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Insect herbivores and pathogens of *Alnus* species in Uganda

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Abstract

Published documentation of insect pests and pathogens associated with *Alnus* species in Africa is very scarce. We surveyed damaging insects and pathogens, and arthropod natural enemies on *Alnus acuminata* and *A. nepalensis* in Kabale and Mbale districts, Uganda between March 1999 and August 2000 in order to identify the range and relative abundance of arthropods and pathogens associated with the *Alnus* species. Frequently encountered damaging insects on the *Alnus* species included *Apis mellifera, Apion globulipenne*, a *Systates* sp. (Coleoptera: Curculionidae), *Phymateus viridipes*, a *Lobotrachelus* sp. (Coleoptera: Curculionidae), *Coloborrtics corticina* and some Chrysomelidae. Some species such as *Aphis fabae, Parastictococcus multispinosus* and a *Cacopsylla* sp. (Homoptera: Psyllidae) were observed feeding on other agroforestry tree species and/or crops although they generally occurred at low population intensities. Spiders and parasitic Hymenoptera were the most common natural enemies. Diseases were more severe in nurseries than in the field. Damping-off caused by *Fusarium oxysporum, Septoria* brown leaf spot and stem canker were the most serious diseases of *Alnus*. The array of damaging insects and pathogens indicates a potential danger to the cultivation of *Alnus* species in Uganda as adoption of the species for agroforestry continues to expand in the country. In view of the increasing demand for *Alnus* species for agroforestry in Uganda, regular pest monitoring and appropriate control strategies are necessary.

Introduction

Insect pest and disease interactions in agroforestry systems are relatively poorly studied (Sileshi et al. 2000) and the literature on the insects and pathogens associated with agroforestry tree species is limited (Liping 1991; Singh-Rathore 1995; Day and Murphy 1998; Schroth et al. 2000; Rao et al. 2000). Day and Murphy (1998) and Boa (1998) emphasised the need for studying pests in agroforestry systems in order to devise preventive rather than curative measures.

Alnus species, particularly *A. acuminata* HBK and *A. nepalensis* D. Don. have proven suitable for highland agroforestry in several tropical countries (National Research Council 1980; Neil 1997; van Houten 1997). Studies on pest infestations on these *Alnus* species have mainly been conducted in their native range in Central America and Asia respectively. Such studies have shown the presence of insects and pathogens as major pests (Cornelius and Masis 1995; Cornelius et al. 1996; Pradhan 1997; Raman 1998), minor pests (Maity and Chakrabarti 1980) or beneficial as natural enemies (Phaloura et al. 1992) on the *Alnus* species. For example, *A. nepalensis* recently suffered from defoliation due to *Gazalina chrysolopha* Kollar (Notodontidae) up to 100% in Bhutan (Raman 1998). *Scolytodes alni* (Scolytidae) is a common borer of *A. acuminata* in Costa Rica (Russo 1995; Gamboa and Reggio 1991; Cornelius and Masis 1995; Cornelius et al. 1996). Similarly, damping-off and leaf spot are prevalent diseases of *A. acuminata* in Costa Rica (Russo 1995) and *A. nepalensis* in India and Nepal (Adhikari and Manadhar 1989; Mahendra-Pradhan and Pradhan 1996; Pradhan 1997). As these examples

indicate, published reports on pest problems on *A. acuminata* and *A. nepalensis* are not only from a limited geographical range, but have often been based on single pest species or observations based on single field visits. Such studies may not give a complete picture of the range of potential pests associated with a given plant species. Boa and Bentley (1998) pointed out that many insects that feed on trees may not attain pest status, but collectively they may not be dismissed as insignificant, hence the emphasis on tree health rather than on any single pest or disease.

Knowledge of the insects and pathogens inhabiting *A. acuminata* and *A. nepalensis* in Africa is particularly scarce. This is in spite of considerable attention being paid to the expansion of these *Alnus* species for highland agroforestry in several African countries, including Uganda (van Houten 1997). Two *Alnus* species, *A. acuminata* and *A. nepalensis*, are presently cultivated in Uganda mainly under alley system as overstorey trees and in rotational woodlots. The *Alnus* species are priority agroforestry woody species to farmers particularly in the Kigezi highlands. They provide the much-needed fuelwood and stakes for climbing beans while the main stem is left to develop into pole or timber (van Houten 1997). In addition, the *Alnus* species are important for fixing atmospheric nitrogen and are well suited for improving soil fertility, restoration of degraded land and for protection of watershed (Russo 1995; Neil 1997).

