International Journal of Pest Management
Vol. 55, No. 4, October–December 2009, 339–345

Host plants of *Stictococcus vayssierei* Richard (Stictococcidae) in non-crop vegetation in the Congo Basin and implications for developing scale management options

Maurice Tindo[a†], Rachid Hanna[a]*, Georg Goergen[b], Louis Zapfack[c], Kasongo Tata-Hangy[d] and Alphonse Attey[a]

[a]*International Institute of Tropical Agriculture, Cameroon, B.P. 2008 Yaoundé-Messa, Cameroon;* [b]*International Institute of Tropical Agriculture, Benin, 08 B.P. 0932 Tri Postal Cotonou, Republic of Benin;* [c]*Department of Plant Biology, University of Yaoundé I, Faculty of Science, B.P. 812 Yaoundé, Cameroon;* [d]*Institut National de Recherche et d'Etude Agronomique, INERA, République Démocratique du Congo*

(*Received 4 January 2008; final version received 31 March 2009*)

Surveys were carried out in five vegetation types to identify, in non-crop vegetation, host plants of *Stictococcus vayssierei* Richard, a pest of cassava in the Congo basin. Along transects within each of these vegetation types, all plants with underground storage structures and including those belonging to the plant families known to be used by *S. vayssierei* were uprooted and inspected for the presence of the scale. Sixteen plant species belonging to 13 families were identified as hosts of *S. vayssierei*. Eleven out of the host species are indigenous and 13 are newly identified hosts for *S. vayssierei*. Six new host families were identified. Infestation levels and the distribution of *S. vayssierei* indicated that native *Dioscorea* species may play an important role in the maintenance of the scale in long fallows and in secondary and primary forests, while exotic plants such as cassava may contribute to *S. vayssierei* population growth in fallows less than eight years old. Our findings suggest that destruction and removal of *S. vayssierei* host plants from non-crop vegetation might be useful in reducing *S. vayssierei* infestations and improving cassava yields.

Keywords: Cameroon; Democratic Republic of Congo; cassava; *Dioscorea*; *Manihot esculenta*; fallows; forest

1. Introduction

The African root and tuber scale (ARTS) *Stictococcus vayssierei* Richard (Hemiptera: Stictococcidae) is an endemic and widely distributed species in all countries within the Congo Basin, including Cameroon, Central African Republic, Democratic Republic of Congo (DRC), Equatorial Guinea, Gabon, and Republic of Congo. It is the only known hypogeous species of the genus *Stictococcus*, which comprises six species (Richard 1976). *Stictococcus vayssierei* is commonly associated with the formicine ant species *Anoplolepis tenella* Santchi (Dejean and Matile-Ferrero 1996; Fotso Kuate et al. 2008; Hanna et al. unpublished data). This ant may play an important role in the biology of *S. vayssierei*, as has been repeatedly observed for the interactions between ants and hemipteran insects (see Buckley 1987; Flatt and Weisser 2000).

Very little is known about the ecology of *S. vayssierei*. Since its description by Richards (1971) from samples collected on cassava (*Manihot esculenta* Crantz), little research has been conducted into its increasing role as a pest on this important food crop (Dejean and Matile-Ferrero 1996; Ambe et al. 1999; Ngeve 2003; Tata Hangy et al. 2006; Hanna et al. unpublished data). The scale has been reported as also attacking cocoyam (*Xanthosoma mafaffa* Schott), groundnut (*Arachis hypogea* L.), taro (*Colocasia esculenta* Schott) and plantain (*Musa* sp.) by Nonveiller (1984); more recently, it has been found on cultivated yam (*Dioscorea* spp.) (Hanna et al. unpublished data). Records of non-cultivated host-plants, however, are largely anecdotal. These include *Balanophora abbreviata* Blume (Balanophoraceae), *Haumania danckelmaniana* Braun & Shum (Marantaceae) (see Dejean and Matile-Ferrero 1996) and *Chromolaena odorata* (L.) R.M. King & H. Rob (Asteraceae) (Bani et al. 2003). Information on the status of *S. vayssierei* infestations of food crops has been steadily accumulating because of the emergence of *S. vayssierei* as a serious threat to cassava production in certain areas of the Congo Basin (Nonveiller 1984; Dejean and Matile-Ferrero 1996; Ambe et al. 1999; Tata-Hangy et al. 2007; Hanna et al. unpublished data). In contrast, relatively little is known about *S. vayssierei's* use of non-cultivated vegetation. We hypothesised that non-crop vegetation (i.e. fallows and forests) might serve as reservoir for the scale, enabling it to infest neighbouring crop fields or those planted following the destruction of forests and fallows.

