Spiders in macadamia orchards in the Mpumalanga Lowveld of South Africa: species diversity and abundance (Arachnida: Araneae)

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Arboreal spiders were collected over a 12-month period (July 1997 – June 1998) from three macadamia orchards in the Mpumalanga Lowveld of South Africa. The spiders were sampled every 2–3 weeks from 10 trees per orchard using dichlorvos as a knock-down spray. In total, 2778 specimens representing 21 families, 57 genera and 80 species were recorded. The Salticidae represented 72.7 % of all spiders collected, followed by the Sparassidae (6.9 %), Hersiliidae (3.9 %) and Araneidae (3.3 %). The families richest in species numbers were the Salticidae (17), followed by the Araneidae (16) and the Thomisidae (11). Wandering spiders dominated the fauna, representing 95.8 % of the total number of specimens collected compared to 4.2 % that were web-builders.

Key words: abundance, agroecosystems, Araneae, diversity, ecology, macadamia, South Africa, spiders.

South Africa is the world's third-largest producer of macadamia (*Macadamia integrifolia* Maiden & Betcke) nuts (Groenewald 1999). Like most commercial crops, macadamia is subject to infestation by pests. About 60 insect and two mite species are known to attack macadamia trees and their fruit (Van den Berg et al. 2000). In South Africa, pentatomid and coreid stinkbugs are the most important pests in macadamia orchards (Van den Berg et al. 1999). Infestation results in young nuts dropping and older nuts developing lesions.

Orchards are populated by numerous spider species (Chant 1956; Dondale 1956; Muma 1975; Carroll 1980; Mansour et al. 1980a,b, 1982; Deutcher et al. 1984; Mansour & Whitcomb 1986; Mizell & Schiffhauer 1987; Yan & Wang 1987; Yan 1988; Jimenez & Tejas 1996; Angeli et al. 1996; Samu et al. 1997; Pekár 1999; Pekár et al. 1999). Reviews on the role of spiders in agroecosystems (Luczak 1979; Riechert & Lockley 1984; Nyffeler & Benz 1987; Sunderland 1987; Nyffeler et al. 1994a,b; Green 1996) indicate an increasing interest in, and recognition of, spiders as natural control agents of insects and mites in such systems.

In South Africa, spiders occur in abundance on commercial crops (Dippenaar-Schoeman 1976; Dippenaar-Schoeman et al. 1999), including tree crops such as citrus (Catling 1970; Van den Berg et al. 1992; Dippenaar-Schoeman 1998). However, little information is available on spider assemblages in macadamia orchards, both locally and elsewhere. Considering the vast number of insect species that attack macadamia in South Africa, it seemed the ideal crop for investigating the implementation of natural control with spiders. The important first step was to determine spider species diversity and abundance (Green 1996). This paper reports on a survey of arboreal spiders conducted over a period of a year in three macadamia orchards in the Mpumalanga Lowveld.

Materials and methods

Spiders were collected between July 1997 and June 1998 from three macadamia orchards in the Lowveld of Mpumalanga Province: an unsprayed orchard at Nelspruit (25.30S, 30.58E), and two commercial orchards within 20 km of Nelspruit, one at Schagen and the other at Glenwood.

Sheets were spread every 2–3 weeks under 10 randomly-selected trees in each orchard. Each tree was sprayed with dichlorvos at 150 ml 100 l^{-1} water. After an hour, specimens that were knocked down by the insecticide were collected from the sheet and placed in 70 % ethanol. Eighteen samples were taken from Nelspruit, 19 from Schagen and 20 from Glenwood. Species were identified and the material deposited in the National Collection of Arachnida at the ARC - Plant Protection Research Institute, Pretoria. A number of taxa collected could not be identified to species level owing to the unresolved taxonomy of some families or absence of adult specimens.

Based on foraging behaviour, the species

Table 1. Total number of spiders collected per family from three macadamia orchards in the Mpumalanga Lowveld, South Africa (July 1997 – June 1998).