Although *Alnus* species are relatively recent introductions to Uganda (Okorio et al. 1994), Maiteki and Owera (1996) and Roux (1999) reported, through single visit surveys, characteristic damage marked by 'leaf perforations' and brown leaf spots as serious pest problems on *A. acuminata* in the country. However, these authors did not identify the causal insect/pathogen species of these symptoms, but recommended an urgent need to do so. Severe brown leaf spots reduce the growth rate and survival of *A acuminata* and *A. nepalensis* seedlings both in the nursery and in the field (Maiteki and Owera 1996; Nyeko 2001). Nyeko (2001) discovered *Apis mellifera* as the main cause of leaf perforations on *A. acuminata* in Uganda. Severe defoliation have been shown to reduce the growth rate and nodulation of *Alnus* trees (Nyeko 2001). However, there remains a general lack of awareness on potential insect pests and pathogens that infest *Alnus* species in Uganda despite pest hazards on these important multipurpose tree species. This study was undertaken to identify the range and relative abundance of herbivorous insects and pathogens, and their natural enemies on *Alnus* species in Uganda. Specifically, we wanted to collect, identify and characterise the arthropods and pathogens associated with *Alnus* species in Uganda. Identification and characterization of insects and pathogens prevailing over a range of sites reveals the range of species occurring on *Alnus* and provide the necessary information to develop control strategies (Stone et al. 1998).

Materials and methods

The study area

Biological surveys of the incidence of arthropods and pathogens on *A. acuminata* and *A. nepalensis* were conducted between March 1999 and August 2000 in Mbale and Kabale districts in Uganda where the *Alnus* species have proven suitable for agroforestry. Kabale district lies in south western Uganda, dominated by conical shaped interlocking hills (the Kigezi highlands) at approximately 2000 m above sea level extending over an area of 1,827 km^2. The pattern of annual rainfall in the district is bimodal, with peaks in March and April, and October and November, and ranges between 1,000 mm to 1,480 mm per annum. As the rainfall is bimodal, two dry seasons intervene the rainy seasons. The mean monthly temperature averages 17.5 °C, and sometimes drops to about 10 °C at night. The natural vegetation in Kabale district includes bamboo forest and afro-alpine shrubs, but intense human activity in the district is steadily changing the vegetation (Rwabwoogo 1997). The major crops grown in Kabale district include sweet potatoes (*Ipomoea batatas* L.), irish potatoes (*Solanum tuberosum* L.), sorghum (*Sorghum bicolour* (L.) Moench), maize (*Zea mays* L.), beans (*Phaseolus vulgaris* L.) and vegetables. Mbale district is in eastern Uganda at an altitudes ranging between 1,299 m and 1,524 m above sea level with an area of 2,546 km^2. The temperature in the district is modified by altitude, and varies between 18 °C to 32 °C for the coolest and the warmest months of the year. As in Kabale district, rainfall in Mbale district is bimodal with two intervening dry seasons. Rainfall in the district peaks in April and May, and August and September, and may reach up to 1,191 mm per annum. Vegetation includes bamboo forests and some giant afro-alpine groundsels and lobelias on Mount Elgon (Rwabwoogo 1997). The major crops cultivated in Mbale district include

beans (*Phaseolus vulgaris* L.), maize (*Zea mays* L.), groundnuts (*Arachis hypogaea* L.), sweet potatoes (*Ipomoea batatas* L.), cassava (*Manihot esculenta* Crantz), bananas (Musa species), sorghum (*Sorghum bicolour* (L.) Moench), yams (*Dioscorea* species), arabica coffee (*Coffea arabica* L.), cotton (*Gossypium hirsutum* L.) and vegetables.

The surveys in Mbale district were conducted in Bulago and Busano sub-counties, and the Forestry Resources Research Institute's (FORRI) peri-urban seed orchard and experimental trials. These were the only sites where *A. acuminata* was available in the district and no *A. nepalensis* was observed in the district during the period of this study. The sites were each visited in March and June 1999, and January, April and July 2000. Thus covering three dry (January, June and July) and two wet (March and April) periods in the district. A total of 15 sites were surveyed in the district. In Kabale district the surveys were more extensive and were often conducted simultaneously with pest population dynamic studies and socio-economic surveys reported elsewhere (Nyeko 2001). In total, 72 farmers' fields and experimental trials belonging to the agroforestry research networks for Africa (AFRENA), and three nurseries were surveyed in the district between March 1999 and August 2000.

