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Natural Resources Institute

Bulletin 77

CONDUCTING ETHNOBOTANICAL SURVEYS

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CONDUCTING ETHNOBOTANICAL SURVEYS: AN EXAMPLE FROM GHANA ON PLANTS USED FOR THE PROTECTION OF STORED CEREALS AND PULSES

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SUMMARY

A survey was undertaken in the Ashanti Region of Ghana to assess the use of plant materials with insecticidal and repellent properties on local farms. Emphasis was placed on plant materials used to protect stores containing cereals and pulses. A total of 27 plant species were recorded as having protective qualities against storage pests of cereals and pulses. The species *Chromolaena odorata* (L.) [siam weed], *Azadirachta indica* A. Juss [neem] and *Capsicum annuum* L. [chilli pepper] were the most commonly used to protect stored food. In addition to plants used to protect stored products, bio-activity against insect pests was reported in approximately 95 plant species. The most frequently mentioned plant species were *Bambusa vulgaris* Schrad. [bamboo], *Citrus* spp. [lime, lemon and orange], *Datura innoxia* Mill., *Manihot esculenta* Crantz [cassava] and *Piper umbellatum* L.

The survey found that 26% of the farmers interviewed used botanicals in some form for stored product protection; however, only a small percentage (7%) relied on them exclusively to protect their harvest from storage pests. Smoking of maize stores was the most common method of control in most districts (28%), with the exception of the major maize-growing districts (Ejura and Mampong), where the majority of farmers used conventional insecticides for the control of stored product pests.

RESUME

Une enquête a été effectuée dans la région d'Ashanti, au Ghana, afin d'évaluer l'utilisation de plantes ayant des propriétés insecticides et insectifuges dans les exploitations agricoles locales. L'accent a été mis sur les plantes utilisées pour protéger les magasins de céréales et de légumineuses. Au total, 27 espèces de plantes ont été enregistrées comme détenant des qualités protectrices contre les ravageurs des céréales et des légumineuses entreposées. Les espèces *Chromolaena odorata* (L.), *Azudirachta indica* A. Juss et *Capsicum annuum* L. [piment] étaient les plus fréquemment utilisées pour protéger les aliments emmagasinés. Outre les plantes utilisées pour protéger les produits entreposés, une activité biologique contre les insectes ravageurs était signalée dans 95 espèces végétales environ. Les espèces végétales les plus fréquemment mentionnées étaient *Bambusa vulgaris* Schrad. [bambou], *Citrus* spp. [citron vert, citron et orange], *Datura innoxia* Mill, *Manihol esculenta* Crantz [manioc] et *Piper umbellatum L.*

L'enquête a indiqué que 26% des cultivateurs interrogés utilisaient des plantes d'une façon ou d'une autre pour protéger les produits emmagasinés; néanmoins, un petit pourcentage (7%) seulement d'entre eux dépendait exclusivement de celles-ci pour protéger leur récolte contre les insectes de stockage. La fumigation des magasins de mais était la méthode la plus fréquente de lutte contre ces insectes dans la plupart des districts (28%), à l'exception des principaux districts de culture du maïs (Ejura et Mampong) dans lesquels la majorité des cultivateurs utilisait des insecticides conventionnels pour lutter contre les ravageurs des produits emmagasinés.

RESUMEN

En la región de Ashanti, Ghana, se llevó a cabo un estudio cuyo objetivo era evaluar el uso en las granjas de la zona de material vegetal con propiedades insecticidas y repelentes, habiéndose prestado particular atención al fitomaterial utilizado para proteger los almacenes de cereales y leguminosas. Se estableció que un total de 27 especies vegetales contaban con cualidades de protección contra las plagas de almacenamiento de cereales y leguminosas, habiendo sido las especies *Chromolaena adorata* (L.) [mala hierba de Siam], *Azadirachta indica* A. Juss [noem] y *Capsicum annuum* L. [chile] las más comúnmente utilizadas para proteger los alimentos almacenados. Además de las plantas utilizadas para el fin antedicho, se obtuvo información sobre la bioactividad contra las plagas de insectos en un total aproximado de 95 especies vegetales. Las especies más frecuentemente mencionadas fueron: *Bambusa vulgaris* Schrad. [bambú], *Citrus* [lima, limón, naranja], *Datura innoxia* Mill., *Manihot esculenta* Crantz [mandioca] y *Piper umbellatum* L.

