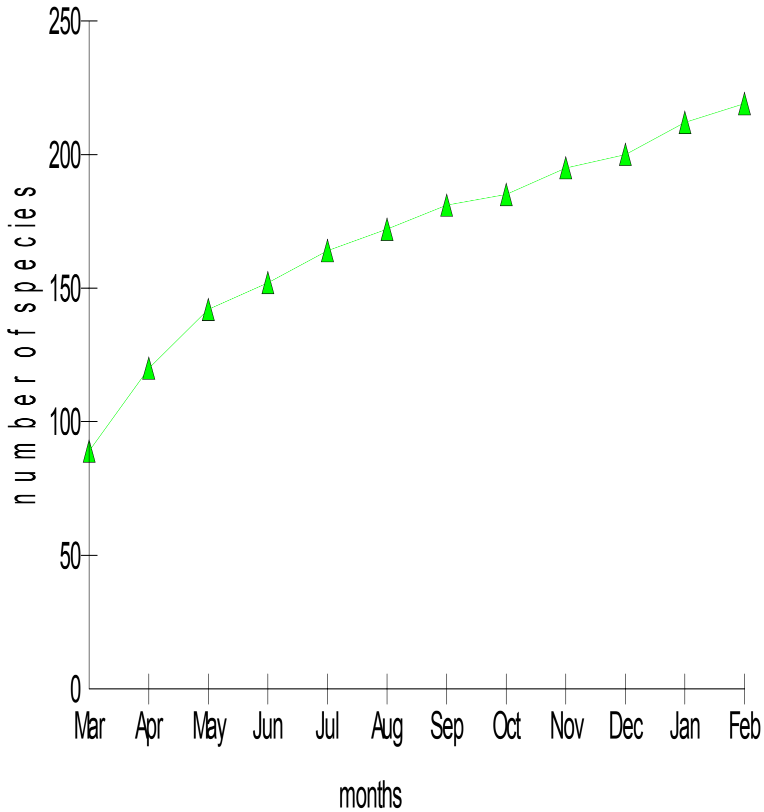

Figure 10. Species accumulation curve for the number of species sampled in consecutive months during a study at the Polokwane Nature Reserve (March 2005-February 2006).

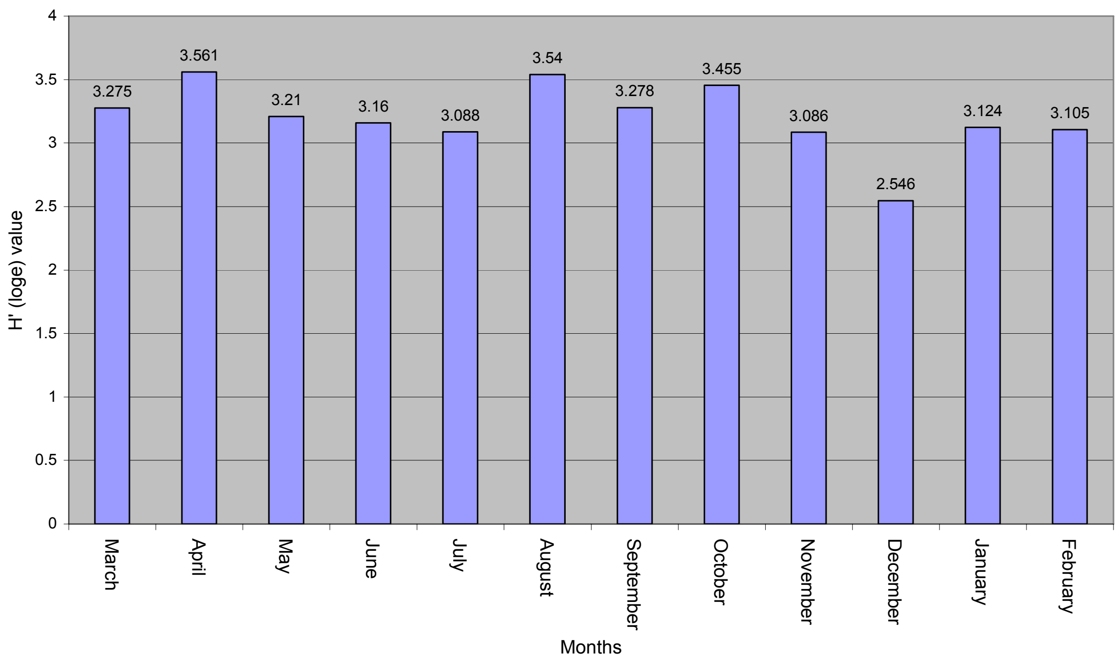

Figure 11. The Shannon-Weiner diversity index values for the species caught on all three sites during a study at the Polokwane Nature Reserve (March 2005- February 2006).

CHAPTER 4
CONCLUSIONS

4.1 An inventory of spiders from the three sampling sites studied

The present study at the Polokwane Nature Reserve has made an important contribution towards increasing our knowledge of spider diversity in the Savanna Biome. The research presented here assessed the spider richness and diversity over a year period in an undisturbed Savanna Biome and the composition of the spider community is discussed.