Sampling procedures and identification of specimens

The surveys focused on diurnal herbivorous insects, their natural enemies and pathogens. During the surveys, *Alnus* trunks, branches, foliage and roots were inspected for insect and disease damage, and signs of pathogens and arthropods. *Alnus* roots were examined only when below ground symptoms of infestation were anticipated. Arthropods were either handpicked or sampled using a beating tray. In the latter case, branches were carefully approached and held over a 100 cm × 75 cm tray. The branches were then beaten, and any fallen arthropods collected using an aspirator. Thereafter, the foliage was thoroughly searched for any remaining arthropods that were picked by hand. Being delicate, Lepidoteran larvae were collected by severing the plant parts on which they were found and putting each individual separately in a ventilated metallic dish for rearing. Arthropods were sorted into orders and species codes within 1–3 days after collection. Where possible immature insects were reared to adult stages for identification by feeding them on the foliage of the *Alnus* species from which they were collected. In addition, larvae were reared in the laboratory in order to allow for the possibilities of parasitoid emergence. All arthropod samples were stored in labelled vials under 99.7% alcohol and later taken for identification at Kawanda Agricultural Research Institute (KARI), Uganda. However, identification of samples to species level was incomplete because of limited reference collection at KARI. Unidentified insects were assigned species codes and lodged at the Faculty of Forestry and Nature Conservation, Makerere University, Uganda for future identification and reference. The determination of the phytophagous status of sap-sucking insects and most natural enemies was unequivocal. However, chewing species were provided with fresh *Alnus* leaves for five days in the laboratory to ensure that the insects feed on the *Alnus* species.

Disease samples were collected in Petri dishes and cultured in the laboratory to enable pathogen identification. This was undertaken at Makerere agricultural research institute, Kabanyolo, Uganda and CABI Bioscience, UK. In addition, pathogenicity tests were conducted at the AFRENA research station, Kabale district. Only four fungal species, a *Septoria* sp., *Pestolatiopsis* sp., *Butrytis* sp. and *Cladosporium* sp. were tested for pathogenicity on *A. acuminata* because of their association with prevalent *Alnus* foliar damage. *Alnus* seedlings used in the pathogenicity test were raised in a greenhouse for four months, after which 12 seedlings were transferred to each of five 1 m^3 greenhouse cubicles. A total of four fungal isolates, one of each species, collected from *A. acuminata* leaves were used in the pathogenicity test. The mycelia, cultured on potato dextrose agar (PDA) growth medium, were introduced into the seedlings in four cubicles by slitting three leaf midribs per seedling using a scalpel. An additional inoculation was made by placing the mycelia into a slit made on the stem of the seedling. After placing the mycelia into the slits, the seedling was immediately covered with a white polythene bag to maintain moisture that may be necessary for the establishment of the fungi. Seedlings in one cubicle were used as controls. The leaf midribs and stems of the control seedlings were similarly slit, but no mycelium introduced in them. The polythene bags were removed 24 hours after inoculation. Seedlings were kept in the greenhouse cubicles for three weeks after which they were assessed for disease symptoms. Diseased leaf samples were sent to CABI Bioscience, UK for confirmation of the identity of the pathogen.

No attempt was made to quantify population densities of the various arthropod and pathogen species encountered. However, the occurrence of insects and diseases were qualitatively ranked as low, moderate and high by evaluating both the constancy and relative abundance of species or damage symptoms observed. Therefore data processing mainly involved simple tabulation and description of observations.

Results

Arthropods

Overall, insect species inhabiting *A. acuminata* and *A. nepalensis* were similar although fewer insect species were recorded on the latter tree species (Tables 1 and 2). However, there was evidence of preference for one or other of the 2 *Alnus* species by some damaging agents. *Apion globulipenne* and a *Lobotrachelus* sp., in particular occurred more frequently on *A. nepalensis* than *A. acuminata*. In contrast, *Apis mellifera* occurred more frequently on *A. acuminata* than on *A. nepalensis*. Similar insect species were recorded on *A. acuminata* in Mbale and Kabale districts, although fewer insect species were encountered in the former than the latter district.

Chewing insects belonging to Coleoptera constituted most of the herbivorous insect recorded (Table 1). Frequently recorded species of this order on the *Alnus* species included *A. globulipenne, Haltica pyritosa*, a *Lobotrachelus* sp. and an unidentified *Chrysomelidae* (Coleopt. 27). Orthoptera and Lepidoptera were less often encountered, as were Isoptera. However, some species in these orders, notably *Phymateus viridipes* and *Conchotopoda leggei* (Orthoptera), and unidentified Geometridae (Lepidopt. 2) and Psychidae (Lepidopt. 7) were observed feeding voraciously on the *Alnus* species. Commonly observed species of sucking insects included *Coloborrtics corticinia, Aphis fabae*, a *Cacopsylla* sp., and species of Pentatomidae including *Atelocera raptoria, Glypsus vigil*, a *Cyclopelta* sp., a *Dinidor* sp. and *Macrorhapis spurcata. A. mellifera* caused the most conspicuous and prevalent insect damage, leaf perforation, particularly on *A. acuminata* (Nyeko 2001).

A number of insect herbivores encountered on the *Alnus* species were also observed on a range of plant species including herbaceous weeds, field crops, shrubs and trees. Of particular importance were *Aphis fabae*, a serious pest of beans (*Phaseolus vulgaris*) in the country, *Parastictococcus multispinosus* and a *Cacopsylla* sp. observed causing serious localized damage to *Grevillea robusta* and *Prunus africana* respectively in Kabale district during this study. *H. pyritosa* was observed seriously defoliating a weedy *Commelina* sp. and to a much lesser extent, sweet potato and newly introduced apples in Kabale district. These observations are indicative that the *Alnus* species were colonized by several generalist insect herbivores, many, if not all, of which are probably native to Uganda.