Este estudio estableció que el 26% de los agricultores entrevistados utilizaban productos botánicos de algún tipo para proteger los productos almacenados. Valga señalar, sin embargo, que solamente un reducido porcentaje (7%) dependía exclusivamente de dicho material para proteger sus cosechas contra las plagas del almacenamiento. Con la excepción de los principales distritos dedicados al cultivo de maíz (Ejura y Mampong), en donde la mayor parte de los agricultores utilizaban insecticidas tradicionales para el control de las plagas de los productos almacenados, en la mayor parte de los distritos (28%), el método de control más comúnmente utilizado era el ahumado de los almacenes de maíz.

Conducting ethnobotanical surveys: an example from Ghana on plants used for the protection of stored cereals and pulses

INTRODUCTION

Plants are well known for their medicinal and insecticidal properties, and considerable research around the world is conducted to screen plants for new drugs and agrochemicals. Because of the overwhelming diversity of plant species and costs involved in developing new drugs or chemicals, ethnobotanical surveys using indigenous knowledge systems have often been employed to develop new compound leads. Ethnobotanical surveys can, therefore, provide a range of information about how plants are used, where the breadth and scope of information is dependent upon the purpose of the survey and how the survey is conducted.

In 1992, the United Nations Convention on Biological Diversity (CBD) was agreed in Rio de Janeiro and has now been ratified by over 120 countries. The treaty reaffirms the sovereign rights of states over their own biological resources, and it is designed to protect indigenous knowledge systems, such as how plants are used, as a form of intellectual property. The CBD states that benefits from biological resources, including ethnobotanical information, should be shared equitably amongst all those involved. It is, therefore, in the interest of signatories to the CBD to invest in the conservation of their biological diversity and to add value to their biological resources by establishing current knowledge systems by indigenous populations.

There are many ways to conduct an ethnobotanical survey where the information required will ultimately be reflected in the methods of survey. However, conducting an ethnobotanical survey should be relatively straightforward. The objective of this Bulletin is to provide an example of how such a survey can be implemented and interpreted on a small scale with very little financial cost. Although the data in this Bulletin relate to the insecticidal properties of plants, and more specifically to stored-product insect pests of grain and legumes in one region of Ghana, the general survey techniques could apply to other ethnobotanical survey objectives, such as finding plants with specific medicinal properties. Although not written as a 'how to' self-help manual, it is to be hoped that the information presented herein will help others interested in the potential benefits of plants to develop their own ethnobotanical survey methodologies.

Historically, botanicals traditionally have been used for pest control in Ghana for generations. They are normally gathered locally and can provide an inexpensive method of control. There is little detailed information regard-

ing the use of local plants with insecticidal properties. However, laboratory studies have confirmed the insecticidal activity of a small number of Ghanaian plant materials traditionally used as protectants (Cobbinah and Osei-Wusu, 1988; Cobbinah and Appiah-Kwarteng, 1989, 1991; Cobbinah and Tuani, 1992; Niber, 1994; Tuani *et al.*, 1994).

The Ashanti Region of southern Ghana has a sub-tropical climate and is characterized by moist/dry semi-deciduous forest or savannah-fringe vegetation. The major crops cultivated in this region include maize (*Zea mays* L.), cassava (*Manihot esculenta* Crantz), groundnuts (*Arachis hypogaea* L.), cowpeas (*Vigna unguiculata* (L.) Walp.), rice (*Oryza sativa* L.), and vegetables (plantain, yam, pepper, garden eggs and tomatoes, etc.).

The main objective of this survey was to gather information on plant species used as protectants, with particular reference to those used against storage pests of cereals and pulses. Information regarding traditional storage methods and the use of conventional insecticides in this region was also assessed.

MATERIALS AND METHODS

A survey was undertaken of all the major farming districts in the Ashanti region of Ghana. Twelve out of 14 administrative districts were surveyed during the period 15 March–15 October, 1995. The two districts not visited were Kumasi, the regional capital, and Obuasi, a gold-mining centre, both of which are highly urbanized and have little agricultural land. Including other major farming areas, a total of 15 farming districts were visited by a two-man survey team, visiting an average of 12 towns and villages within each district (*see* Figure 1).

Contact was initially made with the chief, chief farmer, opinion leader or the assembly man for each town or village. Their assistance was requested as the objectives of the survey were explained. In the majority of towns and villages a discussion meeting was called of elders and farmers. Those individuals identified in the open forum as having relevant information were asked to complete the questionnaire with the assistance of the survey team (*see* Appendix). Information regarding cultivated crops and storage methods was obtained. Botanical protectants used by farmers were identified (by local and/or Latin names), as were the application methodology and perceived efficacy. Farmers were divided into two categories based on their level of literacy; literate individuals were defined as those who had been educated past primary school level.

