Four Footed Pharmacists: Indications of Self-Medicating Livestock in Karamoja, Uganda[1]

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Four Footed Pharmacists: Indications of Self-Medicating Livestock in Karamoja, Uganda. Following observations of goats' possible self-medication browsing the anti-parasitic plant, *Albizia anthelmintica*, an ethnobotanical survey was undertaken to examine whether livestock engage in other self-medicating behaviors, and if people also use the same medications. Information was gathered over a five-month period from 147 Karamojong pastoralists and healers using a checklist of questions. There were 124 observations for 50 proposed self-medicating behaviors, primarily eating plants, to treat a total of 35 disease conditions. Of the plant species, 72% were also prepared by informants to treat human or veterinary diseases. Species importance was estimated by four factors: >3 user citations, informant consensus factor >0.4, fidelity level >40% and presence in the local pharmacopoeia. Eight species fulfilled all of these factors, and 12 had at least three. These results provide support for the hypothesis that animals graze specific plants when ill and suggest that people have developed some of their knowledge through animal observation.

Key Words: Animal self-medication, *albizia anthelmintica*, ethnoveterinary knowledge, pastoralists, zoopharmacognosy, ethnobotany, pharmacopoeia.

Evidence for animals' self-medication has accumulated over the past two decades (Engel 2002; Hart 2005; Huffman 2003; Lozano 1998). Research has concentrated on Africa's great apes. Janzen (1978) was the first to suggest that ingested secondary plant compounds actually help animals to combat parasites. Research has since identified chimpanzees' self-treatment for internal parasitism through leaf-swallowing of *Aspilia* spp. (Asteraceae) (Wrangham and Nishida 1983) and bitter pith chewing of *Vernonia amygdalina* Delille (Asteraceae) (Huffman and Seifu 1989) as well as other species (Lozano 1998).Other studies approach proving self-medication by identifying and isolating biologically active compounds responsible for specific pharmacological effects, for example V. *amygdalina* (Huffman et al. 1993) *Albizia grandibracteata* Taub. (Fabaceae) and *Trichilia rubescens* Oliv. (Meliaceae) (Krief et al. 2005) from which antiparasitic and antibacterial compounds have been isolated following observations of chimpanzees. Watt and Beyer-Brandwijk (1962) earlier documented that indigenous East and South African people use some of these plants as medications.

The study of self-medication in animals is known as 'zoopharmacognosy' (Rodriguez and Wrangham 1993), defined as the study of secondary plant components or other non-nutritive substances used by animals for self-medication (Huffman 1997). Huffman (2007) recently broadened the definition to include behavior and non-plant substances used to suppress disease or to enhance animal health. Use of soils and their properties has been well-documented in non-human primates and elephants (Engel 2002) as have other behaviors that do not include ingestion of soils or plants (Clark and Mason 1985; Lozano 1998).

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Ethnoveterinary knowledge (EVK) refers to people's knowledge, skills, practices, and beliefs about the care of their animals (McCorkle 1986). EVK has documented many local remedies, or ethnoveterinary medicines (EVM), that animal keepers use for livestock health. These EVMs are often taken to mean the use of medicinal herbs, but also include wild plant and mineral products, and processes such as bone setting and vaccination. However, EVK always has a human intervention component (McCorkle et al. 1996).

There has been little reference to livestock or other domestic animals in the field of zoopharmacognosy. Moreover, most research has been by behaviorists' observations of wild or zoo animals, predominantly primates. On the other hand, many farm animals lack access to self-medication because they are confined and given a specifically developed diet that has little bearing on what they would get in the wild (Engel 2002). Research has shown *in vivo* antiparasitic effects of tanniferous plants that small ruminants may browse and graze (Niezen et al. 1998; Paolini et al. 2004). However, definitive work on sheep self-medicating, when challenged with illness-producing foods, was the first demonstration of multiple malaise-medicine associations supporting zoopharmacognosy (Villalba et al. 2006). This paper investigates self-medication by domestic animals, as observed by Karamojong pastoralists of north-eastern Uganda, where the only fodder animals get is what they forage.