The Polokwane Nature Reserve has a rich fauna of spiders. Spiders were present throughout the year in all three sampling sites. A total of 7 776 spiders were captured using four sampling methods (sweep netting, tree beating, active searching and pitfall trapping). The caught specimens belong to 33 families, 131 genera and 219 species. The 33 families caught represent 11 % of the current known families in South Africa (Dippenaar-Schoeman & Jocqué 1997). Therefore, a total of 11 % of South African spiders are presently protected on these three vegetation types in the reserve and efforts should continue to ensure the conservation of the area. The majority of the specimens collected were wanderers (69.8 %; 153) while 30.2 % (66) were web-builders. Most of the spiders caught were immature (6 464; 83.1 %), with 716 (9.2 %) females and 596 (7.6 %) males that can be identified to genus or species level provided that the taxonomic expertise is available.

No work has previously been undertaken in this area and the species collected represent new distribution records for all species collected and a possibility of several new species (13) that are still undescribed. The *Ozyptila* sp. is a new record for South Africa and five other new records for Africa were collected. Several mygalomorph species have been collected such as the protected starbust baboon spider, *Augacephalus junodi* (Simon, 1904), that are endemic to South Africa and a flagship species of the Limpopo Province. Four trapdoor spider species have been caught including three species of Idiopidae (*Ctenolophus fernoulheti* Hewitt, 1913; *Segregara monticola* (Hewitt, 1916) and an *Idiops* sp.) and one species of Cyrtaucheniidae (*Ancylotrypha brevipalpis* (Hewitt, 1916)) which is an important new record for the Limpopo Province.

Dominant families collected include Oxyopidae (1 575; 20.3 %), Eresidae (1 554; 19.9 %), Thomisidae (1 411; 18.1), Araneidae (582; 7.4 %), Lycosidae (568; 7.3 %), Salticidae (527; 6.7 %) and Theridiidae (471; 6.1 %). The seven most abundant species collected during this study included species of *Stegodyphus dumicola* (Eresidae) (1 549) followed by two oxyopids, an undescribed oxyopid *Oxyopes* sp.3 (535) and *Oxyopes russoi* (476), *Runcinia flavida* (Thomisidae) (437), another oxyopid *Oxyopes pallidecoloratus* (384) followed by a lycosid *Evippomma squamulatum* (282) and another thomisid *Monaeses austrinus* (201). Families that had the highest number of species include Araneidae (33), Thomisidae (31), Salticidae (25), Gnaphosidae (20), Theridiidae (18), Lycosidae (16) and the Philodromidae (12).

4.2 Comparison of the differences among the spider communities of the vegetation types sampled

The highest number of spiders and species were caught in the Woodland site (3 520 specimens; 173 species) contributing 45.3 % of the total number of spiders collected, followed by the Open Savanna (2 823 specimens; 159 species) with a contribution of 36.3 % and the Grassland (1 433 specimens; 115 species) which contributed only 18.4 % of the total number sampled. The highest number of spider families was recorded from the Open Savanna site (28) followed by the Woodland site (27) and the Grassland site (21). The Shannon's diversity index values were the highest for the Open Savanna site (H'=3.777), followed by the Woodland site (H'=3.569) and the Grassland site (H'=3.273). Species seem to be reasonably uniformly distributed across sites according to evenness values (H_E=0.6 – 0.7) and a relatively high overlap of species occurs on the different vegetation types sampled according to calculated beta-diversity estimates (β=0.5 – 0.7).

4.3 Comparison of spiders caught with different sampling methods

The highest number of specimens (2 972, 18 families) were caught by sweep netting, followed by active searching (2 572 specimens, 27 families), tree beating (1 895, 17 families) and pitfall trapping (323, 21 families). Leaf litter sifting was used once in the Woodland site but due to too little litter it was not used again.

4.4 Comparison of spiders caught during different months and seasons of the year

Most spiders were caught during autumn (March, April and May) (2 238), followed by summer (December, January and February) (1 892), spring (September, October and November) (1 844) and winter (June, July and August) (1 802). The Shannon's diversity index values calculated for species caught in different months was the highest during April (H'=3.561), while the lowest diversity was caught during December (H'=2.546).

4.5 Limitations of the study and suggestions for future studies

No replication of sampling using each method in each vegetation type was performed on a monthly basis. Hence, the data could not be tested for statistical significance among sites or using different sampling methods. Additionally, the specimens collected on a sampling site using a specific sampling method were pooled rather them keeping each sample separate (e.g. every 20 sweeps on a site should have been a single sample). This would have provided several samples per method per site per month that could have been examined for statistical significance. It is also suggested that each sampling site should be quantified in terms of surface area and that sampling should be conducted on the same surface area during every sampling event. Since the current study took place in a nature reserve, sampling sites could not be distinguished from the surrounding area by any means and therefore an attempt was made to sample the same surface area every time by sampling for a constant period of time (i.e. two hours). However, it is possible that a larger surface area was sampled as the sampling period continued since one becomes more familiar with the sampling site and methods used and sample quicker than in the beginning of the sampling period.

Future studies with the aim to compile an inventory of the spider composition of an area in the Savanna Biome can use results from this and previous studies (e.g. Foord *et al.* 2002; Whitmore *et al.* 2002; Modiba *et al.* 2005; Haddad *et al*. 2006) to determine the best period of sampling. This will include the period when high numbers of mature species are collected in order to be able to identify collected material to species level. Comparative results of this and previous studies can furthermore assist in determining an applicable approach to sampling depending on the aim and objectives of the study. Additionally the results can also be used to determine the most effective collecting methods to use with e.g. leaf litter sifting being ineffective in an area dominated by *Acacia* trees since the leaves are too small to form enough litter.