RESULTS

Five hundred and twenty farmers were interviewed from 179 towns and villages in the 15 farming districts surveyed. The majority of farmers who took part were defined as illiterate (mean±sem, 64±3.3%). The age and sex of farmers interviewed were biased towards old males. Male respondents comprised 86% of the total number of farmers interviewed, and the mean (±sem) age of all respondents was 60 (±3.1) years old. However, age range and sex ratio of respondents did not vary among districts (Kruskal-Wallis, $n = 15$, $P > 0.05$).

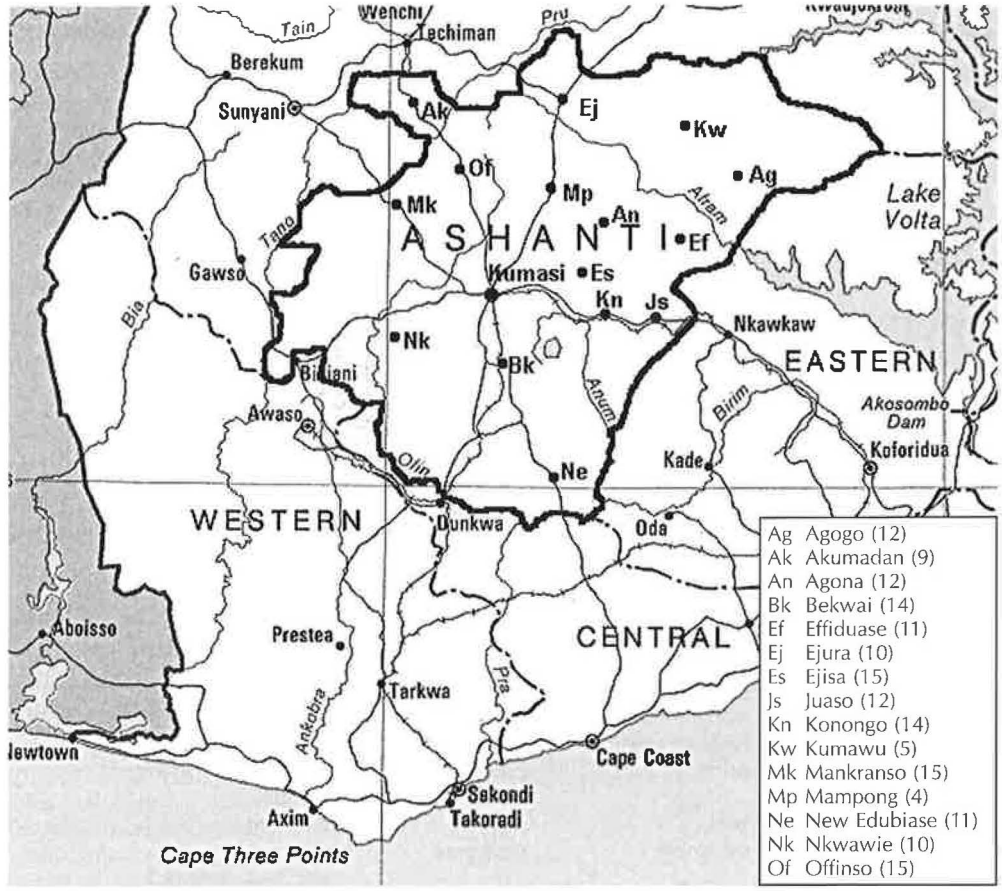

Figure 1 Map of the Ashanti region in Ghana showing the district capitals and other major farming centres that were covered by the survey. The numbers in brackets are the number of towns and villages visited in each farming area.

Plant species exhibiting insecticidal activity against storage pests

Twenty-seven plant species were recorded as being used by farmers in stores to protect cereals and pulses against storage pests (*see* Table 1). The most commonly mentioned of these species were *Chromolaena odorata* (L.) [siam weed], *Azadirachta indica* A. Juss [neem] and *Capsicum annuum* L. [chilli pepper].