Parasitism by natural enemies was not established in field and laboratory studies. However, literature (especially Borror et al. (1989)) was used to establish their general feeding habits. The most commonly encountered natural enemies were spiders and parasitic Hymenoptera. Other natural enemy groups included predatory Coleoptera (Coccinellidae and Staphylinidae), Hemiptera (Reduviidae), Mantodea and Neuroptera (Table 2). Of the Lepidoptera larvae raised in the laboratory, only one (Lepidopt. 2) was found to be parasitised. The parasitoid that emerged from the larva was an unidentified species of Braconidae (Hymenopt. 21). Identification of spiders was not possible due to lack of reference collection and taxonomic expertise at KARI.

Diseases

Several diseases were observed on the *Alnus* species, both in nursery and on mature trees in the field (Table 3). Three diseases, including damping-off, brown leaf spot and wilt were observed on *Alnus* seedlings in nurseries. Damping-off was prevalent on both *A. acuminata* and *A. nepalensis* in sowing beds or trays. Infected seedlings developed water-soaked lesions at the stem base, which soon dried, and the seedling toppled. Infection started as small circular patches that eventually spread into bigger patches of dead seedlings. The pathogen consistently isolated from infected seedlings was *Fusarium oxysporum* Schlect.

Brown leaf spot was the most prevalent disease of *Alnus*, attacking *A. acuminata* and *A. nepalensis* both in nurseries and field conditions. This disease appears as reddish-brown spots, sometimes turning dark-brown, that may be restricted or may rapidly form irregular blotches extending from the leaf apex or leaf margin to the midrib causing local leaf distortions. The spots are visible from both the adaxial and abaxial leaf surfaces albeit less distinct from the latter. The pathogenicity test confirmed a *Septoria* sp. as the

Table 1. The range and occurrence of insect herbivores encountered on *Alnus acuminata* and *A. nepalensis* in Kabale and Mbale districts, Uganda.

Insect	Family	Nature of damage	Kabale District		Mbale District
			A.acuminata	*A. nepalensis*	*A. acuminata*
Coleoptera					
Anthicus sp.	Anthicidae	Nibbles leaves	+ +	+ +	+ +
Unidentified (Coleopt. 41)	Anthribidae	Eats seeds	+	+	–
Apion globulipenne	Apionidae	Nibbles leaves	+ +	+ + +	+ +
Phaeocylotomus sp.	Cleridae	Defoliator	+	–	+
Euleptus sp.	Carabidae	Defoliator	+	+	–
Apomecyna binubila	Cerambycidae	Bores into wood?	+	+	–
Sothronica grisea	Cerambycidae	Bores into wood?	+	+	–
Unidentified (Coleopt. 64)	Cerambycidae	Bores into wood?	+	–	–
Haltica pyritosa	Chrysomelidae	Nibbles leaves	+ +	+	+
Aspidomorpha tecta	Chrysomelidae	Nibbles leaves	+	+	+
Hyperacantha senegalensis	Chrysomelidae	Nibbles leaves	+ +	+ +	+
Unidentified (Coleopt. 2)	Chrysomelidae	Nibbles leaves	+ + +	+ + +	+
Monolepta apicalis	Chrysomelidae	Nibbles leaves	+ +	+ +	+ +
Monolepta sp.	Chrysomelidae	Nibbles leaves	+	–	–
Hyperacantha pallipes	Chrysomelidae	Nibbles leaves	+	+	–
Megaleruca sp.	Chrysomelidae	Nibbles leaves	+	–	–
Unidentified (Coleopt. 16)	Chrysomelidae	Nibbles leaves	+ +	–	+
Unidentified (Coleopt. 19)	Chrysomelidae	Nibbles leaves	+ +	+	+
Unidentified (Coleopt. 22)	Chrysomelidae	Nibbles leaves	+ +	+	+
Unidentified (Coleopt. 25)	Chrysomelidae	Nibbles leaves	+ +	+ +	+
Unidentified (Coleopt. 27)	Chrysomelidae	Nibbles leaves	+ + +	+ + +	+ +
Dactylispa sp.	Chrysomelidae	Nibbles leaves	+	+	+
Systates sp.	Curculionidae	Defoliator	+ +	+	+
Myllocerus nemorusus	Curculionidae	Nibbles leaves	+	+	–
Alcides crassirostris	Curculionidae	Defoliator	+	+	+
Lixus pingaerostris	Curculionidae	Defoliator	+	+	–
Phylaitis caffer	Curculionidae	Defoliator	+	–	–
Lobotrachelus sp.	Curculionidae	Nibbles leaves	++	+ + +	+ +
Chrysolagria ugandica	Lagriidae	Nibbles leaves	+	+	+
Derolagria sp.	Lagriidae	Defoliator	+ +	+ +	–
Unidentified (Coleopt. 7)	Lagriidae	Nibbles leaves?	+ +	+ +	+
Hemiptera					
Serinetha aethiops	Coreidae	Suck sap	+	–	+
Plectrocnema bicolor	Coreidae	Suck sap	+	–	–
Camtobrochis sp.	Miridae	Suck sap	+	+	–
Notostira sp.	Miridae	Suck sap	+	+	–
Atelocera raptoria	Pentatomidae	Suck sap	+ +	+	+ +
Glypsus vigil	Pentatomidae	Suck sap	+ +	+	+ +
Cyclopelta sp.	Pentatomidae	Suck sap	+ +	+	+ +
Dinidor sp.	Pentatomidae	Suck sap	+ +	+	+ +
Macrorhapis spurcata	Pentatomidae	Suck sap	+ +	+	–
Plinachtus fuscescens	Pentatomidae	Suck sap	+	–	–
Piezodorus pallescens	Pentatomidae	Suck sap	+	+	+
Unidentified (Hemipt. 27)	Tangidae	Suck sap	+ +	+ +	–