Family	Number of specimens collected				
	Glenwood	Schagen	Nelspruit	Total	%
Salticidae	805	542	673	2020	72.7
Sparassidae	68	37	86	191	6.9
Hersiliidae	51	24	32	107	3.9
Araneidae	34	26	31	91	3.3
Clubionidae	57	9	14	80	2.9
Miturgidae	21	2	44	67	2.4
Thomisidae	31	19	16	66	2.4
Philodromidae	26	10	3	39	1.4
Corinnidae	3	11	13	27	1.0
Selenopidae	5	2	18	25	0.9
Tetragnathidae	4	5	6	15	0.5
Oxyopidae	4	4	5	13	0.5
Theridiidae	2	6	0	8	0.3
Gnaphosidae	3	3	1	7	0.3
Mimetidae	2	1	3	6	0.2
Lycosidae	0	3	2	5	0.2
Liocranidae	0	0	4	4	0.1
Pisauridae	1	2	1	4	0.1
Deinopidae	1	0	0	1	0.1
Phyxelididae	1	0	0	1	0.1
Nesticidae	0	0	1	1	0.1
Total	1119	706	953	2778	
No. samples taken	20	19	18	57	
No. spiders per tree	5.6	3.7	5.3	4.9	

collected were grouped into the following guilds: web-builders (WB) that snare their prey with silk, and wanderers (W) that wander around in search of prey. The web-builders construct the following types of webs: orb webs (OWB), gum-foot webs (GWB) and retreat webs (RWB). The wanderers include plant wanderers (PW) and ground wanderers (GW).

Rank species abundance curves were prepared for each orchard with an overall curve for the three sites (Lambshead et al. 1983).

Results and discussion

In total, 2778 specimens representing 21 families, 57 genera and 80 species were collected from the three macadamia orchards over a period of a year (Tables 1, 2). The physical structure of the habitat has a distinct effect on the composition of spider communities (Wise 1993). Vegetation not only provides the necessary support for anchoring webs but also increases the availability of retreat space and modifies the microclimate, which could have an effect on the spiders as well as their prey. Carroll (1980) showed that spiders outnumbered all other large insect predators in citrus canopies, and Castello & Daane (1999) found that spiders constituted 98 % of all predators in vineyards. In South Africa, Van den Berg & Dippenaar-Schoeman (1991) identified 75 % of the predacious arthropods found on cotton as spiders.

The species abundance found in this study corresponds with the results of similar surveys of spider assemblages in orchards elsewhere. The number of species present usually varies between 50 and 90. Benfatto et al. (1995) recorded 89 spider species from citrus orchards in Italy. Ninety-one species were recorded from citrus in Florida (Muma 1975), 41 from Mexico (Jimenez & Tejas 1996), 62 from California (Carroll 1980) and 82 from South Africa (Dippenaar-Schoeman 1998). Angeli et al. (1996) collected 60 spider species from apple orchards in Italy.

Table 1 lists the total number of spiders collected per family from the three orchards and Table 2

Table 2. Spider species collected from three macadamia orchards in the Mpumalanga Lowveld, South Africa (July 1997 – June 1998).