Chromolaena odorata was the most widely used of these plants (mentioned in 10 districts by 19% of respondents); however, there was a mixed reaction among farmers to its efficacy as a protectant. *C. odorata* was recognized mainly for its medicinal qualities, and it is used to dress wounds. Leaves of *C. odorata* have been reported to preserve the dead for up to two days. Its use as a protectant in maize (*Zea mays* L.) stores was considered a relatively new innovation, occurring during the last 10 years. It was more popular amongst the younger, more literate generation of farmers who were well informed about present-day storage methods. Harvested maize was generally stored in a barn made of bamboo or wood. A layer of freshly cut *C. odorata* was first spread on the floor, then alternate layers of maize cobs and *C. odorata* were added. Protection has been reported to last for six months using this treatment. *C. odorata* was also used to protect stored cowpea (*Vigna unguiculata* (L.) Walp.). The leaves were dried in the sun and then ground to form a powder. The powder was mixed with loose cowpeas before they were placed in storage sacks. Using this procedure, the cowpeas were reported to be free of insect infestation for four months.

Table 1 Plant species used as protectants of stored grains in the Ashanti region of Ghana

Plant species	Plant part or extract employed	Grain protected	Effects	Number of districts reported
Chromolaena odorata	leaves, leaf powder	maize, cowpeas	repellent	10
Azadirachta indica	leaves, leaf extract, seeds, seed extract	maize, cowpeas	repellent, toxic, oviposition inhibition	7
Capsicum annuum	dried fruits, powdered fruits	maize, cowpeas	repellent, oviposition inhibition	4
Citrus aurantiifolia	ripe and unripe whole fruit, juice	maize, cowpeas	repellent	4
Piper umbellatum	leaves, leaf powder	maize	repellent, toxic	3
Arachis hypogaea	oil from seeds	cowpeas	oviposition repellent, ovicidal	2
Cedrela odorata	leaves	maize	repellent	2
Datura innoxia	leaves, leaf extract	maize, cowpeas	toxic	2
Nicotiana tobacum	leaf extract, leaf powder	maize	toxic	2
Thevetia peruviana	paste from fresh roots, leaves, leaf extract	maize	toxic, repellent	2
Citrus sinensis	dried peel	maize, cowpeas	repellent, adult mortality	1
Cleistopholiis patens	bark powder	maize	toxic, repellent	1
Cocos nucifera	oil (seed kernel)	cowpeas	oviposition repellent, ovicidal	1
Crossopterix febrifuga	bark	maize	repellent	1
Elaeis guineensis	oil (seed)	cowpeas	oviposition repellent, ovicidal	1
Ficus exasperata	wood ash	maize	toxic, repellent	1
Griffornia simplicifolia	leaves	maize	repellent	1
Khaya senegalensis	leaf powder	cowpeas	oviposition inhibition repellent	1
Mormodica charanta	leaves, leaf extract (combined with lime juice)	maize		1
Parkia clappertoniana	pod extract	maize, millet, cowpeas	repellent	1
Plumbago zeylanica	leaves and leaf powder	rice	toxic	1
Vitellaria paradoxa	residue	cowpeas	repellent	1
Gyakporkporki (gruma)	leaves	maize	toxic	1
Kasali (dagbani)	bark exudate	maize	toxic	1
Krubutu (banda)	bark powder	maize	toxic	1
Te (banda)	bark powder	maize	toxic	1
Vinlee (busanga)	leaves	maize, millet	repellent	1

The insecticidal properties of the two other commonly used species, *A. indica* and *Capsicum annuum*, were consistently reported throughout the survey (mentioned in seven and four districts, respectively, by 11% and 8% of respondents, respectively). Therefore, both species were used less frequently than *Chromolaena odorata*. *A. indica* was more often recognized, like *C. odorata*, for its medicinal properties rather than its insecticidal properties. There were two methods of application for *A. indica* and *Capsicum annuum*; the first was similar to the way *Chromolaena odorata* was used in that leaves or small branches were layered between maize cobs in stores. The sheaths were removed from the cobs to obtain the best results. The second method involved soaking ground, fresh neem leaves in a bucket of water for a day. The mixture was sieved and the extract sprayed on the maize before storage. Maize stored using this second method was reported to stay free of infestations for approximately one year. *C. annuum* was used to protect stores of

both maize and cowpeas (*Vigna unguiculata* (L.) Walp.). Shelled maize was bagged and large amounts of dried chilli peppers were placed at the opening before sealing. Dried chillies were ground and moderate amounts of the powder were mixed with the cowpeas for protection. The cowpeas were then bagged and sealed; the chilli powder was reported to be effective at controlling infestation for well over a year.