The aim of this study was to identify *S. vayssierei's* host plants and infestation levels in fallows and forests

*Corresponding author. Email: r.hanna@cgiar.org
†Present address: Department of Animal Biology, University of Douala, Faculty of Science, B.P. 24157 Douala, Cameroon. E-mail: tindodouala@yahoo.com

ISSN 0967-0874 print/ISSN 1366-5863 online

DOI: 10.1080/09670870902934864
http://www.informaworld.com

in Cameroon and Southwestern DRC; these areas are known to have severe scale infestations. Knowledge of the identity and relative infestation levels on host plants in non-crop vegetation can provide important information regarding the role that those plants play in *S. vayssierei* population persistence. This information is also necessary for developing sustainable options to reduce scale infestations on targeted crops (e.g. cassava). We discuss the role of the recorded host plants in the ecology and management of *S. vayssierei* in the Congo Basin.

2. Materials and methods

2.1. Surveyed sites

This study was conducted in Central, Southern, Southwestern and Western Provinces of Cameroon and in the Bas Fleuve district (Bas-Congo Province) of DRC. In Central and Southern Provinces, the surveys were conducted in the Forest Margin Benchmark Area (FMBA) which is characterized by a gradient of forest cover and population, ranging from dense forest and low human population density on its southern side (Ebolowa) to degraded forest and high human population density on its northern side (Gockowski et al. 1998). Site selection in FMBA was based on the results of socio-economic surveys carried out by J. Gockowski, IITA, unpublished data), which classified sites according to the magnitude of *S. vayssierei* problem reported by farmers. Six villages were selected in the FMBA: Nkometou III (04°04′74″N; 11°33′93″E) and Etoud (03°54′29″N; 11°24′63″E) in the north, Awae II (03°54′30″N; 11°25′58″E) and Evindissi (03°23′40″N; 11°22′41″E) in the centre, and Loubessa (02°35′17″N; 11°25′25″E) and Mengomo (02°34′21″N; 11°01′03″E) in the south.

Similar surveys were conducted in Banga-bakundu (05°28′90″S; 13°18′13″E) near Mount Cameroon in Southwestern province where vegetation is dominated by industrial plantations (e.g. rubber, plantain and palm). Three sites were also surveyed in Western province: Ndoungue (04°54′30″N, 09°54′22″E), Melong-Lelem (05°05′22″N; 009°55′91″E), and Santchou (05°10′07″N, 09°58′27″E), where vegetation is dominated by intensively farmed land (e.g. coffee plantations) with low fallow frequency. In DRC, the surveys were conducted in the Bas Fleuve District in a forest zone at Tsinga Makanzu (05°14′60″S; 13°00′17″E), and in a forest-savanna mosaic near Kinzau Mvuete (05°29′12″S; 13°17′37″E).

2.2. Selection of vegetation types and sampling of potential host plants

At each of the survey sites, the basic sampling unit was a 40-m long and 5-m wide (200 m^2) transect takes within each of the various vegetation types. The number of transects ranged from 2 to 31, depending on prevailing vegetation types (e.g. primary forests were not found at intensively farmed sites). In the FMBA in Central and Southern Cameroon, four vegetation types (Zapfack 2005) were surveyed. They included young fallows (<4 years), mid-fallows (4–8 years), old fallows (>8 and <15 years), and secondary and primary forests. Each transect was subdivided into 5 × 5-m quadrats in which all suspected plants were uprooted, and their root area inspected for the presence and densities of *S. vayssierei*. Forty four transects were surveyed including 31 in the FMBA, 2 and 4, respectively, in Southwestern and Western Provinces of Cameroon, and seven in DRC. Overall, 6 transects were located in primary forests, 7 in secondary forests, 8 in old fallows, 10 in mid-fallows, and 12 in young fallows.