Taxon	Number of specimens collected[a]				Guild[b]
	G	S	N	Total	
Family Araneidae					
Arachnura scorpionoides Vinson, 1863	0	0	1	1	OWB
Araneus apricus (Karsch, 1884)	1	2	0	3	OWB
A. holzapfelae Lessert, 1936	5	0	0	5	OWB
A. nigroquadratus Lawrence, 1937	1	1	6	8	OWB
A. strupifer (Simon, 1885)	0	0	1	1	OWB
Araneus sp. 2	2	0	0	2	OWB
Argiope levii Bjørn, 1997	0	0	2	2	OWB
Cyclosa insulana (Costa, 1834)	4	0	0	4	OWB
C. oculata (Walckenaer, 1802)	0	0	1	1	OWB
Cyphalonotus larvatus (Simon, 1881)	8	11	0	19	OWB
Neoscona blondeli (Simon, 1885)	1	0	0	1	OWB
N. rufipalpis (Lucas, 1858)	2	0	0	2	OWB
N. subfusca (C L Koch, 1837)	8	5	7	20	OWB
N. triangula (Keyserling, 1864)	2	4	12	18	OWB
Araneilla sp. 1	0	0	1	1	OWB
Undetermined genus	0	3	0	3	OWB
TOTAL	34	26	31	91	
Family Clubionidae					
Clubiona abbajensis Strand, 1906	17	6	5	28	PW
C. africana Lessert, 1921	40	3	9	52	PW
TOTAL	57	9	14	80	
Family Corinnidae					
Copa benina Strand, 1915	3	11	4	18	PW
Trachelas schenkeli Lessert, 1923	0	0	9	9	PW/GW
TOTAL	3	11	13	27	
Family Deinopidae					
Deinopis cylindrica Pocock, 1898	1	0	0	1	OWB
Family Gnaphosidae					
Echemus erutus Tucker, 1923	2	0	0	2	PW
Setaphis sp. (juvenile)	1	3	1	5	PW
TOTAL	3	3	1	7	
Family Hersiliidae					
Hersilia sericea Pocock, 1898	51	24	32	107	PW
Family Liocranidae					
Rhaeboctesis trinotatus Tucker, 1920	0	4	0	4	PW
Family Lycosidae					
Pardosa crassipalpis Purcell, 1903	0	1	2	3	PW
Trabea sp. (juvenile)	0	2	0	2	PW
TOTAL	0	3	2	5	
Family Mimetidae					
Mimetus natalensis Lawrence, 1938	2	1	3	6	PW
Family Miturgidae					
Cheiracanthium furculatum Karsch, 1879	20	2	43	65	PW
Cheiramiona simplicitarsis (Simon, 1910)	1	0	1	2	PW
TOTAL	21	2	44	67	

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Table 2 *(continued).*

Taxon	Number of specimens collected[a] G	S	N	Total	Guild[b]
Family Nesticidae					
Nesticella sp. (juvenile)	0	1	0	1	GWB
Family Oxyopidae					
Hamataliwa kulczynskii (Lessert, 1915)	0	1	2	3	PW
Oxyopes jacksoni Lessert, 1915	0	2	0	2	PW
O. longispinosus Lawrence, 1938	4	0	0	4	PW
O. pallidecoloratus Strand, 1906	0	0	2	2	PW
O. schenkeli Lessert, 1927	0	0	1	1	PW
Oxyopes (undetermined sp.)	0	1	0	1	PW
TOTAL	4	4	5	13	
Family Philodromidae					
Philodromus brachycephalus Lawrence, 1952	2	2	1	5	PW
P. guineensis Millot, 1942	24	8	2	34	PW
TOTAL	26	10	3	39	
Family Phyxelididae					
Xeviosa aululata Griswold, 1990	1	0	0	1	RWB
Family Pisauridae					
Cispius problematicus Blandin, 1978	1	1	0	2	PW
Rothus purpurissatus Simon, 1898	0	1	1	2	PW
TOTAL	1	2	1	4	
Family Salticidae					
Afraflacilla (undetermined sp.)	6	0	6	12	PW
Goleba (undetermined sp.)	3	2	4	9	PW
Habrocestrum annae Peckham & Peckham, 1903	18	0	10	28	PW
Heliophanus transvaalicus Simon, 1901	2	3	6	11	PW
Hyllus argyrotoxus Simon, 1902	9	7	0	16	PW
H. brevitarsis Simon, 1902	0	7	7	14	PW
Meleon kenti Lessert, 1925	3	0	6	9	PW
Mogrus (undetermined sp.)	0	1	0	1	PW
Myrmarachne laurentina Bacelar, 1953	0	9	0	9	PW
Phintella (undetermined sp.)	36	135	28	199	PW
Portia schultzi Karsch, 1878	2	3	0	5	PW
Thyene coccineovittata Peckham & Peckham, 1903	360	140	326	826	PW
T. natalii Peckham & Peckham, 1903	165	94	135	394	PW
Thyenula ogdeni Peckham & Peckham, 1903	6	6	0	12	PW
Tusitala guineensis Berland & Millot, 1941	70	120	41	231	PW
Viciria alba Peckham & Peckham, 1903	123	14	103	240	PW
Undetermined taxa	2	1	1	4	PW
TOTAL	805	542	673	2020	
Family Selenopidae					
Anyphops rubicundus (Lawrence, 1940)	5	2	18	25	PW
Family Sparassidae					
Olios tuckeri Lawrence, 1927	34	23	44	101	PW
Palystes superciliosus L Koch, 1875	34	14	42	90	PW
TOTAL	68	37	86	191	
Family Tetragnathidae					
Leucauge festiva (Blackwall, 1866)	1	1	0	2	OWB
L. thomeensis Kraus, 1960	2	0	3	5	OWB