Future studies can use the baseline information and check list provided by the current study to focus on aspects of the spider’s endemicity, distribution and biology and attempt to make recommendations concerning their conservation status or possible use as bio-indicators.

4.6 Summary

In comparing these results with other surveys the importance of using different methods to survey different field layers is emphasized as spiders are found in all the different vegetation layers. A combination of at least two or more methods gives the best results in surveys that attempt to determine the diversity and distribution of spiders. All sampling methods are cost effective and recommended for efficient surveys. In conclusion, it is important to consider both temporal and spatial factors during surveys since both have an influence on the spider community of an area.

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APPENDIX 1

Spider surveys so far undertaken in floral biomes, provincial, agro-ecosystems and conserved areas in South Africa.

	Period	Methods	Authors
1. FLORAL BIOMES			
Grassland			
Rietondale Research Station, Pretoria	3 years	pittraps	Van den Berg & Dippenaar-Schoeman 1991
Bloemfontain, Central Free State	1 year	pittraps	Lotz *et al*. 1991
Prieska Nama Karoo Grassland, Northern Cape			Haddad & Dippenaar-Schoeman 2005
Savanna			
Roodeplaat Dam Nature Reserve, Gauteng	4 years	beating, active & sweep net	Dippenaar-Schoeman *et al*. 1989
Western Soutpansberg, Limpopo	5 years	active, litter/ sweep net/ beating & pittraps	Foord *et al*. 2002, Foord & Dippenaar-Schoeman 2003
Makalali Nature Reserve, Limpopo	11 months	active, beating, pittraps & sweep net	Whitmore *et al*. 2001 & 2002
Sovenga Hill, Polokwane, Limpopo Province	9 months	all	Modiba *et al*. 2005
Ndumo Nature Reserve, KZN			Haddad *et al*. 2006
Kruger National Park, Limpopo & Mpumalanga	16 years	all	Dippenaar-Schoeman & Leroy 2003
Polokwane Nature Reserve	1 year	active, sweep net, beating & pittraps	Dippenaar *et al*. 2008
Fynbos			
Proteaceous plants in the fynbos biome	1 year	beating, knock & removal of inflorescence	Coetzee *et al*. 1990
Protea nitida (Proteaceae)	2 years	beating	Visser *et al*. 1999
Nama Karoo			
Green Valley Nuts Estate, Prieska, Northern Cape	1 year	pittraps	Haddad & Dippenaar-Schoeman 2005
Forest			
Ngome State Forest, indigenous forest	1 year	pittraps	Van der Merwe *et al*. 1996
Richard Bay, Coastal dune forests	1 year	pitttraps	Dippenaar-Schoeman & Wassenaar 2002, 2006

Succulent Karoo			
Swartberg Nature Reserve	10 years	active/ sweep net/ beating	Dippenaar-Schoeman *et al*. 2005b
Mountain Zebra National Park	3 months	sweep net, beating & active	Dippenaar-Schoeman 1988, 2006
Karoo National Park	10 years	active, beating litter, sweep net	Dippenaar-Schoeman *et al*. 1999a
2. PROVINCIAL SURVEYS			
Gauteng			
Rietondale Research Station, Pretoria	3 years	pittraps	Van den Berg & Dippenaar-Schoeman 1991
Roodeplaat Dam Nature Reserve	4 years	beating, active & sweep net	Dippenaar-Schoeman *et al*. 1989
Roodeplaat Research station – strawberries	19 months	shake	Dippenaar-Schoeman 1979
Cotton fields, Brits	4 months	WPBS*	Van den Berg *et al*. 1990
Free State			
Bloemfontain, Central Free State			Lotz *et al*. 1991
Snouted harvester termite *Trinervitermes trinervoides*			Haddad & Dippenaar-Schoeman 2006b
KwaZulu-Natal			
Ngome State Forest	1 year	pittraps	Van der Merwe *et al*. 1996; Dippenaar-Schoeman 2006
Richard Bay –Coastal dune forests	1 year	pittraps	Dippenaar-Schoeman & Wassenaar 2002, 2006
Ndumo Nature Reserve, KZN			Haddad *et al*. 2006
Limpopo Province			
Makalali Nature Reserve, Limpopo	11 months	active, beating, pittraps & sweep net	Whitmore *et al*. 2002
Sovenga Hill, Polokwane, Limpopo Province	9 months	all	Modiba *et al*. 2005
Kruger National Park, Limpopo & Mpumalanga			Dippenaar-Schoeman & Leroy 2003
Western Soutpansberg, Limpopo	5 years	active, litter/ sweep net/ beating & traps	Foord *et al*. 2002, Foord & Dippenaar-Schoeman 2003
Polokwane Nature Reserve	1 year	active, sweep net, beating & pittraps	Dippenaar *et al*. 2008
Mpumalanga Province			
Kruger National Park, Limpopo & Mpumalanga	16 years	Litter, active/ sweep net/ beating	Dippenaar-Schoeman & Leroy 2003
Nelspruit – citrus orchards			Van den Berg *et al*. 1992