Table 1. Continued.

Insect	Family	Nature of damage	Kabale District		Mbale District
			A.acuminata	*A. nepalensis*	*A. acuminata*
Homoptera					
Aphis fabae	Aphididae	Suck sap	+ +	+ +	+
Unidentified (Homopt. 16)	Aphididae	Suck sap	+ +	+	−
Oxyrhachis tuberculatus	Membracidae	Suck sap	+	−	+
Leptocentrus ugandensi	Membracidae	Suck sap	+	+	+
Monocentus leighi	Membracidae	Suck sap	+	+	+
Coloborrtics corticina	Jassidae	Suck sap	+ + +	+ +	+ +
Dagama sp.	Jassidae	Suck sap	+	−	+
Cicadulina mbira	Jassidae	Suck sap	+	+	−
Tettigoniella mitrata	Jassidae	Suck sap	+	+	−
Unidentified (Homopt. 8)	Cercopidae	Suck sap	+	−	+
Parastictococcus multispinosus	Stictococcidae	Suck sap	+	−	+
Cacopsylla sp.	Psyllidae	Suck sap	+ +	−	−
Thysanoptera					
Unidentified (Thysanopt. 1)	Thripidae	Suck sap	+ +	+ +	+ +
Unidentified (Thysanopt. 2)	Thripidae	Suck sap	+ +	+ +	+ +
Orthoptera					
Faureia milanjica	Acrididae	Nibbles leaves	+	−	−
Phymateus viridipes	Acrididae	Skeletonize leaves	+	+	+
Phymateus sp. (?)	Acrididae	Skeletonize leaves	+	+	+
Acanthacris ruficornis	Acrididae	Defoliator	+	+	+
Auloserpusia sp.	Acridiidae	Defoliator	+	+	−
Gryllus sp.	Gryllidae	Eats leaves/shoots			
Plangia sp.	Tettigoniidae	Nibbles leaves	+	+	−
Conchotopoda leggei	Tettigoniidae	Defoliator	+	+	+
Vescanthus pellucens	Tettigoniidae	Nibbles leaves	+	+	+
Oedaleus sp.	Tettigoniidae	Defoliator	+	+	−
Lepidoptera					
Unidentified (Lepidopt. 1)	Geometridae	Defoliator	+	+	−
Unidentified (Lepidopt. 2)	Geometridae	Defoliator	+	+	+
Unidentified (Lepidopt. 4)	Lasiocampidae	Defoliator	+	+	+
Unidentified (Lepidopt. 5)	Lasiocampidae	Defoliator	+	+	+
Unidentified (Lepidopt. 3)	Noctuidae	Defoliator	+	+	−
Unidentified (Lepidopt. 6)	Noctuidae	Defoliator	+	−	−
Unidentified (Lepidopt. 7)	Psychidae	Defoliator	+	+	+
Unidentified (Lepidopt. 8)	Psychidae	Defoliator	+	+	−
Hymenoptera					
Apis mellifera	Apidae	Perforates leaves	+ + +	+	+ +
Myrmicaria eumenoides	Formicidae	Seed feeder	+	+	+
Unidentified (Hymenopt. 6)	Tethredinidae	Feeds on leaves	+	+	−
Diptera					
Unidentified (Hymenopt. 5)	Mycetophilidae	Feeds on flowers	+	−	−

Table 1. Continued.