Two criteria were used to select plants for inspection: (1) plant taxon: species belonging to the families Araceae, Asteraceae, Balanophoraceae, Dioscoreaceae, Euphorbiaceae and Leguminosae (Caesalpiniaceae, Fabaceae and Mimosaceae), which have been reported as *S. vayssierei* host plant families; (2) Plant root type: species with tuberous/storage roots or with rhizomes. Known cultivated plants found in the surveyed vegetation types were also considered and included in the sampling. Additional casual inspections were conducted on other plants were not found in the transects to increase the coverage of our sampling and minimize the chance that some host plants are not included in the surveys. Sampled plants were identified *in situ* by a botanist (L. Zapfack) or collected and preserved for further identification at the Cameroon's National Herbarium. Spelling of plant names and their authors were checked on the International Plant Names Index database (2008).

2.3. Statistical analysis

A statistical analysis was conducted only using data obtained in the FMBA where the surveys were most intensive. Host plants with very low *S. vayssierei* incidence (see section 3) were excluded from this analysis. Scale incidence (proportion of plants infested with *S. vayssierei*) and density on the inspected host plants were compared using the Generalized Linear Model (GLM) procedure (SAS 2000) with logistical and log transformations for incidence and density, respectively. For the Generalized Linear Model (GLM), the test statistic is the log likelihood Chi-squared, rather than the F statistic.

3. Results

In total, 11,316 plants representing 88 species and belonging to 23 families were uprooted and inspected in all surveyed sites combined (Table 1). Sixteen species belonging to 13 families were identified as *S. vayssierei* host plants, representing 18.2 and 54.2% of the

Table 1. Checklist of plant species surveyed as potential hosts of the African root and tubers scale (ARTS) in non-food crop vegetation in Cameroon (CM) and the Democratic Republic of Congo (DRC). The region is also indicated, but the vegetation type is given only for ARTS host plants.