Avocado orchards, Mpumalanga Lowveld	13 months 1 year	Dichlorvos spray Dichlorvos spray	Dippenaar- Schoeman *et al*. 2005a Dippenaar-Schoeman *et al*. 2001b
Macadamia orchards, Mpumalanga Lowveld	1 year	beating	Dippenaar-Schoeman *et al*. 2001a
Bt –cotton, Marble Hall			Mellet, *et al*. 2006
Northern Cape Province			
Prieska Nama Karoo Grassland, Northern Cape			Haddad & Dippenaar-Schoeman 2005
Pistachio orchards, Northern Cape	1 year; 10 months	pittraps & active, sweep net	Haddad *et al*. 2004a & Haddad & Dippenaar-Schoeman 2006
Western Cape Province			
Proteaceous plants in the fynbos biome	1 year	beating & removal of inflorescence	Coetzee *et al*. 1990
Protea nitida (Proteaceae)	2 years	beating	Visser *et al*. 1999
Swartberg Nature Reserve	10 years	active/ sweep net/ beating	Dippenaar-Schoeman *et al*. 2005
Mountain Zebra National Park	3 months	beating, sweep net & active	Dippenaar-Schoeman 1988, 2006
Karoo National Park	10 years	active, beating litter, sweep net	Dippenaar-Schoeman *et al*. 1999

3. CONSERVED AREAS

Roodeplaatdam Nature Reserve	4 years	beating, active & sweep net	Dippenaar-Schoeman *et al*. 1989
Mountain Zebra National Park	3 months	sweep net, beating & active	Dippenaar-Schoeman 1988, 2006
Makalali Nature Reserve, Limpopo	11 months	active, beating, pittraps & sweep net	Whitmore *et al*. 2002
Ndumo Nature Reserve, KZN			Haddad *et al*. 2006
Kruger National Park, Limpopo & Mpumalanga	16 years	litter, active/ sweep net/ beating	Dippenaar-Schoeman & Leroy 2003
Karoo National Park	10 years	active, beating litter, net	Dippenaar-Schoeman *et al*. 1999
Swartberg Nature Reserve	10	active/ sweep net/ beating	Dippenaar-Schoeman *et al*. 2005
Western Soutpansberg, Limpopo	5 years	active, litter/ sweep net/ beating & traps	Foord *et al*. 2002, 2003
Polokwane Nature Reserve	1 year	active, sweep net, beating & pittraps	Dippenaar *et al*. 2008

4. AGRO-ECOSYSTEMS, PROBLEM SPECIES & MAN-MADE FORESTS

Ngome State Forest - pine plantations	1 year	pittraps	Van der Merwe *et al*. 1996

Harvester termites: Rietondale Research Station, Pretoria	3-years	pittraps	Van den Berg & Dippenaar-Schoeman 1991
Roodeplaat Research station - strawberries	19 months	shake	Dippenaar-Schoeman, A.S. 1979
Nelspruit - citrus orchards			Van den Berg *et al*. 1992
Cotton fields, Brits	4 months	WPBS*, pittraps & active	Van den Berg *et al*. 1990, Dippenaar-Schoeman *et al*. 1999
Macadamia orchards, Mpumalanga Lowveld	1 year	beating, dichlorvos spray	Dippenaar-Schoeman *et al*. 2001a, b
Avocado orchards, Mpumalanga Lowveld	1 year	Dichlorvos spray	Dippenaar- Schoeman *et al*. 2005a
Pistachio orchards, Northern Cape	1 year; 10 months	pittraps & active, sweep net	Haddad *et al*. 2004a, Haddad & Dippenaar-Schoeman 2005, Haddad & Dippenaar-Schoeman 2006a
Pine plantation, Sabie	8 months	pittraps & corrugated paper trap	Van den Berg & Dippenaar-Schoeman 1988
Termites			Haddad & Dippenaar-Schoeman 2006b
Cotton fields, SA	16 years	pittraps, sweep net/ beating	Dippenaar-Schoeman *et al*. 1999
Nysius natalensis (Hemiptera: Lygaeidae), a pest of pistachio nuts.			Haddad, C. R., Louw, S. VdM. & Dippenaar-Schoeman, A. S. 2004.
Snouted harvester termite *Trinervitermes trinervoides*			Haddad, C.R. & Dippenaar-Schoeman, A.S. 2006b
Bt -cotton			Mellet *et al*. 2006

*Whole plant bag sampling technique

APPENDIX 2

A check list of the spider families and species, indicating the guild and status of each species collected from the three different sampling sites (*Acacia rehmaniana* woodland, *Acacia tortilis* open savanna and plateau false grassland) in the Polokwane Nature Reserve, Limpopo Province (March 2005-February 2006). (Guild: PD = plant dweller; GD = ground dweller; BD = burrow dweller; WD = web dweller. Status: NA = not applicable; NS = new species; NR = new record; 1 = only in PNR; 2 = only Limpopo Province; 3 = Limpopo & one other province; 4 = South Africa; 5 = Southern Africa; 6 = Africa; 7 = cosmopolitan)