Control methods and the effects of literacy

Amongst all farmers interviewed, the use of botanicals as the only control measure was relatively low (7.3%) (*see* Table 2). Literacy/illiteracy had no significant effect upon the percentage of farmers exclusively using botanicals (Binomial test, $P > 0.05$). However, the total use of botanicals (used alone and in combination with other control treatments) by all farmers (26.1%) showed that literacy increased the usage of plant materials against stored product pests (Binomial test, $P < 0.05$).

Table 2 Control methods used among literate and illiterate farmers in the Ashanti region of Ghana

Control method	Percentage of literate farmers	Percentage of illiterate farmers	Total percentage of farmers
Botanicals only	6.9	7.6	7.3
Chemical insecticides only	21.3	6.6	12.25
Smoke only	18.1	34.8	28.4
Botanicals and insecticides	8.0	4.0	5.5
Botanicals and smoke	11.2	9.3	10.0
Insecticides and smoke	12.2	12.3	12.25
Botanicals, insecticides and smoke	6.4	1.3	3.3
Other methods (e.g. ash)	16.0	24.2	21.0
Total botanical usage	32.5	22.2	26.1

Other methods of pest control used in the Ashanti region included conventional insecticides, smoke and ash. Smoke was the most popular of all control measures employed in the region (28.4%) (*see* Table 2). Generally, maize cobs were hung on cross-bars in the kitchen to allow smoke to pass over them. Alternatively, they were stored in raised barns under which a fire could be lit periodically. The practice of adding wood ash to maize stores was also reported. Ash was spread in alternate layers with maize cobs to provide protection against storage pests.

Between the two groups of farmers, literate and illiterate, the highest users of smoke were illiterate farmers (34.8%), and the use of insecticides was highest among literate farmers (21.3%) (*see* Table 2). In general, the literate farmers lived in Ghana's largest maize-growing districts (Ejura and Mampong) where farmers cultivate larger areas of land and store for longer periods (up to one year).

Plants exhibiting bioactivity against pests other than those of stored products

With regard to all plants mentioned in the survey, it was found that different parts of plants could be utilized: leaves, bark, fruit, seeds, roots and, in some cases, extracts or powdered material. For any given plant species, the plant parts utilized and the method of preparation of plant material varied amongst villages. There was a high usage of botanicals in districts where 90±4.2% (mean±sem) of respondents mentioned more than three uses of botanicals

against pests. Approximately 95 plant species were cited during the survey as being used to control a variety of insect pests (*see* Tables 3 and 4). Eleven of these plants were previously mentioned as having activity against storage pests of cereals and pulses (*see* Table 1). For other pest problems, the most frequently mentioned species (30+ reports) were *Bambusa vulgaris* (bamboo), *Citrus* spp. (lime, lemon and orange), *Datura innoxia* Mill. (pepiewuo), *Manihot esculenta* Crantz (cassava) and *Piper umbellatum* (amumuaha). Plants listed in Table 4 are by local name only as reliable botanic names could not be found. Therefore, data in Table 4 may show different local names that refer to the same plant species, or different plant species referred to by the same local name.

Table 3 Plant species reported to have pesticidal properties in the Ashanti region of Ghana