In 1998, an ethnoveterinary survey catalogued over 70 different medicines pastoralists in central Karamoja use to treat and prevent livestock diseases (Gradé and Shean unpublished). Some of these veterinary remedies are also used to treat human afflictions. Following this survey, validation field trials of selected EVMs were undertaken to evaluate their efficacy in the field (Gradé 2001). Early in one such study, the first author observed an abrupt drop in individual goats' internal parasite loads (measured by daily fecal eggs per gram and fecal egg count reduction), whereas this was not observed in other species studied (unpublished data). Shepherds suggested that this was related to selective browsing of a bitter plant, *Albizia anthelmintica* Brongn. (Fabaceae). It was explained that goats suffering from internal parasites tend to graze *A. anthelmintica,* followed by expulsion of gross worms in the feces and improvement in their symptoms (Gradé et al. 2007). This observation led us to search for other self-medicating behaviors by similar livestock in the project area.

The primary objective of the present study was to investigate self-medicating behaviors of Karamojong livestock, to examine the hypothesis that animals seek out and graze specific medicinal plants or employ other behaviors when sick. The survey addressed three central questions: Do animals (domestic and wild) perform self-medicating behaviors? If so, what plants or other materials do they use? And finally, do people locally use these same items to treat disease in livestock and/or themselves (i.e., are they included in the local pharmacopoeia)? A secondary objective was to select those plants/materials that were most important in order to validate their use potential for promotion within the subregion, e.g. establishing them in home gardens, follow-up field trials and possible drug development.

Methods

Study Site

The region of Karamoja is located in north-eastern Uganda. This study took place in south-western Karamoja between 2° to 2°03′ N and 34° 15′ to 34°40′ E (Fig. 1). Mean annual rainfall ranges from 500 to 750 mm, with 380 to 500 mm in the plains and higher levels in the surrounding mountain ranges. Daily temperatures average 30–35° C. The region has a semi-arid to arid environment and is prone to cyclical droughts. Pratt and Gwynne (1977) grouped Karamoja in Eco-Climate Zone VI of East Africa, in which evaporation greatly exceeds precipitation (Karamoja Data Centre unpublished data).

Thomas (1943) described the vegetation of Karamoja as consisting of *Acacia-Combretum-Terminalia* species associations, with an herb layer of *Hyparrhenia, Setaria, Themeda, Chrysopogon* and *Sporobolus* species. In contrast with neighboring districts, the short vegetation shows evidence of heavy grazing.

Karamoja consists of five geopolitical districts. Total population is around 935,000 (UBOS 2002) and contains five distinct Nilotic peoples in the plains and two small Kuliak groups found along the mountains (Gulliver 1952). All of these groups live in conflict with one another and neighboring tribes. One of the Eastern Nilotic ethnic groups in Uganda, the Karimojong, has three major clans, from which the county names