Family (33)	Species (219) Genera (131)	Guild	Status	Woodland	Open Savanna	Grassland	Total
Agelenidae	*Agelena* sp. 1	WD	NA	0	2	2	4
	Olorunia sp. 1	WD	NA	0	2	2	4
Amaurobiidae	*Pseudauximus* sp. 1	WD	NA	1	0	0	1
Ammoxenidae	*Ammoxenus amphalodes* Dippenaar& Meyer, 1980	GD	4	0	3	0	3
Araneidae	*Acanthepeira* sp. 1	WD	NS	2	0	1	3
Araneidae	Araneidae sp. 1 (genus undertermined)	WD	NS	6	6	7	19
Araneidae	*Araneilla* sp. 1	WD	NS	49	16	21	86
Araneidae	*Araneilla* sp. 2	WD	NS	3	3	0	6
Araneidae	*Araneilla* sp. 3	WD	NS	5	8	2	15
Araneidae	*Araneus apricus* (Karsch, 1884)	WD	6	0	0	10	10
Araneidae	*Araneus coccinella* Pocock, 1898	WD	4	0	0	1	1
Araneidae	*Araneus nigroquadratus* Lawrence, 1937	WD	4	0	0	1	1
Araneidae	*Argiope aurocincta* Pocock, 1898	WD	6	6	2	2	10
Araneidae	*Argiope lobata* (Pallas, 1772)	WD	6	8	2	2	12
Araneidae	*Argiope trifasciata* (Forskal, 1775)	WD	7	24	8	10	42
Araneidae	*Argiope* sp. 5	WB	NA	0	1	1	2
Araneidae	*Caerostris sexcuspidata* (Fabricius, 1793)	WD	6	1	1	1	3

Araneidae	*Cyclosa insulana* (Costa, 1834)	WD	7	26	1	4	31
Araneidae	*Cyphalanothus larvatus* (Simon, 1881)	WD	6	1	0	0	1
Araneidae	*Cyrtophora citricola* (Forskal, 1775)	WD	7	3	3	0	6
Araneidae	*Gasteracantha sanguinolenta* C.L. Koch, 1884	WD	6	2	0	2	4
Araneidae	*Gea infuscata* Tullgren, 1910	WD	6	0	1	0	1
Araneidae	*Hypsosinga lithyphantoides* Caporiacco, 1947	WD	6	27	14	15	56
Araneidae	*Hypsosinga* sp. 2	WD	NS	15	1	0	16
Araneidae	*Larinia natalensis* (Grasshoff, 1971)	WD	4	3	0	4	7
Araneidae	*Lipocrea longissima* (Simon, 1881)	WD	6	3	0	3	6
Araneidae	*Neoscona blondeli* (Simon, 1885)	WD	6	18	22	14	54
Araneidae	*Neoscona moreli* (Vinson, 1863)	WD	6	19	10	3	32
Araneidae	*Neoscona quincasea* Roberts, 1983	WD	6	19	60	4	83
Araneidae	*Neoscona subfusca* (C.L. Koch, 1837)	WD	6	15	13	6	34
Araneidae	*Pararaneus cyrtoscapus* (Pocock, 1898)	WD	6	12	7	8	27
Araneidae	*Paraplectana* sp. 1	WD	NA	0	1	0	1
Araneidae	*Prasonica* sp. 1	WD	NS	2	1	0	3
Araneidae	*Pycnacantha tribulus* (Fabricius, 1781)	WD	6	2	1	2	5
Araneidae	*Singa lawrencei* (Lessert, 1930)	WD	6	0	0	1	1
Araneidae	*Singa* sp. 1	WD	NA	2	0	0	2
Araneidae	*Singa* sp. 2	WD	NA				
Caponiidae	*Caponia chelifera* Lessert, 1936	GD	6	4	1	0	5
Clubionidae	*Clubiona abbajensis* Strand, 1906	PD	6	1	4	0	5
Clubionidae	*Clubiona* sp. 1	PD	NA	5	2	1	3

Corinnidae	*Cetonana simoni* (Lawrence, 1942)	GD	4	1	0	0	1
Corinnidae	*Copa flavoplumosa* Simon, 1885	GD	6				
Corinnidae	*Graptartia mutillica* Haddad, 2004	GD	4	0	1	0	1
Ctenidae	*Ctenus* sp. 1	GD	NA	3	0	0	3
Cyrtaucheniidae	*Ancylotrypha brevipalpis* (Hewitt, 1916)	BD	4	4	0	2	6
Dictynidae	*Archaeodictyna* sp. 1	WD	NA	2	2	1	5
Eresidae	*Dresserus colsoni* Tucker, 1920	WD	4	0	1	2	3
Eresidae	*Gandanameno fumosus* (C.L.Koch, 1837)	WD	4	1	1	0	2
Eresidae	*Stegodyphus dumicola* Pocock, 1898	WD	6	835	287	427	1549
Gnaphosidae	*Aneplasa* sp. 1		NA	0	1	0	1
Gnaphosidae	*Asemesthes ceresicola* Tucker, 1923	GD	4	30	62	32	124
Gnaphosidae	*Asemesthes decoratus* Purcell, 1908	GD	4	0	3	0	3
Gnaphosidae	*Camillina aestus* Tucker, 1923	GD	4	0	4	0	4
Gnaphosidae	*Camillina maun* Platnick & Murphy, 1987	GD	5	2	0	0	2
Gnaphosidae	*Drassodes bechuanicus* Tucker, 1923	GD	4	2	0	0	2
Gnaphosidae	*Drassodes solitarius* Purcell, 1907	GD	4				
Gnaphosidae	*Drassodes splendens* Tucker, 1923	GD	4	15	17	17	49
Gnaphosidae	*Drassodes stationis* Tucker, 1923	GD	4	1	0	0	1
Gnaphosidae	*Echemus* sp. 8	GD	NA	3	1	0	4
Gnaphosidae	*Poecilochoa* sp. 1	GD	NA	0	2	1	3
Gnaphosidae	*Setaphis anchoralis* Purcell, 1908	GD	4	1	0	0	1