Insect	Family	Nature of damage	Kabale District		Mbale District
			A.acuminata	*A. nepalensis*	*A. acuminata*
Dermaptera					
Unidentified (Unknown 34)	Forficulidae	Nibbles leaves	+	–	–
Psocoptera					
Unidentified (Pscopt. 1)	Polypsocidae	Nibbles leaves/pollen	+ +	+ +	+ +
Unidentified (Pscopt. 2)	Polypsocidae	Nibbles leaves/pollen	+	+	+
Isoptera					
Unidentified (Isopt. 1)	Termitidae	Eats roots and stem	+	–	+

+, low; ++, moderate; +++, high; ?, not confirmed; names in brackets are species codes referring to unidentified specimens. Sample specimens for all species are lodged at the Faculty of Forestry and Nature Conservation, Makerere University.

cause of the disease. The conidial dimensions (48–60 × 1.5 μm) of isolations made from the inoculation experiment were significantly longer than the conidia of isolations of *Septoria alni* made from field *A. acuminata* leaf samples (32 × 1.5 μm). Due to the much needed review of the genus *Septoria* (C. Ellison, pers. comm., 2000) it could not be confirmed whether the *Septoria* from the inoculation experiment was *Septoria alni* Sacc.

Septoria brown leaf spot was more severe in the nursery than in the field. It occurred in all the three nurseries visited in Kabale district infecting up to 100% of *Alnus* seedlings observed, particularly in the wet season. The disease was more prevalent on *Alnus* trees in Kabale than in Mbale district probably because of the more extensive cultivation of *Alnus* in the former with seedlings largely obtained from already infected nurseries. In addition, the generally cooler weather in Kabale probably offers more favourable conditions for the spread of the pathogen in the district.

Another disease on *Alnus* seedlings in nursery was wilt that was observed on both *A. acuminata* and *A. nepalensis* seedlings at AFRENA nursery and on field *A. acuminata* seedlings in Rwene, Kabale district. In the nursery the disease occurred on potted seedlings. Infected seedlings developed drooping leaves, starting from the tip of the seedling, and the whole seedling dried up a few days later. The primary pathogen consistently identified from the nursery specimens was *Fusarium oxysporum* Schlecht. *F. equiseti* (Corda) Sacc., a probable saprophyte, was also isolated. Seedling wilt was rare in the nursery, but it is potentially devastating as infected seedlings often die. In Rwene, several *A. acuminata* seedlings at an AFRENA fallow trial wilted after about a year of outplanting. Isolated pathogens from disease specimens from this site included *F. oxysporum* (from roots), a *Pestalotiopsis* species (from stems and leaves) and a *Butrytis* species (from leaves). This suggests that the observed wilting of *Alnus* seedlings in the field was a result of infections from a complex of pathogens. However, the inoculation experiment with *Pestalotiopsis* sp., *Butrytis* sp. and *Cladosporium* sp. did not produce any disease symptoms on the *Alnus* seedlings, suggesting that these fungi are secondary invaders on *Alnus*. The isolation of *F. oxysporum* from both nursery and field specimens is not only indicative of the wide distribution of the fungus in Kabale, but also the ability of the fungus to infest older *Alnus* seedlings in the field.

Small black leaf spots (1–2 mm in diameter) were fairly common on field trees in Kabale, but were not observed in Mbale district. *Alternaria alternata* (Fr.) Keissl. was isolated from diseased samples. The fungus is extremely saprophytic, but some isolates can also be pathogenic (C. Ellison, pers. comm., 2000). It is thus likely to be the primary cause of the black leaf spots observed on *Alnus*. Another field disease on *Alnus* was stem canker, observed on saplings and mature *A. acuminata* trees in both Kabale and Mbale districts. The canker occurred mainly within 2 m of tree trunk base, characterised by bark cracks and slight swellings. Some infected trees gradually dried up, but a few were observed sprouting afterwards. The primary pathogen isolated was *Rhizoctonia solani* Kühn., a soil borne pathogen. An indeterminate *Diplodia* sp., a *Fusicoccum* sp., *Pestalotiopsis guepi-*

Table 2. The range and occurrence of insect natural enemies encountered on *Alnus acuminata* and *A. nepalensis* in Kabale and Mbale districts, Uganda.