Scientific name	Local name	Plant part or extract employed	Organism(s) affected
Aframomum spp.	Atiagya	leaves	insect repellent
Albizia ferniginea	*Albizia*	leaf extract	kills ticks
Albuliton mauritianum	Nwaha	leaves	repel lice on fowls
Alcohonea cordifolia	Gyamma	leaves	control lice on fowls
Ananas comosus	Pineapple	fresh peels and leaf extract	attract mosquitoes, control earth-borne insects
Anchomanes defformis	Awope/ope	tuber extract	kills lice on fowls
Antrocaryon micraster	Apokuma	leaves	control lice on fowls
Aspilia africana	Mfofoo	leaves	repel mosquitoes
Bambusa vulgaris	Bamboo	leaves	repel lice on fowls
Bathia nitida	Odwen	leaves	control insects
Blighia sapida	Akyee	leaves	control mosquitoes
Borassus aethiopum	Fan palm	fruit extract	controls lice on fowls
Capsicum annuum	Chilli pepper	fruit powder (in soap solution)	controls field insects
Carica papaya	Pawpaw	leaves and root extract	kill ticks
Cassia alata	Nsempiidua	leaves	control insects
Cassia occidentalis	Nkodaabodee	fruit and leaves	mosquito repellent
Celtis mildbraedii	Esa	ash	insecticide
Citrus aurantiifolia	Lime	leaves (burnt)	mosquito repellent
Citrus limon	Lemon	fruit juice	insecticide
Citrus sinensis	Sweet orange	peel (burnt)	mosquito repellent
Coix lacryma-jobi	Job's tears	seeds soaked in oil (burnt)	mosquito repellent
Cola gigantia var. *glabrenscens*	Apupua	leaves	control ticks
Costus spp.	Kwekuotoma	leaves	repel honey bees
Culcasia angolensis	Konkrahae	leaves	kill bed bugs
Dalbergia heudelotii	Akasie	leaf extract	kills household insects
Daniellia ogea	Gum copal tree	gum (burnt)	mosquito repellent
Daniellia oliveri	Sanya	gum (burnt)	mosquito repellent
Datura innoxia	Pepiewuo	leaf extract (with clay)	controls earth-borne insects
Datura metel	Kwaseadua	leaf extract (with clay)	controls earth-borne insects
Dombeya spp.	Mfo	leaves	repel lice on fowls
Drypetes floribunda	Dwon	leaf extract	controls ticks
Elaeis guineesis	Oil palm	kernel oil and palm wine	control lice, earth-borne insects
Entada africana	Bonyo/kaboya	leaves	control lice on fowls
Erythrophleum ivorense	Odom	bark extract	insecticide
Ficus exasperata	Fiscus	leaves (burnt)	repel lice on fowls
Griffornia simplicifolia	Kagya	leaves (burnt)	repel lice on fowls
Ipomoea batatas	Sweet potato	leaf extract	controls lice
Jatropha curcas	Physic nut	leaves and ash from leaves	kill domestic insects and bed bugs

Scientific name	Local name	Plant part or extract employed	Organism(s) affected
Justicia flava	Ntumunumu	leaves	mosquito repellent
Lannea prob		fruits	kill and repel lice on fowls
Mangifera indica	Mango tree	bark (burnt)	mosquito repellent
Manihot esculenta	Cassava	leaves and root tuber (burnt)	repel honey bees and mosquitoes
Mareya micrantha	Nkodaa bodee	leaf powder	kills crawling insects
Mormodia charantia	Nyanya	plant and leaf extract	control insects (especially ticks), and mosquito repellent
Mucuna sloanei	Horse-eye bean	leaves	mosquito repellent
Musa paradisiaca	Plantain	ash from peel	mosquito and termite repellent
Nicotina tobacum	Tobacco	leaves	control domestic insects and termites
Ocimum basilicum	Eme	leaves (burnt)	repel mosquitoes and lice on fowls
Ocimum gratissimum	Tea bush	leaves	mosquito repellent
Okoubaka aubrevillei	Odee	seed extract	insecticide
Olyra latifolia	Droben	leaves	repel honey bees
Parinari curatellifolia	Atena	leaves	control insects
Parkia clappertoniana	Daudawa	pod extract	controls insects
Piper umbellatum	Amumuaha	leaves	repel lice on fowls
Psydrax parviflora	Kwawu nsusua	leaf extract	repels honey bees
Pycnocoma macrophylla	Akofie-kofi	leaf extract	toxic to insect pest of domestic animals
Solanum aethiopicum	Egg plant	leaf extract	repels honey bees
Solanum spp.	Nkokodwe	leaves	control lice on fowls
Tectona grandis	Teak	leaf extract (mixed with neem extract)	controls termites
Tetrapteura tetraptera	Prekese	fruit extract	insecticide
Theobroma cocoa	Cocoa	dried pods (burnt)	mosquito repellent
Tragia spp.	Sansono	leaves	insect larvae
Trema orientalis	Sesea	leaves	control ticks
Triplotaxis stellulifera	Kooko	stalk and leaves, plants	kill lice on fowls, controls termites
Vernonia conferta	Flakwa	leaves	insecticide
Vernonia amygdalina	Awoweno	leaf extract	controls ticks
Vitellaria paradoxa	Shea butter tree	leaf powder	kills ticks

Table 4 Local plants reported to have pesticidal properties (local names only) in the Ashanti region of Ghana

Local name	Language	Plant part or extract employed	Organism(s) affected
Afama	Twi	leaves	repel lice on fowls
Alata kwadu	Twi	fruit extract	kills insects
Aprowah	Twi	leaves	control ticks
Bondwaha	Twi	root extract	kills insects
Bruma	Kusasi	leaves	control insects
Dumkpaa	Dagbani	leaves (burnt)	repel mosquitoes
Emrodwa	Twi	leaves	repel lice on fowls
Epe	Dagomba	rhizome	kills lice on fowls
Godge-te	Ewe	leaves	kill mosquitoes
Kanden	Twi	leaves	repel lice on fowls
Kookopaa	Twi	seed extract	kills lice on fowls
Kuka/dadee	Twi	leaf extract	kills head lice
Mbrodwa	Twi	leaves	repel ticks
Mitsimitsi	Ewe	flowers and fruits	trap lice on fowls