Family	Species	Country	Region	Vegetation type
Araceae	*Anchomanes difformis* Engl.	CM		YF, OF, MF, SF, PF
	Amorphophallus preussii N.E.Br.	CM	SC, WC	
	Colocasia esculenta Schott	CM	WC	YF
	Cercestis dinklagei Engl.	CM	SC, WC	
	Cercestis mirabilis (N.E.Br.) Bogner	CM	SC, WC	
	Cyrtosperma senegalense Eng.	CM, DRC	SC	YF, SF
	Xanthosoma mafaffa Schott	CM	SC, WC	YF, MF
Arecaceae	*Elaeis guineensis* Jacq.	CM	SC	YF, MF, OF, SF
Asparagaceae	*Asparagus flagellarus* Baker	CM	SC	
Asteraceae	*Chromolaena odorata* (L.) R.M. King & H. Rob	CM, DRC	SC, WC, SW	
Balanophoraceae	*Balanophora abbreviata* Blume	CM	SC	
Caesalpiniaceae	*Anthonotha fragrans* (Baker f.) Exell & Hillc.	CM	SC	
	Berlinia sp.	CM	SC, WC	
	Distemonanthus benthamianus Baill.	CM	SC	
	Erythrophleum suaveolens (Guill. & Perr.) Brenan	CM	SC	
Commelinaceae	*Palisota ambigua* C.B.Clarke	CM		
	Palisota hirsuta K.Schum.	CM, DRC	SC, WC	YF, OF, MF, SF
	Palisota barteri Hook.f.	CM	SC, WC	
Costaceae	*Costus afer* Ker Gawl.	CM, DRC	SC, WC	YF, MF, SF
	Costus dinklagei K.Schum.	CM	SC, WC	
Cyperaceae	*Cyperus alternifolius* Steud.	CM	SC	
	Cyperus sp.	CM	SC, WC	
	Cyperus subumbellatus Kük.	CM	SC	
	Kyllinga sp.	CM	SC, WC	
	Mapania sp.	CM	SC	
	Scleria boivini Steud.	CM	SC, WC	
Denstaedtiaceae	*Pteridium aquilinum* (L.) Kuhn	CM	SC	
Dioscoreaceae	*Dioscorea* spp.	CM, DRC	SC, WC, TD	YF, OF, MF, SF, PF
Euphorbiaceae	*Alchornea cordifolia* Müll.Arg.	CM	SC, WC	
	Alchornea floribunda Müll.Arg.	CM	SC	
	Alchornea laxiflora Pax & K.Hoffm.	CM	SC	
	Bridelia micrantha Baill.	CM	SC, WC	
	Croton oliganthus Müll.Arg.	CM	SC	
	Euphorbia heterophylla L.	CM	SC	
	Euphorbia hirta L.	CM	SC	
	Macaranga assas A.Amougou	CM	SC	
	Macaranga barteri Müll.Arg.	CM, DRC	SC, WC	
	Macaranga spinosa Müll.Arg.	CM, DRC	SC, WC	
	Mallotus oppositifolius Müll.Arg.	CM	SC	
	Manihot esculenta Crantz	CM, DRC	SC, WC	YF, MF
	Manihot dichotoma Ule	CM	SC	YF, OF
	Manniophyton fulvum Müll.Arg.	CM	SC, WC	
	Margaritaria discoidea (Baill.) Webster	CM	SC	
	Phyllanthus amarus Schumach. & Thonn.	CM	SC, WC	
Icacinaceae	*Lavigeria macrocarpa* Pierre	CM		
Marantaceae	*Haumania danckelmaniana* (J.Braun & K.Schum.)	CM, DRC	SC	SF, PF
	Hypselodelphys violacea (Ridl.) Milne-Redh.	CM, DRC	SC, WC	
	Marantochloa sp.	CM, DRC	SC, WC	
	Megaphrynium macrostachyum (Benth.) Milne-Redh.	CM, DRC	SC, WC	
	Thalia welwitschii Ridl.	CM	SC	
	Sarcophrynium brachystachyum K.Schum.	CM, DRC	SC, WC	
	Trachyphriniom sp.	DRC		OF, SF
Musaceae	*Musa* spp	CM	SC	FF
Mimosaceae	*Acacia kamerunensis* Gand.	CM	SC	
	Albizia adianthifolia W.F.Wight	CM	SC, WC	
	Albizia ferruginea Benth.	CM	SC, WC	
	Albizia gummifera C.A.Sm.	CM	SC	
	Albizia zygia Macbride	CM	SC, WC	
	Mimosa sp.	CM	WC	
	Pentaclethra macrophylla Benth.	CM	SC, WC	
	Piptadeniastrum africanum (Hook.f.) Brenan	CM	SC, WC	
Orchidaceae	*Eulophia* sp.	CM.	WC	
Oxalidaceae	*Biophytum zenkeri* Guillaumin	CM	SC	
Fabaceae	*Abrus precatorius* L.	CM	SC	
	Arachis hypogea L.	CM	SC	YF

(*continued*)

Table 1. (*Continued*).

Family	Species	Country	Region	Vegetation type
	Baphia nitida Lodd.	CM	SC	
	Crotalaria retusa L.	CM	SC	
	Dalbergia hostilis Benth.	CM	SC WC	
	Desmodium adscendens (Sw.) DC.	CM	SC, WC	
	Duparquetia orchidacea Baill.	CM	SC	
	Indigofera sp.	CM	SC	
	Millettia laurentii De Wild.	CM	SC	
	Millettia sp. 1	CM	SC	
	Millettia sp. 2	CM	SC	
	Mucuna pruriens DC.	CM	SC	
	Mucuna sp.	CM	SC	
	Pueraria sp.	CM	WC	
	Tephrosia sp.	CM	SC	
	Trifolium sp.	CM	SC	
	Vigna sp.	CM	SC	
Poaceae	*Pennisetum purpureum* Schumach.	CM	WC	
	Olyra latifolia L.	CM		
Portulacaceae	*Talinum triangulare* Willd.	CM	SC	
Smilacaceae	*Smilax anceps* Willd.	DRC		OF, SF
	Smilax kraussiana Meisn.	CM	SC, WC	
Zingiberaceae	*Aframomum daniellii* K.Schum.	CM, DRC	SC	YF, MF, OF, SF
	Aframomum albo-violaceum K.Schum	CM	WC	
	Zingiber officinale Rosc	CM	WC	FF

SC, southern Cameroon; WC, western Cameroon; SW, southwestern Cameroon; YF, young fallow; MF, mid fallow; OF, old fallow; SF, secondary forest; PF, primary forest; FF, farmer field.

surveyed species and families, respectively. Eleven out of 16 species (68.7%) of these hosts are indigenous to Africa.