Insect	Family	Role	Kabale District		Mbale District
			A. acuminata	*A. nepalensis*	*A. acuminata*
Coleoptera					
Halyzia variegata	Coccinellidae	Predator	+ +	+ +	+
Platynaspis marginata	Coccinellidae	Predator	+	+	+
Alesia aurora	Coccinellidae	Predator	+	+	+
Epilachna annulata	Coccinellidae	Predator	+	+	+
Chilomenes lunata	Coccinellidae	Predator	+	+	+
Unidentified (Coleopt. 55)	Lampyridae	Larvae predaceous	+	−	−
Lathrobium sp.	Staphylinidae	Predator/parasite?	+	+	−
Unidentified (Coleopt. 62)	Staphylinidae	Predator/parasite?	+	+	−
Hemiptera					
Harpactor onatellus	Reduviidae	Predator	+	+	−
Platymeris biguttata	Reduviidae	Predator	+	−	−
Hymenoptera					
Unidentified (Hymenopt. 21)	Braconidae	Parasite of insects	+	+	−
Unidentified (Unknown 4)	Braconidae	Parasite of insects	+	+	−
Podagron sp.	Chalcididae	Parasite of insects	+	+	−
Eupelma sp.	Chalcididae	Parasite of insects	+	+	−
Unidentified (Unknown 3)	Chalcidoidae	Parasite of insects	+ + +	+ +	+ +
Unidentified (Hymenopt. 20)	Evaniidae	Parasite of insects	+	+	−
Camponotus species	Formicidae	Predator	+	+	+
Unidentified (Unknown 31)	Formicidae	Predator	+	+	+
Unidentified (Unknown 10)	Ichneumonidae	Parasite of insects	+	+	−
Pimpla calliphora	Ichneumonidae	Parasite of insects	+	+	−
Dentichasmias busseola	Ichneumonidae	Parasite of insects	+	+	−
Hemicospilus vecors	Ichneumonidae	Parasite of insects	+	+	−
Unidentified (Unknown 23)	Ichneumonidae	Parasite of insects	+ +	+ +	+
Unidentified (Hymenopt. 7)	Ichneumonidae	Parasite of insects	+	+	−
Unidentified (Hymenopt. 12)	Ichneumonidae	Parasite of insects	+	+	−
Unidentified (Hymenopt. 16)	Scelionidae	Parasite of arthropods	+	+	−
Unidentified (Hymenopt. 3)	Siricoidea *	Parasite of arthropods	+	+	−
Unidentified (Hymenopt. 15)	Sphecidae	Parasite of arthropods	+	+	−
Polistes maginalis	Vespidae	Parasite of insects	+	+	+
Mantodea					
Spodromantis centralis	Mantidae	Predator	+	−	+
Calidomantis sp.	Mantidae	Predator	+	−	−
Diptera					
Unidentified (Dipt. 1)	Tipulidae	Larvae predaceous	+	+	−
Neuroptera					
Mantispilla sp.	Mantispidae	Larvae predaceous	+	−	−
Unidentified (Neuroppt. 1)	Chrysopidae	Predator	+	+	+

+, low; ++, moderate; +++, high; ?, not confirmed; *, super family; names in brackets are species codes referring to unidentified specimens. Sample specimens for all species are lodged at the Faculty of Forestry and Nature Conservation, Makerere University.

Table 3. Diseases of *Alnus acuminata* and *A. nepalensis* in Uganda.

Disease symptom	Susceptible *Alnus* growth stage	Occurrence		Associated pathogen
		A. acuminata	*A. nepalensis*	
Damping-off	Seedlings in sowing beds	+ +	+ +	*Fusarium oxysporum* (Schlecht.)
Brown leaf spots	All growth stages	+ + +	+ +	*Septoria alni* (Sacc.)
				Unconfirmed *Septoria* sp.
Black leaf spots	All field growth stages	+ +	+ +	*Alternaria alternata* (Fr.) Keissl.
Seedling wilt	Nursery and field seedlings	+	+	*F. oxysporum* (Schlecht.)
				F. equiseti (Corda) Sacc.
				Pestalotiopsis sp.
				Butrytis sp.
Stem canker	Saplings and mature trees	+ +	–	*Rhizoctonia solani* (Kühn.)
				Diplodia sp.
				Fusicoccum sp.
				Pestalotiopsis guepinii (Desm.)
				Acremonium stictum (W. Gams)

+, low prevalence, + + commonly occurring; + + +, highly prevalent; –, not observed.

nii (Desm.) Steyaert and *Acremonium strictum* W. Gams. were also isolated. However, these fungi are probable saprophytes or weak pathogens (C. Ellison, pers. comm., 2000) and are thus unlikely to be the primary causes of the stem canker.

Discussion

Arthropods

Overall, this study showed more species inhabiting *A. acuminata* than *A. nepalensis*. This could be attributed to the relatively low occurrence of *A. nepalensis* in Uganda. Until 1999 *A. nepalensis* was planted only at AFRENA experimental trials without dissemination to farmers and hence the species has been less exposed to potential pests in the country than *A. acuminata* that occurred widely on farmlands, especially in Kabale district. Kabale district exhibited a greater range of insects and fungi on *A. acuminata* than Mbale although the insect species encountered in both the districts were similar. In addition, the range of insects and pathogens encountered was greater in Kabale than in Mbale possibly because of more frequent and extensive surveys conducted in the former. The preference of some pest species such as *Apis mellifera, Apion globulipenne* and a *Lobotrachelus* sp. for either *A. acuminata* or *A. nepalensis* could be attributed to genetic variation between the *Alnus* species. Such variability may be useful in selecting and/or breeding for pest resistance.