Gnaphosidae	*Setaphis arcus* Tucker, 1923	GD	4	5	1	1	7
Gnaphosidae	*Setaphis subtilis* (Simon, 1897)	GD	7	2	0	0	2
Gnaphosidae	*Xerophaeus appendiculatus* Purcell, 1907	GD	6	0	5	0	5
Gnaphosidae	*Xerophaeus bicavus* Tucker, 1923	GD	4	18	12	8	38
Gnaphosidae	*Trachyzelotes jaxartensis* (Kronerberg, 1875)		4	1	0	0	1
Gnaphosidae	*Zelotes reduncus* (Purcell, 1907)	GD	4	1	2	0	3
Gnaphosidae	*Zelotes ungulus* Tucker, 1923	GD	4	0	0	1	1
Gnaphosidae	*Zelotes* sp. 1	GD	NA	0	1	4	5
Hersiliidae	*Tyrotama soutpansbergensis* Foord & Dippenaar-Schoeman, 2005	WD	CHECK	0	9	0	9
Idiopidae	*Idiops* sp. 1	BD	NA	1	2	0	3
	Ctenolophus fernoulheti Hewitt, 1913	BD	3	1	0	0	1
	Segregara monticola (Hewitt, 1916)	BD	3	2	1	0	3
Linyphiidae	*Mircolinyphia sterilis* (Pavesi, 1883)	WB	6	1	0	0	1
Lycosidae	*Evippomma squamulatum* (Simon, 1898)	GD	5	160	78	44	282
Lycosidae	*Lycosa* sp. 1	GD	NA	3	3	73	79
Lycosidae	*Lycosa* sp. 2	GD	NA	3	85	1	89
Lycosidae	Lycosidae sp. 1	GD	NA	3	3	0	6
Lycosidae	Lycosidae sp. 2	GD	NA	9	11	1	21
Lycosidae	Lycosidae sp. 3	GD	NA	0	2	0	2
Lycosidae	Lycosidae sp. 4	GD	NA	0	1	3	4
Lycosidae	Lycosidae sp. 6	GD	NA	2	0	0	2
Lycosidae	Lycosidae sp. 7	GD	NA	0	1	0	1
Lycosidae	Lycosidae sp. 10	GD	NA	0	2	0	2
Lycosidae	*Pardosa* sp. 1		NA	2	2	0	4
Lycosidae	*Pardosa* sp. 10	GD	NA	12	8	0	20

Lycosidae	*Pardosa* sp. 11	GD	NA	2	2	0	4
Lycosidae	*Proevippa* sp. 1	GD	4	15	4	18	37
Lycosidae	*Trabea purcelli* Roewer, 1951	GD	4	1	2	4	8
Lycosidae	*Zenonina albocaudata* Lawrence, 1952	GD	NS	6	0	2	8
Mimetidae	*Ero* sp. 1	PD	NS	0	1	0	1
Miturgidae	*Cheiracanthium furculatum* Karsch, 1879	PD	6	30	29	2	61
Miturgidae	*Cheiracanthium inclusum* (Hentz, 1847)	PD	7	20	13	10	43
Miturgidae	*Cheiracanthium vansoni* Lawrence, 1936	PD	5	11	6	0	17
Nephilidae	*Nephila senegalensis* (Walckenaer, 1842)	WD	6	12	4	1	17
Oxyopidae	*Hamataliwa fronticornis* (Lessert, 1927)	PD	6 NR	1	1	0	2
Oxyopidae	*Oxyopes affinis* Lessert, 1915	PD	6	0	1	0	1
Oxyopidae	*Oxyopes bedoti* Lessert, 1915	PD	6	4	18	2	24
Oxyopidae	*Oxyopes bothai* Lessert, 1915	PD	6	7	2	0	9
Oxyopidae	*Oxyopes hoggi* Lessert, 1915	PD	6	60	17	7	84
Oxyopidae	*Oxyopes jacksoni* Lessert, 1915	PD	6	13	19	7	39
Oxyopidae	*Oxyopes pallidecoloratus* Strand, 1906	PD	6	83	268	33	384
Oxyopidae	*Oxyopes russoi* Caporiacco, 1940	PD	6 NR	266	206	4	476
Oxyopidae	*Oxyopes schenkeli* Lessert, 1927	PD	6	6	0	0	6
Oxyopidae	*Oxyopes* sp.3	PD	NA	336	196	3	535
Oxyopidae	*Peucetia viridis* (Blackwall, 1858)	PD	7	4	9	3	16
Palpimanidae	*Diaphorocellus biplagiatus* Simon, 1893	GD	4	4	0	1	5