In the FMBA, 7,937 plants representing 84 species from 20 families were inspected (Table 1). The following 13 plant species were found to host at least one *S. vayssierei* individual: *Aframomum daniellii* Schum (Zingiberaceae), *Chromolaena odorata* (L.) R.M. King & H. Rob (Asteraceae), *Costus afer* Ker Gawl (Costaceae), *Cyrtosperma senegalense* Eng. (Araceae), *Dioscorea* spp. (Dioscoreaceae), *Elaeis guineensis* Jacq. (Arecaceae), *Haumania danckelmaniana* Braun & Shum (Marantaceae), *Manihot esculenta* Crantz (Euphorbiaceae), *Manihot dichotoma* Ule (Euphorbiaceae), *Musa* sp. (Musaceae), *Palisota hirsuta* K. Schum (Commelinaceae); *Talinum triangulare* Wild (Portulacaceae) and *Xanthosoma mafaffa* Schott (Araceae). Ten out of these 13 plant species are newly recorded hosts of *S. vayssierei*. *Elaeis guineensis* Jacq. (Arecaceae), *Manihot dichotoma* Ule (Euphorbiaceae) and *Musa* sp. (Musaceae) were recorded only during casual observations and on two occasions. *Elaeis guineensis* (oil palm) and *Musa* sp. (plantain) are common but difficult to sample because of their large stems and economic importance to farmers, whereas *M. dichotoma* was encountered only during casual inspections in the northern part of the FMBA, where it grows mainly on roadsides, and in the Mbalmayo forest reserve (IITA experimental station). Host plant status for *S. vayssierei* was thus confirmed for the Araceae, Asteraceae, Diocoreaceae, Euphorbiaceae, Marantaceae and Musaceae, but not for Balanophoraceae and Fabaceae. Newly recorded host families were the Commelinaceae, Costaceae, Arecaceae, Portulacaceae and Zingiberaceae.

In Southwestern Cameroon, 188 plants, consisting of 71 species from 13 families were inspected (Table 1); however, none were infested by *S. vayssierei*. In Western Cameroon, 1,015 plants consisting of 37 species from 16 families were inspected (Table 1). *Dioscorea* spp. (Dioscoreaceae) and *Zingiber officinale* Rosc (Zingiberaceae) were infested by *S. vayssierei*, but the latter, a newly identified host of *S. vayssierei*, was observed on only one occasion during a casual inspection and not during the work on the transects.

In DRC, 476 plants representing 15 species from nine families were inspected. Six species were attacked by *S. vayssierei* (Table 1). *Smilax anceps* Meisn (Smilacaceae) and *Trachyphrynium* sp. (Marantaceae) are two newly recorded host plants and Smilacaceae is a newly recorded host family for *S. vayssierei*.

Stictococcus vayssierei incidence and density were low – with only one infested plant – on *C. odorata, H. danckelmaniana, P. hirsuta* and *T. triangulare*. Incidence and density were relatively high on *A. daniellii, Co. afer, Cy. senegalense, Dioscorea* spp., *E. guineensis, M. esculenta, Musa* sp., *S. anceps, Trachyphrynium* sp., *X. mafaffa* and *Z. officinale*. Host plants with low scale density and infested with only scale crawlers were considered as casual or minor hosts, and were thus excluded from the statistical analysis. Scale incidence varied considerably among host plants found during the surveys ($\chi^2 = 516.4$, df = 5; $P < 0.001$). *Manihot esculenta* was the most frequently infested host plant, with an overall incidence level of 74.4% ($N = 177$). There was no significant difference between *Dioscorea* spp. (22.3%, $N = 104$) and *X. mafaffa* (15.0%, $N = 10$), but these two plant species were more frequently infested compared with *Co. afer* (11.6%, $N = 319$) and *A. daniellii* (11.8%, $N = 736$). Scale densities on host-plants also differed significantly ($\chi^2 = 680.75$, df = 5; $P < 0.001$). Of the host plants encountered in the survey, *Dioscorea* spp. had the highest *S. vayssierei* densities (63.1 ± 43.6 individuals per plant), followed by *M. esculenta* (28.5 ± 11.73 individuals per plant), *Co. afer* (6.33 ± 1.65), *X. mafaffa* (4.6 ± 0.0) and *A. daniellii* (4.19 ± 0.6).