Continued on p. 43

Table 2 *(continued).*

Taxon	Number of specimens collected[a]				Guild[b]
	G	S	N	Total	
Nephila senegalensis (Walckenaer, 1842)	1	0	0	1	OWB
Tetragnatha subsquamata Okuma, 1985	0	4	3	7	OWB
TOTAL	4	5	6	15	
Family Theridiidae					
Theridion purcelli O.P.-Cambridge, 1904	2	2	0	4	GWB
T. pictum (Walckenaer, 1802)	0	3	0	3	GWB
Tidarren (undetermined sp.)	0	1	0	1	GWB
TOTAL	2	6	0	8	
Family Thomisidae					
Diaea diana Audouin, 1826	7	0	1	8	PW
Misumena tuckeri Lessert, 1919	1	1	1	3	PW
Misumenops rubrodecoratus Millot, 1942	9	4	1	14	PW
Oxytate argenteooculata (Simon, 1886)	3	3	6	12	PW
O. concolor (Caporiacco, 1947)	0	1	0	1	PW
Synema imitator (Pavesi, 1883)	2	2	1	5	PW
S. langheldi Dahl, 1907	2	2	1	5	PW
Thomisus daradioides Simon, 1890	0	1	0	1	PW
Tmarus cameliformis Millot, 1942	4	4	5	13	PW
T. natalensis Lessert, 1925	2	0	0	2	PW
Xysticus natalensis Lawrence, 1938	1	1	0	2	PW
TOTAL	31	19	16	66	

[a]G = Glenwood; N = Nelspruit; S = Schagen.
[b]GWB = gum-foot web; OWB = orb-web; RWB = retreat-web; GW = ground wanderer; PW = plant wanderer.

provides an annotated checklist of species recorded. Based on the total of all three orchards, a mean of 4.9 spiders were recorded per tree. Slightly higher numbers were recorded at Glenwood, where the mean of 5.6 spiders per tree represented 18 families and 60 species. At Schagen, the other commercial orchard, the mean of 3.7 spiders per tree represented 17 families and 50 species. The unsprayed orchard at Nelspruit, yielded 5.2 spiders per tree representing 18 families and 55 species. Although species accumulation curves were prepared for each orchard, the curves crossed over and species diversity could not be compared. It nevertheless indicated that little differences in species diversity existed between the three orchards.

Spider families were skewly distributed, with Salticidae representing 72.7 % of all the spiders collected, followed by Sparassidae with 6.9 %, Hersiliidae with 3.9 % and Araneidae with 3.3 %. None of the remaining 18 families represented more than 3 % of the total (Table 2). Similar patterns were observed in other studies. Angeli et al. (1996) reported that three species constituted >50 % of all spiders collected from pear and apple orchards, whereas a single miturgid species represented 63 % of the arboreal spider fauna on avocado trees in Israel (Mansour et al. 1985). According to Odum (1971) a certain proportion of organisms in a community usually determines the nature and function of the entire community. This group constitutes the ecological dominants of the community and usually consists of relatively few species. Rare species, however, also play an important role in the community structure for they contribute to the diversity of the community.

The more abundant species in the macadamia orchards were all members of the Salticidae, viz. *Thyene coccineovittata* (29.7 %), *T. natalii* (14.2 %), *Viciria alba* (8.6 %) and *Tusitala guineensis* (8.3 %). The phenology of the dominant salticid species associated with macadamia is discussed in a companion paper (Dippenaar-Schoeman et al. 2001). Salticids were also the most abundant family in citrus orchards in South Africa (Dippenaar-Schoeman 1998), but were present in lower num-

Table 3. Number of species and total number of spiders collected per family from three macadamia orchards in the Mpumalanga Lowveld, South Africa (July 1997 – June 1998).