Although several insects were encountered on *Alnus* species in this study, none was at high densities. Possibly the natural enemies encountered were a major force in keeping the insect populations relatively low. However, the host specificity of the natural enemies could not be readily established in this study. Nevertheless conservation of such indigenous natural enemies is essential in enhancing biological pest control (Singh-Rathore 1995; Rao et al. 2000). Insect species that were observed feeding voraciously on *Alnus* species may become more important as the use of *Alnus* in agroforestry intensifies in Uganda. Therefore regular monitoring is required to assess the population and damage dynamics of such pest species, and also to identify new important pest species that may emerge on the *Alnus* species.

Another concern is the occurrence on the *Alnus* species of insects known to be serious pests of crops or other multipurpose tree species. This finding is contrary to the view held by Stamps and Linit (1998) that pests commonly found on the crops in alley cropping system might not be able to exploit the trees and vice versa, thereby resulting in lower pest population overall. Particularly noteworthy in this study were *Aphis fabae, Parastictococcus multispinosus* and an unidentified *Cacopsylla* sp. observed on *P. vulgaris, G. robusta* and *P. africana* respectively. In southern Malawi, Sileshi et al. (2000) recorded *A. fabae* feeding on *Arachis hypogeae*, trees including *Cajanus ca-*

jan, Gliricidia sepium and *Sesbania sesban*, and some weedy species. Populations of such pests, particularly on annual crops, may be increased by the presence of *Alnus* species as the latter, being perennial, can provide ready food source for the pests in periods when the crop hosts are off-season (Mchowa and Ngugi 1994; Singh-Rathore 1995).

Pathogens

The *Alnus* species were found to be hosts to several fungi, some already causing lethal infections. Brown leaf spot was the most widespread disease of *A. acuminata* and *A. nepalensis* in Uganda. This disease, as observed by Maiteki and Owera (1996), was the most damaging on the *Alnus* species in nursery. *Septoria anli* and an unidentified isolates of a *Septoria* sp. were confirmed causing the brown leaf spot. This contrasts with an earlier report (Maiteki and Owera 1996) that attributed the cause of *Alnus* brown leaf spot in the country to an unidentified *Cercospora* sp. In fact, no *Cercospora* species was isolated from any culture of diseased *Alnus* samples examined in this study. *Septoria* species are well-known leaf pathogens of many different plants worldwide (Agrios 1997). Several species of the genus including *S. olnifolia, S. ostryae, S. alnicola* have been reported as damaging on *Alnus* (C. Ellison, pers. comm.). The incidence of up to 100% seedling infection by *Septoria* brown leaf spot indicates an immediate need for control measures against the disease in nurseries.

F. oxysporum was lethal to *Alnus* seedlings both in germination beds and transplant pots. Russo (1995) reported *Fusarium* species as damaging on *A. acuminata* seeds in Costa Rica. It is thus apparent that the genus *Fusarium* consists of *Alnus* pathogens of wide distribution. Therefore it is important that preventive measures against such pathogens be integrated in nursery management practices, and more importantly disseminated to farmers raising *Alnus* from their own nurseries. Locally designed soil sterilization technology such as that used at AFRENA nursery is a feasible option, especially for groups of farmers. In addition, cultural practices such as watering regimes, shading and general nursery hygiene ought to be strictly adhered to.

A potentially devastating disease of saplings and mature *A. acuminata* trees is stem canker. The primary cause of this disease was not obvious due to a complex of fungal species isolated from diseased specimens. It is likely that *Rhizotonia solani*, a well known primary pathogen, associated with the disease was the primary cause. However, the observed tree mortality could be a summation of the effects of the fungal complex isolated. Clearly, an inoculation experiment is necessary to establish the cause of this disease.

Conclusion

In as far as can be ascertained, this study presents the most elaborate list of the arthropods and pathogens that inhabit *A. acuminata* and *A. nepalensis* in Africa. The study has indicated several damaging insects and pathogens on these *Alnus* species in Uganda. Although most damaging insects and pathogens on *Alnus* were not at high densities, the array of species identified indicates a potential danger to *Alnus* species in agroforestry in Uganda. Insects and pathogens that may become important pests on the *Alnus* species include *Fusarium oxysporum* and *Septoria alni* in nurseries, and *Apis mellifera, Apion globulipenne*, a *Systates* sp., *Phymateus viridipes* and unconfirmed stem canker pathogen(s) in the field. New pests may emerge and will need to be detected through regular monitoring. This is especially so in light of recent plans to intensify cultivation of the species in the country. Therefore it would be important for such developments to take into account pest management aspects, an idea that appears to have been omitted when introducing the *Alnus* species in the country. The suite of damaging insects and pathogens observed on *Alnus* species is a pointer to the need for systematic observations on pest problems in ongoing agroforestry research. In this way, pest specialists may identify pest problems that could be alleviated through agroforestry practices and develop corresponding experimentation programs in cooperation with agroforestry scientists and farmers.

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