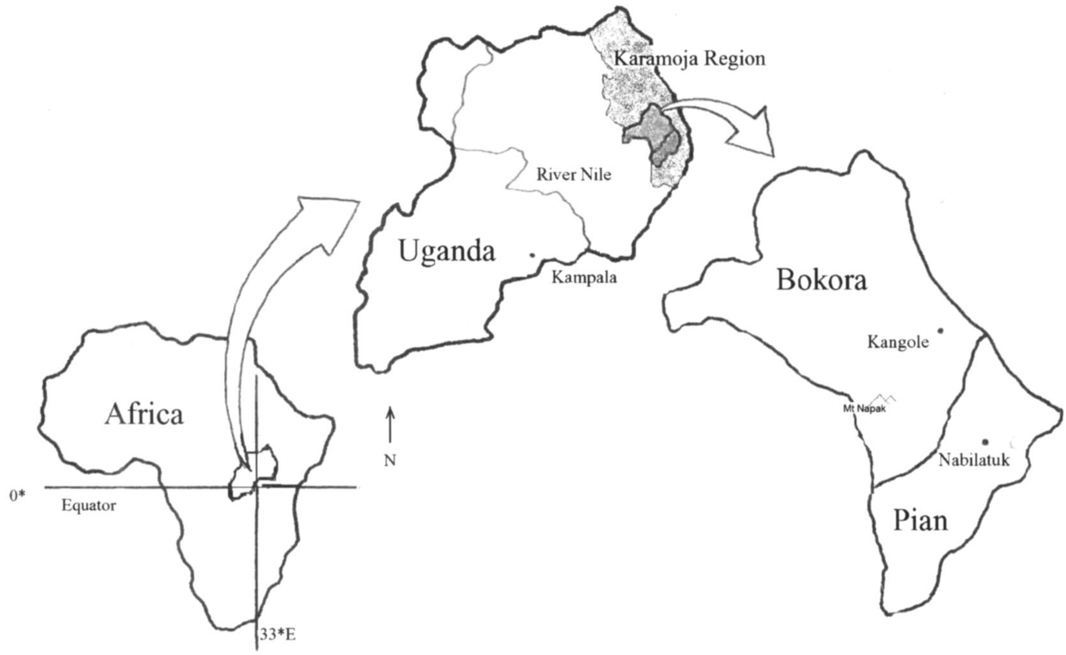

Fig. 1. Study area (credit: John O. Grade).

are derived. Two of these clans, Bokora and Pian, are the focus of this paper. The Bokora county population is 95,000, while Pian has 38,000 people (UBOS 2002). They share a transhumant agro-pastoral lifestyle and speak the same language, with slight differences. However, due to armed bilateral cattle rustling, there are strong cultural taboos against sharing livestock information between clans (Mirzeler and Young 2000).

These pastoralists rely almost entirely on livestock for survival and cultural events. Karamojong are semi-nomadic and have minimal health care infrastructure for humans or livestock, with only one doctor per 57,133 people (Netherlands Development Organisation unpublished) and one veterinarian for 90,000 livestock (Moroto District Veterinary Office unpublished; Uganda Wildlife Authority unpublished). Culturally, people rarely disclose their true number of animals, so even this low ratio may be overestimated. Thus, the Karamojong rely almost exclusively on local knowledge and medicines for treating diseases in both people and animals (Gradé et al. 2007).

Daily patterns and problem solving revolve around their livestock: when to graze, when to water, when and how to protect livestock from wild animals or raiders, how often to milk or bleed for human consumption, which animals to select for sacrifice, and so on. Thus, they are highly motivated to observe and well-manage their livestock.

METHODS

We conducted our study, interviewing 12 groups (Table 1), from April to August 2005. Twenty four traditional healers participated, not only in discussions, but also in collections. These healers are representatives of the Bokora and Pian- registered traditional healer associations. An additional 123 pastoralists from the community joined the discussions; of these 147 total respondents, 55% were from Bokora and 45% were from Pian. One survey was performed at a cattle market in Pian, while 11 were held in home villages of traditional healers.

Information was gathered by a checklist of questions performed during field excursions and group discussions (Martin 1995). Participants were asked to list behaviors in livestock that were performed indicative of self-medication or symptomatic relief of disease conditions; and also whether these practices, behaviors and remedies were used by people in the treatment of disease in animals and/or people. Data were cross-referenced by the first author's observations to

TABLE 1. BREAKDOWN OF COMMUNITY MEMBER NUMBERS SURVEYED.

	Groups: (home, market) [a]	Registered Traditional Healers: (men, women)	Non-healers: (men, women)
Pian	8: (7, 1)	21: (16, 5)	60: (31, 29)
Bokora	3: (3, 0)	3: (2, 1)	63: (31, 32)
total	12	24	123

[a] number of groups and their interview location

determine if the observed self-medications were part of the pharmacopoeia of Karamojong-prepared medications. They were also asked from where they believed their indigenous knowledge had originated.

Informants were asked to narrate observations with the following processes: 1) animals having an obvious ailment (one the pastoralists could visually diagnose); 2) these animals displaying behavior that is absent or rare when healthy, such as grazing an unpalatable plant part; 3) following this behavior, they observe an improvement in the animals' symptoms; and subsequently 4) the animal ceasing the said behavior as symptoms improve. Provided their observation included step two (i.e. animals displayed a behavior that is absent or rare when healthy) and most of the other steps, the observation was included in the results. We are intrigued by the possibility of a fifth step, in which after observation of steps one through four, pastoralists experiment with using the relevant self-medicating material as a prepared medicine. For points one through four, we relied upon the pastoralists' observations, memories, and willingness to share information. Pastoralists are the best resource for self-medicating livestock observations due to their constant close proximity to the animals, high motivation to observe and monitor disease, and years of accumulated experience on animal care, diagnosis, and treatment. It is important to note the potential barriers and layers of translation between the author and the animals in this study. There was a clear barrier between the animals and pastoralists, who discerned disease conditions – including subjective conditions such as headache and nausea – from healthy animal behavior. There were also barriers separating the first author and pastoralists, due to differences in language, and in cultural views of disease etiology, medication, and livestock behavior. Therefore indices of informant consensus factor (ICF) and fidelity level (FL) were used to guide interpretation of our observations and efforts were made to draw responses from the emic perspective.