Palpimanidae	*Palpimanus armatus* Pocock, 1898	GD	4	1	0	0	1
Palpimanidae	*Palpimanus transvaalicus* Simon, 1893	GD	4	21	2	2	25
Philodromidae	*Ebo* sp. 1	PD	NS	0	11	0	11
Philodromidae	*Gephyrota* sp. 1	PD	NS	2	20	0	22
Philodromidae	*Hirriusa variegata* (Simon, 1895)	GD	4	0	3	9	12
Philodromidae	*Philodromus browningi* Lawrence, 1952	PD	4	21	12	1	34
Philodromidae	*Philodromus grosi* Lessert, 1943	PD	6	24	40	1	65
Philodromidae	*Philodromus guineensis* Millot, 1942	PD	6	8	56	0	64
Philodromidae	*Suemus punctatus* Lawrence, 1938	PD	4	16	3	4	23
Philodromidae	*Thanatus dorsilineatus* Jézéquel, 1964	PD	6 NR	19	3	5	27
Philodromidae	*Thanatus* sp. 1	PD	6 NR	5	9	2	16
Philodromidae	*Tibellus gerhardi* Van den Berg & Dippenaar-Schoeman, 1994	PD	6	15	9	3	27
Philodromidae	*Tibellus hollidayi* Lawrence, 1952	PD	6	18	17	8	43
Philodromidae	*Tibellus minor* Lessert, 1919	PD	6	15	10	5	30
Pholcidae	*Smeringopus atomrius* Simon, 1910	WD	5	3	1	0	4
Pisauridae	*Afropisaura* sp. 1	PD	NA	15	1	0	16
Pisauridae	*Euprosthenopsis vuattouxi* Blandin, 1977	WD	6	50	4	7	61
Pisauridae	*Maypacius bilineatus* (Pavesi, 1895)	PD	6	5	0	2	7
Pisauridae	*Maypacius stuhlmanni* (Bösenberg & Lenz, 1895)	PD	6	1	0	0	1
Pisauridae	*Rothus purpurissatus* Simon, 1898	PD	6				

Prodidomidae	*Theuma parva* Purcell, 1907	GD	4	5	1	1	7
Salticidae	*Aelurillus* sp. 1	GD	NA	2	0	0	2
Salticidae	*Baryphas ahenus* Simon, 1902	PD		3	0	0	3
Salticidae	*Brancus bevisi* Lessert, 1925	PD	6	42	3	8	53
Salticidae	*Cosmophasis* sp. 2	GD	NA	4	0	0	4
Salticidae	*Dendryphantes* sp. 1	PD	NA	2	2	1	5
Salticidae	*Dendryphantes* sp. 2	PD	NA	1	2	1	4
Salticidae	*Euophrys* sp. 1	PD	NA	70	52	3	125
Salticidae	*Heliophanus debilis* Simon, 1901	PD	6	3	27	9	39
Salticidae	*Heliophanus demonstrativus* Wesolowska, 1986	PD	6	1	0	0	1
Salticidae	*Heliophanus insperatus* Wesolowska, 1986	PD	5	1	3	3	7
Salticidae	*Heliophanus transvaalicus* Simon, 1901	PD	4	1	0	0	1
Salticidae	*Hyllus treleaveni* Peckham & Peckham, 1902	PD	5	7	2	0	9
Salticidae	*Hyllus* sp. 5	PD	NA	2	0	0	2
Salticidae	*Langelurillus* sp. 1	GD	NA	0	3	1	4
Salticidae	*Mogrus* sp. 1	PD	NA	1	6	0	7
Salticidae	*Natta horizontalis* Karsch, 1879	GD	6	2	1	0	3
Salticidae	*Pellenes* sp. 1	PD	NA	8	7	12	27
Salticidae	*Phlegra* sp. 1	GD	NA	0	8	0	8
Salticidae	*Pseudicius* sp. 1	PD	NA	5	3	2	10
Salticidae	*Rhene machadoi* Berland & Millot, 1941	PD	NA	26	10	2	38
Salticidae	*Stenaelurillus* sp. 1	GD	NA	5	11	9	25
Salticidae	*Stenaelurillus* sp. 2	GD	NA	9	18	22	49
Salticidae	*Stenaelurillus* sp. 3	GD	NA	5	3	0	8
Salticidae	*Stenaelurillus nigricaudus* Simon, 1885	GD	6	1	0	0	1
Salticidae	*Thyene inflata* (Gerstäcker, 1873)	PD	6	52	10	25	87
Salticidae	*Thyenula aurantiaca* (Simon,	PD	4	7	0	0	7

	1902)						
Selenopidae	*Anyphops* sp. 1	PD	NA	0	1	0	1
Sparassidae	*Olios* sp. 1	PD	NA	3	0	0	3
Sparassidae	*Olios* sp. 2	PD	NA	0	1	1	2
Sparassidae	*Olios* sp. 3	PD	NA	1	0	0	1
Sparassidae	*Palystes superciliosus* L. Koch, 1875	PD	5	0	1	0	1
Sparassidae	*Pseudomicrommata longipes* (Bösenberg & Lenz, 1895)	PD	6	6	0	0	6
Theraphosidae	*Augacephalus junodi* (Simon, 1904)	BD	3	0	0	1	1
Theridiidae	*Argyrodes convivans* Lawrence, 1937	WD	4	5	0	0	5
Theridiidae	*Argyrodes zonatus* (Walckenaer, 1842)	WD	6	4	2	1	7
Theridiidae	*Dipoena* sp.4	WD	NA	3	0	0	5
Theridiidae	*Enoplognatha molesta* O.P.-Cambridge, 1904	WD	4	19	33	4	56
Theridiidae	*Latrodectus geometricus* C.L.Koch, 1841	WD	7	12	8	4	24
Theridiidae	*Latrodectus renivulvatus* Dahl, 1902	WD	6	25	8	3	36
Theridiidae	*Phoroncidia eburnea* (Simon, 1895)	WD	4	3	3	2	8
Theridiidae	*Steatoda* sp. 1	WD	NA	0	5	0	5
Theridiidae	*Theridiidae* sp. 21	WD	NA	2	3	0	5
Theridiidae	*Theridiidae* sp. 14	WD	NA	0	1	0	1
Theridiidae	*Theridiidae* sp. 30	WD	NA	0	1	0	1
Theridiidae	*Theridiidae* sp. 33	WD	NA	1	1	2	4
Theridiidae	*Theridion* sp. 4	WD	NA	1	0	0	1
Theridiidae	*Theridion* sp. 11	WD	NA	2	1	0	3
Theridiidae	*Theridion* sp. 13	WD	NA	132	70	87	189
Theridiidae	*Theridion* sp. 19	WD	NA	9	5	0	14
Theridiidae	*Theridion* sp. 23	WD	NA	5	1	0	6
Theridiidae	*Tidarren* sp. 8	WD	NA	1	0	0	1