Table 2 shows the relative frequency of hosts found in the various vegetation types during the survey and considered in the statistical analysis. Most of the hosts were present in young and mid-fallows and absent from old fallows and forests. *Dioscorea* spp. occurred in all surveyed vegetation types.

4. Discussion

We identified 16 *S. vayssierei* host plant species in 13 families of which 10 species and six families are newly recorded hosts for the scale. The true number of host plants would be higher if wild yams were identified to species, as wild yams diversity is known to be particularly high in West and Central Africa (Hamon et al. 1995). The majority of *S. vayssierei* host plants identified in this study (11 out of the 16) are indigenous to Central Africa. None of the inspected native plants belonging to Euphorbiaceae (14) and Fabaceae (29) was infested by *S. vayssierei*, suggesting that the scale's association with *A. hypogea* and *M. esculenta* reported by Nonveiller (1984) must be recent. In contrast, the association of *S. vayssierei* with native host species of the Araceae and Dioscoreaceae must be old and so this system has co-evolved in its native range. Moreover, wild yams are likely to have played a significant role in the ecology and evolution of *S. vayssierei* in Central Africa. We therefore recommend paying greater attention to Dioscoreaceae to understand the ecology and evolution of *S. vayssierei* and to develop management strategies for this pest. Additionnally, the interaction between *S. vayssierei* and the native members of the Musaceae still needs to be clarified since they were not encountered during our study.

The importance of wild hosts in the survival and growth of pest populations depends on their suitability for the development and production of vigorous adults (Panizzi 1997). Experiments on the development and survival of *S. vayssierei* on its wild hosts are needed to compare the suitability of these hosts for *S. vayssierei*. A close examination of the frequency of developmental stages of *S. vayssierei* on infested plants encountered during the surveys suggests that not all plants are equally suitable for this insect. Several host plants, including *C. odorata, H. danckelmaniana, P. hirsuta* and *T. triangulare*, supported only a few first instar crawlers and never adult scales, suggesting that they are casual or accidental hosts, playing at best a minor role in the ecology of *S. vayssierei.* Of particular significance, our results do not support the suggestion by Bani et al. (2003) to avoid cropping cassava after *C. odorata* fallows as a management strategy against *S. vayssierei*. Of 37 plants of *C. odorata* inspected during our survey, only one plant was found harbouring one first instar crawler. It would be indeed catastrophic if *S. vayssierei* adapts and proliferates on the roots of *C. odorata*, which dominates all disturbed humid forest landscapes in West and Central Africa.

In contrast to the plant species infested only with scale crawlers, other host plants, namely *A. daniellii, Co. afer, Cy. senegalense, Dioscorea* spp. (Dioscoreaceae), *E. guineensis, M. esculenta, Musa* spp. *S. anceps, Trachyphrynium* sp., *X. mafaffa* and *Z. officinale*, were found harbouring many individuals of all developmental stages, indicating that they are suitable host plants for the development of the scale. Although, they are not likely to be equally suitable to the scale, these host plants are expected to play a relatively important role in the ecology of *S. vayssierei* populations. Based on available data, wild yams may be most suitable for *S. vayssierei* development as they supported more scale individuals than any of the plant species encountered in non-crop vegetation; therefore they may play a more important role than previously thought in the persistence and proliferation of *S. vayssierei*. Wild yams are indeed quite common in fallows and crop fields, as farmers rarely remove them entirely during field

Table 2. Relative frequency of various hosts of the African root and tuber scale (ARTS) identified during surveys in various vegetation types found in the forest margin in southern Cameroon.