Indigenous disease terminology was verified by the primary author, an experienced veterinarian. Diseases, processes, and disorders were grouped according to the usage category standard for human symptoms and ailments developed by Cook (1995). In alphabetical order, the usage categories are as follows: digestive system disorders, ill-defined, infection/infestations, injuries, metabolic disorders, nutritional disorders, pregnancy/birth/puerperium disorders, prophylaxis, respiratory disorders and skin disorders. Self-medicating remedies were grouped according to botanical family (Angiosperm Phylogeny Group 2003), if plant-based; as 'mineral' if inorganic; or as 'water' if water was a component.

Plants mentioned by participants were photographed and collected *in situ*. Collected plants were sent to Makerere University Herbarium in Kampala for botanical identification according to Flora of Tropical East Africa. Karamojong names for some plants are connected to more than one scientific name; we refer to these data as ethnospecies (Reyes-Garcia et al. 2006). All plant species and material are listed with small caps in vernacular. Vouchers are kept at Makerere herbarium and a community herbarium located at the study's partner NGO, KACHEP, in Nabilatuk, Karamoja.

We conducted our survey as part of KACHEP's ongoing community development project focusing on animal health care, local capacity building and EVK awareness. Key informants were healers associations' formations registered at the national level with whom the first author has a long standing (8 years) relationship, facilitating their whose associations were, development of intellectual property rights awareness, and their goals and vision; therefore prior consent was obtained.

DATA ANALYSIS

Interview responses were compiled into narrative form, coded and entered into an Excel spreadsheet. Analysis included calculation of ICF (Equation 1) and FL (Equation 2). ICF was adapted from Trotter and Logan's informant agreement ratio

(1986) to measure informant groups' consensus and thereby infer consensus among different animals observed. We specifically looked into three areas; individual self-medicating remedies and categories of these remedies, and usage categories of disease (e.g. a specific plant species, and a particular plant family and category of disease as described by Cook). In this method, the relative importance of each use is calculated directly from the degree of consensus in informants' responses (Phillips 1996). The importance of different plants or uses is assessed by the proportion of informant groups who independently corroborate different animals' self-medicating behaviors. The ICF has a maximum of 1.0 (maximum consensus) and a minimum of 0 (no consensus). ICF for an individual self-medicating remedy, for example, is calculated, as follows: number of observations of the remedy (obs) subtracted by the number of ailments (use category of disease, UC), divided by the number of observations of the particular remedy minus one:

$$ICF = \frac{obs - UC}{obs - 1} \quad (1)$$

We used ICF to evaluate the hypothesis that livestock self-medicate. A self-medicating behavior (SM) with a positive ICF indicates that livestock in different areas displayed a consistent behavior; i.e. that local people observed animals with a given disease tended to perform a particular SM. Among usage categories, a positive ICF indicates specificity of the SM for a given disease condition; i.e., animals performing a given SM tended to have the same disease condition, rather than haphazardly chewing an unpalatable plant part for any illness. ICF for disease categories took into account a summation of observations within the category. Each SM was counted only once, even if it appeared in more than one disease within the usage category.

Fidelity level (FL, Equation 2), adapted from Phillips (1996), was used to determine the most important self-medicating species in each specific usage category. Fidelity level is derived from

$$FL(\%) = \frac{N_p}{N} \times 100 \quad (2)$$

where N_p is the number of observations of a particular self-medicating behavior for one usage category, and N is the total observations for the behavior for any use.

We are confident that our findings are significant, particularly given that Bokora and Pian forbid sharing livestock-related information between clans. Elevated ICF and FL are therefore strong indicators of multiple, independent and congruent observations.

We estimated plant/material importance as a function of four criteria. The species must have at least three uses in order to be considered, The other three criteria are: ICF >0.4 (Moerman 2007), FL >40% and presence of the treatment in the local pharmacopoeia.