Thomisidae	*Heriaeus crassispinus* Lawrence, 1942	PD	4	3	2	5	10
Thomisidae	*Heriaeus transvaalicus* Simon, 1895	PD	5	19	8	7	34
Thomisidae	*Hewittia gracilis* Lessert, 1928	PD	6	1	0	1	1
Thomisidae	*Misumenops rubrodecoratus* Millot, 1942	PD	6	27	134	20	181
Thomisidae	*Monaeses austrinus* Simon, 1910	PD	6	4	138	59	201
Thomisidae	*Monaeses fuscus* Dippenaar-Schoeman 1984	PD	4	0	5	0	5
Thomisidae	*Monaeses gibbus* Dippenaar-Schoeman 1984	PD	4	15	61	27	103
Thomisidae	*Monaeses paradoxus* (Lucas, 1846)	PD	7	0	8	3	11
Thomisidae	*Monaeses pustulosus* Pavesi, 1895	PD	6	2	3	1	6
Thomisidae	*Monaeses quadrituberculatus* Lawrence, 1927	PD	5	11	49	29	89
Thomisidae	*Ozyptila* sp. 1	PD	NR	3	0	0	3
Thomisidae	*Pherecydes tuberculatus* O.P.-Cambridge, 1883	PD	4	17	15	1	33
Thomisidae	*Runcinia aethiops* (Simon, 1901)	PD	6	3	0	1	4
Thomisidae	*Runcinia affinis* Simon, 1897	PD	6	3	18	4	25
Thomisidae	*Runcinia erythrina* Jézéquel, 1964	PD	6	4	42	24	70
Thomisidae	*Runcinia flavida* (Simon, 1881)	PD	6	186	130	121	437
Thomisidae	*Synema diana* (Audouin, 1826)	PD	6	2	0	0	2
Thomisidae	*Synema imitator* (Pavesi, 1883)	PD	6	40	15	3	58
Thomisidae	*Synema nigrotibiale* Lessert, 1919	PD	6	33	10	8	51
Thomisidae	*Thomisops sulcatus* Simon, 1895	PD	6	0	0	1	1
Thomisidae	*Thomisus blandus* Karsch, 1880	PD	6	1	0	0	1

Thomisidae	*Thomisus citrinellus* Simon, 1875	PD	6	0	2	0	2
Thomisidae	*Thomisus congoensis* Comellini, 1957	PD	6	2	0	0	2
Thomisidae	*Thomisus granulatus* Karsch, 1880	PD	5	1	0	0	1
Thomisidae	*Thomisus kalaharinus* Lawrence, 1936	PD	6	1	0	0	1
Thomisidae	*Thomisus stenningi* Pocock, 1900	PD	6	1	4	1	6
Thomisidae	*Tmarus africanus* Lessert, 1919	PD	6	3	0	0	3
Thomisidae	*Tmarus cameliformis* Millot, 1942	PD	6	15	34	0	49
Thomisidae	*Tmarus longicaudatus* Millot, 1941	PD	6	0	5	0	5
Thomisidae	*Tmarus foliatus* Lessert, 1928	PD	6	2	0	0	2
Thomisidae	*Xysticus fagei* Lessert, 1919	GD	6	6	1	0	7
Uloboridae	*Miagrammopes longicaudus* O.P.-Cambridge, 1882	WD	4	8	2	0	10
Uloboridae	*Uloborus* sp. 1	WD	NA	1	1	0	2
Uloboridae	*Uloborus* sp. 2	WD	NA	0	1	0	1
Zodariidae	*Capheris decorata* Simon, 1904	GD	4	5	0	0	5
Zodariidae	*Chariobas cylindraceus* Simon, 1893	GD	6	1	1	0	2
Zodariidae	*Cydrela* sp. 1	GD	NA	18	0	5	23
Zodariidae	*Diores auricula* Tucker, 1920	GD	5	5	2	4	11
Zodariidae	*Diores* sp. 2	GD	NS?	44	1	0	45
Zodariidae	*Psammoduon* sp. 1	GD	NA	0	1	3	4
Zodariidae	*Ranops* sp. 1	GD	NS	0	1	0	1
Total number of species	119			173	159	115	
Total number of specimens				3520	2823	1433	7776