Local name	Language	Plant part or extract employed	Organism(s) affected
Mmaa kube	Dagbani	fruit	repel lice on fowls
Nkokotaho	Twi	leaves and seeds (burnt)	control lice on fowls
Nulummnuuya	Dagbani	leaves	control mosquitoes
Nyanyanini	Twi	leaf extract	controls soil-borne insects
Nyutuyowa	Dagbani	leaves	repel mosquitoes
Ponopuw	Dagbani	leaves	repel lice on fowls
Posomono	Ewe	leaves (burnt)	repel mosquitoes
Prison	Kotokori	leaves	control ticks
Samanakatua	Twi	fruit and leaves burnt)	repel mosquitoes and lice on fowls
Sampete	Twi	tuber extract	kills termites
Sumenku	Twi	leaves	control insects
Tuankrea	Twi	leaves	control ticks
Twomprowa	Twi	leaves	control ticks

DISCUSSION AND CONCLUSIONS

Knowledge about the insecticidal and repellent properties of plants was found widely among farmers in the Ashanti region of Ghana. However, this knowledge base varied greatly among villages and districts within the region. Although many plant species cited were often endemic across the region, most cases of their use were isolated to one or two districts (*see* Table 1). The restricted use of commonly occurring plants highlights the often poor communication between villages, perhaps reflecting cultural and ethnic biases that prevent the adoption of new knowledge. Although survey methods suggested that increased education may increase the usage of botanicals in combination with other control strategies, the knowledge base of botanical usage was biased towards old males. This could indicate that traditional information is failing to reach younger farming generations. Technology transfer among villages and villagers could result in greater efficacy of pest control using botanicals.

For most of the plants mentioned in this survey, reliable scientific research and mode-of-action studies on the insecticidal and/or repellent properties are lacking. For example, some laboratory studies showed extracts of *Chromolaena odorata* have no effect on growth and development of *Sitophilus zeamais, Callosobruchus maculatus* and *Pseudothermes militaris* (Cobbinah and Appiah-Kwarteng, 1991). However, similar research using extracts and slurries of *Chromolaena odorata* against *Prostephanus truncatus* and *Sitophilus oryzae* showed insecticidal activity at 1% (wt/wt) (Niber, 1994). Evidence is lacking on whether *C. odorata* interferes with host selection and chemo-orientation behaviour of stored-product pests, and it is unknown if volatiles of *C. odorata* are repellent to insect pests. The shoots and foliage of this plant are highly pubescent and physically abrasive. Therefore, if whole plant material were used, it could be possible that these physical characteristics would deter pests. However, *C. odorata* is the most widely distributed weed in Ghana, and its availability, rather than its efficacy, could account for its high usage. Research on the phytochemistry and bioactivity of *C. odorata* (Wollenweber and Roitman, 1996; Wollenweber *et al.*, 1995) and *Chromolaena* spp. (Biller, *et al.*, 1994), showing the presence of novel flavonoids and other secondary metabolites which may be responsible for the insecticidal properties demonstrated (Irobi, 1992; Pancho, 1983), is limited.

It is scientifically recognized that seeds, rather than the other parts, of the neem tree contain the highest proportion of insect antifeedant and growth-regulating factors (Sundaram, 1996; Gahukar, 1995). However, farmers in the survey region were using the leaves of neem trees to protect their produce. Several factors may account for this, such as lack of knowledge, seasonality of seed production, and time and effort required to process the seeds to extract the oil. Education from appropriate sources could increase the efficacy of neem usage. The use of neem against storage pests (Dales, 1996; Xie *et al.*, 1995; Chinwada and Giga, 1993), its chemical constituents (Johnson *et al.*, 1996; Salimuzzaman *et al.*, 1992), insecticidal and growth-regulating properties (Ascher, 1993) and vertebrate toxicity (Oguge *et al.*, 1997; Cohen *et al.*, 1996; Chinnasamy *et al.*, 1993) are well researched. The use of hot peppers against post-harvest pests has also been previously researched (Mbata *et al.*, 1995; Onu and Aliyu, 1995; Lale, 1992).