Family	No. of species	Total
Salticidae	17	2020
Araneidae	16	91
Thomisidae	11	66
Oxyopidae	6	13
Tetragnathidae	4	15
Theridiidae	3	8
Lycosidae	2	5
Sparassidae	2	191
Corinnidae	2	27
Philodromidae	2	39
Pisauridae	2	4
Miturgidae	2	67
Gnaphosidae	2	7
Clubionidae	2	80
Hersiliidae	1	107
Mimetidae	1	6
Nesticidae	1	1
Selenopidae	1	25
Deinopidae	1	1
Liocranidae	1	4
Phyxelididae	1	1
Total no. species	80	2778

bers in perennial crops such as cotton (Dippenaar-Schoeman et al. 1999). In Israel, a miturgid (*Cheiracanthium* sp.) was the dominant species on citrus (Mansour & Whitcomb 1986), in Italy a *Clubiona* sp. (Benfatto et al. 1995) and in the USA an oxyopid species (Carroll 1980).

Species richness

The Salticidae had the highest number of species (17) representing 21.3 % of the total number of species collected (Table 3), followed by the Araneidae (16), Thomisidae (11) and Oxyopidae (6). Of the 57 genera collected, 21 were represented by a single species. Variation commonly occurs in the species composition found on different cultivated crops. Benfatto et al. (1995) recorded 18 theridiid and 13 thomisid species from citrus in Italy and Jimenez & Tejas (1996) 19 theridiid and 12 araneid species from mango groves in Mexico. The Thomisidae were the richest in species (21), followed by the Araneidae (18) on cotton in South Africa (Dippenaar-Schoeman et al. 1999), while Thomisidae and Lycosidae were each represented by five species on strawberries (Dippenaar-Schoeman 1979).

Guilds

Wandering spiders dominated the fauna, representing 95.8 % of the total number compared to 4.2 % of the web-builders (Table 2). Although the web-builders were low in number (117) they were represented by 26 species (32.5 %) in six families. Their low numbers can possibly be ascribed to them not dropping onto the sheets after being killed by the dichlorvos spray but instead remaining hanging in their webs. The web-builders that were collected construct four different kinds of webs: orb-webs (Araneidae and Tetragnathidae), adapted orb-webs (Deinopidae), gum-foot webs (Theridiidae and Nesticidae) and retreat-webs (Amaurobiidae).

The other 28 species collected (67.5 %) were wanderers. Some wanderers mainly live on the bark of trees, e.g. Hersiliidae, Selenopidae and some species of the Philodromidae, whereas families like the Salticidae, Sparassidae, Miturgidae, Clubionidae and Thomisidae are mostly foliage dwellers. Some of them, e.g. salticids and thomisids, are diurnal, free-living hunters while others are nocturnal, hiding during the day under loose bark, beneath leaves or in silk sac-like retreats. Most wanderers are aggressive spiders and will kill any prey they encounter, even though not always feeding on it. In some families predation is not limited to adult prey but includes the egg and larval or nymphal stages as well (Whitcomb 1974; Nyffeler et al. 1990). Salticids, the most abundant group in this study, are known to feed on a wide variety of arthropods such as Diptera, Orthoptera, Hemiptera and Lepidoptera (Carroll 1980; Edwards 1981; Mansour et al. 1982). In Israel, wandering spiders have been observed to cause a disturbance effect in apple orchards while wandering around and a larval mortality of about 30 % in *Spodoptera littoralis* (Boisduval) could be attributed to this effect (Mansour et al. 1980b). On citrus trees where spiders were present, populations of citrus scale (*Ceroplastes floridensis* Maskell) could not develop to a level sufficient to cause economic damage (Mansour & Whitcomb 1986). Silk retreats or webs of spiders also have an effect on populations of insects such as citrus psylla (*Trioza erytreae* (Del Guercio)) (Van den Berg et al. 1992).

Conclusion

Spiders form part of the natural enemy complex in macadamia orchards in South Africa. Studies worldwide indicate that spiders play a role in the suppression of insect pests (Mansour et al. 1995) and, according to Riechert & Lockley (1984), generalist predators such as spiders can limit exponential increases in pest populations and need to form a part of integrated pest management strategies in agro-ecosystems.

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