Vegetation type	Plant species				
	Aframomum daniellii	*Costus afer*	*Dioscorea* spp.	*Manihot esculenta*	*Xanthosoma mafaffa*
Young fallows	0.33 (69)	0.25 (53)	0.14 (30)	0.22 (46)	0.06 (13)
Mid fallows	0.43 (316)	0.32 (239)	0.07 (52)	0.18 (131)	0.00 (0)
Old fallows	0.88 (173)	0.06 (11)	0.06 (12)	0.00 (0)	0.01 (1)
Secondary forests	0.88 (174)	0.08 (16)	0.04 (8)	0.00 (0)	0.00 (0)
Primary forests	0.44 (4)	0.00 (0)	0.56 (5)	0.00 (0)	0.00 (0)
All vegetation	0.54 (736)	0.24 (319)	0.08 (107)	0.13 (177)	0.01 (14)

Numbers in parentheses are the frequency of each host plants in each of the vegetation types.

Table 3. African root and tuber scale densities, frequency of infestation, and reservoir index value for the five scale hosts encountered in various vegetation types found in the forest margin in Southern Cameroon.

Vegetation type	*Aframomum daniellii*	*Costus afer*	*Dioscorea* spp.	*Manihot esculenta*	*Xanthosoma mafaffa*
			Scale densities/plant		
Young & mid-fallows	3.79	5.29	28.5	28.5	4.67
Old fallows	3.82	2.33	0.00	0.00	0.00
Forests	5.57	0.00	29.0	0.00	0.00
			Frequency of infested plants		
Young & mid-fallows	4.80	13.5	25.0	81.1	33.3
Old fallows	16.0	1.35	0.00	0.00	0.00
Forests	4.86	0.00	27.8	0.00	0.00
			Reservoir index		
Young & mid-fallows	0.01	0.02	0.21	0.71	0.05
Old fallows	0.95	0.04	0.00	0.00	0.00
Forests	0.03	0.00	0.96	0.00	0.00

Reservoir index is calculated as the product of host plant frequency and scale density in each vegetation type, each divided by the sum of all products.

preparation due to the large size of their stems (M. Tindo pers. obs). This might explain why yams were present in all vegetation types, contrasting with volunteer cassava which decreases in frequency with increasing fallow length and completely disappears in the fallow vegetation after eight years (old fallows).

Our results show considerable variation in both host plant frequency and scale density on these plants in various vegetation types found in *S. vayssierei* environment in Central Africa. While some host plants like *A. daniellii* were considerably more abundant than all other plants, *A. daniellii* supported the least number of scales. By contrast, yams were much less abundant than all hosts except *X. mafaffa*, yet they supported the highest scale densities per sampled plant. To obtain a clearer measure of the relative overall significance of these plants as reservoir hosts for the scale in non-crop vegetation, we calculated a 'reservoir index' (RI) using the product of scale density and frequency of infested host in each vegetation type. This reservoir index was normalized by dividing the resulting product of each host by the sum total of the products of all five hosts (Table 3). The resulting RI provides a much clearer assessment of the potential role of the five main host plants in each vegetation type. Cassava, while supporting almost the same number of scale as yams in young and mid fallows, is nearly four times more important than yams as reservoir for the scale because of the combined effects of frequency and scale density. *Aframomum daniellii* and yams are more important in old fallows and forest, respectively. The information on RI highlighted volunteer cassava as the most important reservoir for the scale in non-crop vegetation, particularly in young and medium-aged fallows.

Knowledge of wild or non-cultivated host-plants is an important step in developing integrated pest management strategies. Depending on pests feeding behaviour, it can be manipulated in various ways to reduce pest population growth (Panizzi 1997). Host plants can be used as trap crops or may be selectively destroyed, especially when they belong to the same species as the targeted cultivated crops (Panizzi 1997). Trap-cropping is an option that has been more intensively explored than removal and destruction of residual host plants (see Shelton and Badenes-Perez 2006 for review), but it is unlikely to be useful for *S. vayssierei* management due primarily to the close association of *S. vayssierei* with ants, particularly *Anoplolepis tenella* Santschi (Dejean and Matile Ferrero 1996; Fotso Kuate et al. 2008). This ant facilitates scale dispersal (by selectively transporting first instar scales to new plants), rendering a trap crop as a source of scale infestation of the newly planted crop (e.g. cassava). For this reason, host destruction and removal is likely to be more useful in *S. vayssierei* management than trap-cropping. Host destruction and removal has been explored with encouraging results for *S. vayssierei* management (IITA, 2009).

Acknowledgements

This study was supported financially by special project funds provided to IITA by the International Fund for Agricultural Development (IFAD), and on Biodiversity research by the Austrian Government. We thank two anonymous referees for their critical review of an earlier version of the manuscript and the editor for his careful editorial assistance.