Traditional methods of stored-product protection were not considered viable alternatives in the large-scale farming of maize that occurred mainly in the districts of Ejura and Mampong. Literate farmers in these districts regarded conventional insecticides as the safest method to ensure the control of post-harvest pests. The most commonly used insecticides by farmers for this purpose were Actellic, Phostoxin, Thiodan, Endosulfan, Gammalin 20 and Cymbush. The usage of botanicals or smoking in large-scale storage is generally not common (Proctor, 1994; Poswal and Akpa, 1991). Botanical usage is dependent upon local availability and collection of plant material; large stores would require very large amounts of plant material. As information and scientific support on botanical protectants is lacking, large-scale farmers also feel more locally traditional methods cannot guarantee the safety of their produce. Although increasing, the amount of research on botanicals used for protection in stored-food systems is still inadequate (Dales, 1996). Therefore, difficulties arise in recommending botanicals as a replacement for chemical insecticides because efficacy levels of botanicals often vary among storage pests, application methods, and stored products. Reliable vertebrate toxicity data and active component/mode-of-action studies are not often available for traditional botanicals, making it impractical to recommend the widespread use of potentially harmful materials.

The survey has found that, while approximately one-quarter of the farmers interviewed used botanicals in some form, only a small percentage relied on them exclusively to protect their harvest from stored-product pests. Literacy did increase the chances that a farmer would consider botanicals as an aspect of a protection regime. Increasing education should, therefore, increase the farmer's ability to choose the types of protection most suitable to his needs. The slow pace of scientific recognition and development of botanicals combined with the increasing availability of conventional pesticides has prevented wide-scale adoption of botanically derived protectants. Increased financial and political support for research on the use of botanicals as alternatives to synthetic pesticides may eventually lead to better stored-product protection at farm level.

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APPENDIX

Questionnaire Part I

Name:	Town/village:
Age:	House no.:
Sex:	District:
Educational status:	Region:
Occupation:	Date:

1. What major crop(s) do you grow?
2. What varieties do you cultivate (if known)?
3. How much of your produce do you store (all, half, third, etc.)?
   (a) Chemical insecticide (specify)
   (b) Plant part or extract
   (c) Any other method (specify)
4. If you ticked 3b (above) mention the name of the plant
5. Where did you obtain it?
6. How did you come by it?
7. How long have you been using it?
8. Did you buy it?
9. What storage methods do you use?
10. What is the length of storage period?
11. What method is used to protect against insect pests?
12. Which part of the plant is used (i.e. stem, bark, leaves, roots, etc.)?
13. How do you process it before use?
14. How do you administer it (i.e. spraying, sprinkling, etc.)?
15. What quantities are used?
16. How effective is it against target insect (i.e. kills, repels, etc.)?
17. How long does it remain effective?

Questionnaire Part II

1. Apart from the above, do you know about any plant(s) which is used in some way to control insects in any situation (i.e. control of mosquitoes, cockroaches, houseflies, termites, etc.)?
2. If yes, give details
   (a) Name of plant
   (b) Purpose
   (c) Source
   (d) Others
3. Other comments

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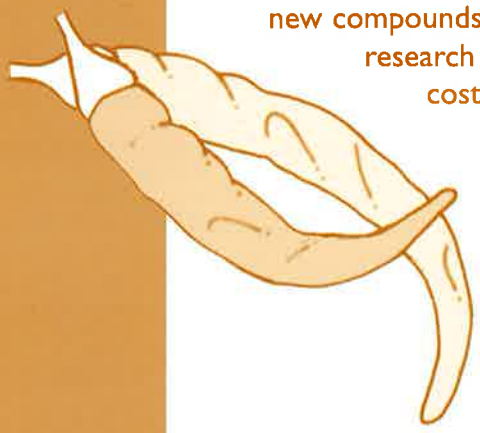

Plants are well known for their medicinal and insecticidal properties, and considerable research around the world is conducted to screen plants for new compounds. Ethnobotanical surveys are often used to target research activity because of the diversity of plant species and costs involved in developing new compounds. The United Nations Convention on Biological Diversity reaffirms the sovereign rights of States over their own biological resources. Adding value to biological resources by establishing current indigenous knowledge systems could, therefore, lead to financial gains and effective biodiversity conservation. In **Conducting Ethnobotanical Surveys: an example from Ghana on plants used for the protection of stored cereals and pulses** information is presented to show how ethnobotanical data can be used towards promoting research and conservation of indigenous plant species.

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