References

Ambe JT, Ntonifor NN, Awah ET, Yaninek JS. 1999. The effect of planting dates on the incidence and population dynamics of the cassava root scale, *Stictococcus vayssierei*, in Cameroon. Int J Pest Manage. 45:125–130.

Bani G, Mapangou Divassa S, Nzemba MD, Magem JM. 2003. Présence au Congo-Brazzaville de *Stictococcus*-vayssierei Richard, ravageur du manioc (*Manihot esculenta* Crantz) (Hem., Stictococcidae). Bull Soc Entomol Fr. 108:495–529.

Buckley RC. 1987. Ant-plant-homoptera interaction. Adv Ecol Res. 16:53–85.

Dejean A, Matile-Ferrero D. 1996. How a ground-dwelling forest ant species favors the proliferation of an endemic scale insect (Hymenoptera: Formicidae; Homoptera: Stictococcidae). Sociobiology. 28:183–195.

Flatt T, Weisser WW. 2000. The effects of mutualistic ants on aphid life traits. Ecology. 81:3522–3529.

Fotso Kuate A, Tindo M, Hanna R, Kenne M, Goergen G. 2008. Foraging activity and diet breath of the ant *Anoplolepis tenella* Santschi in southern Cameroon. Afr Entomol. 16:107–114.

Gockowski J, Tonye J, Baker D, Weise SF, Tiki-Manga T, Ndoumbe M. 1998. Characterisation and diagnosis of agricultural systems in the alternatives to slash-and-burn forest margins benchmark of Southern Cameroon. IITA/IRAD. ASB Report Phase II. Yaoundé, Cameroon. p. 28.

Hamon P, Dumont R, Zoundjihekpon J, Tio-Touré B, Hamon S. 1995. Wild yams in West Africa. Morphology characteristics. Orstom, Paris. p. 84.

IITA. 2009. Scaling down ARTS. In: IITA Annual Report 2008/9. International Institute of Tropical Agriculture, Ibadan Nigeria. p. 10–11.

Ngeve JM. 2003. The cassava root mealybug (*Stictococcus vayssierei*) (Homoptera: Stictococcidae): a threat to cassava production and utilization in Cameroon. Int J Pest Manage. 49:327–333.

Nonveiller G. 1984. Catalogue des insectes du Cameroun d'intérêt agricole. Institut pour la protection des plantes, Mémoires XV, Beograd. p. 210.

Pannizi AR. 1997. Wild host of Pentatomids: Ecological significance and role in their pest status. Annu Rev Entomol. 42:99–122.

Richard C. 1971. Contribution à l'étude morphologique et biologique des Stictoccocinae (Hom. Coccoidea). Ann Soc Entomol Fr. (n.s.). 7:571–609.

Richard C. 1976. Révision du groupe des *Stictococcus*, et création de taxa nouveaux (Homoptera, Coccoidea). Ann Soc Entomol Fr. (n.s.). 12:653–669.

SAS Institute Inc. 2000. SAS Technical Report P-243, SAS/STAT Software: The GENMOD Procedure, Release 8.02. Cary (NC).

Shelton AM, Badenes-Perez FR. 2006. Concepts and application of crop trapping in pest management. Annu Rev Entomol. 51:285–308.

Tata Hangy K, Hanna R, Toko M, Lema KM, Solo M. 2006. Changes in population abundance of the African root and tuber scale *Stictococcus vayssierei* Richard (Homoptera; Stictococcidae) on cassava in the bas-fleuve district in the Democratic Republic of Congo. In: Mahungu NM, Manyong VM, editors. Advances in Root and Tuber Crops Technologies for Sustainable Food Security, Improved Nutrition, Wealth and Environmental Conservation in Africa. Proceedings of 9th ISTRC-AB symposium Mombassa, Kenya. p. 574–582.

The International Plant Names Index. 2008. Published on the Internet. http://www.ipni.org [accessed in March 2008].

Zapfack L. 2005. Impact de l'agriculture itinérante sur brûlis sur la biodiversité végétale et la séquestration de carbone. Thèse d'Etat. Yaoundé, Université de Yaoundé I. p. 225.