Results

There were 124 use citations (observations) for 50 proposed self-medicating behaviors used to treat a total of 35 disease conditions, as observed by 12 informant groups. The domesticated animals mentioned were goats, cattle, sheep, donkeys, camels, poultry and dogs, in decreasing order of self-medicating behavior observations. Cats and pigs were not mentioned. There were single self-medicating behavior mentions for three wild animal species; buffalo, kudu and guinea fowl. As stated in the methods section, to be considered a self-medicating activity, the informants observed animals displaying a behavior that is absent or rare when healthy, as part of the following process: 1) animals having an obvious ailment (with symptoms pastoralists could visually diagnose); 2) these animals displaying behavior that is absent or rare when healthy, such as grazing an unpalatable plant part; 3) subsequent improvement in the animals' symptoms; and 4) subsequent cease in self-medicating behavior. All the 50 proposed self-medicating behaviors fulfilled criterion two, almost all of the 50 also fulfilled steps one, three and four with step four being the least, but still fetching > 70% of 124 observations.

Most Observed Self-Medicines

Table 2 shows the 50 observed self-medicating remedies and behaviors in alphabetical order, divided in three parts, i.e. specific oral remedies, non-specific oral remedies and non-oral self-medicating behaviors. The most commonly mentioned self-medicating behavior was grazing Ekosimabu (*Loudetia superba* De Not), which was reported nine times out of the total of 124 reports. Three Karamojong remedies had eight observations: Akawoo (*Cymbopogon giganteus*

TABLE 2. LIST OF SELF-MEDICATION REMEDIES AND BEHAVIORS, (A) FOR SPECIFIC ORAL TREATMENTS' (B) FOR NON-SPECIFIC ORAL (C) FOR BEHAVIOR, NOT INGESTION OF REMEDY.

material (part used)	Scientific name	Family	Obs	UC	ICF	PM	FL
(a)							
Abalongit	Mineral - soda ash	'mineral'	2	2	0	yes	50 R, D
Abir (wp)	*Sphaeranthus ukambensis* O Huffm.	Asteraceae	1	1	0	yes	100 D
Abwach (b, l)	*Warburgia ugandensis* Sprague	Canellaceae	3	3	0	yes	33
***Akawoo* (l)**	***Cymbopogon giganteus* *Chiov.***	**Poaceae**	**8**	**3**	**0.71**	**no**	**50 I**
	***Bothriochloa insculpta* (A. Rich.) A. Camus**	**Poaceae**					
Akouma	Anthill or termite mound	'mineral'	1	1	0	yes	100 N
Amojoi (l, fl)	*Agave sisalana* Perrine ex Engelm.	Agavaceae	1	1	0	no	100 P
Apuna (l)	*Bulbostylis pusilla* (A. Rich) C. B. Cl. Subsp congolensis (De Wild) R. Haines	Cyperaceae	5	4	0.25	no	40 N
Cassava (l)	*Manihot esculenta* Crantz	Euphorbiaceae	1	1	0	yes	100 D
Ecorgorum (l)	Not collected	NI	1	1	0	yes	100 I
***Ecucukwa* (l)**	***Aloe tweediae* Christian**	Aloaceae	6	4	0.4	yes	50 X
	Aloe dawei Berger	Aloaceae					
Edapal (l, fr)	*Opuntia cochenillifera* (L) Mill	Cactaceae	3	3	0	yes	33
***Edipidipi* (l, b)**	***Erythrococca bongensis* PAX**	Euphorbiaceae	3	2	0.5	yes	67 I
Edoot	Clay or anthill like soils	'mineral'	8	4	0.57	yes	63 N
Egigith (wp-r)	*Cissus quadrangularis* L.	Vitaceae	2	2	0	yes	50 I, ID
***Ekadolia* (l, fr)**	***Capparis tomentosa* Lam.**	Capparidaceae	3	2	0.5	yes	67 X
Ekamuria (l, b)	*Carissa edulis* (Forsk.) Vahl.	Apocynaceae	1	1	0	yes	100 I
***Ekapangiteng* (l, b)**	***Albizia anthelmintica* Brongn.**	Fabaceae	6	2	0.8	yes	83 I
Ekapeliman (l)	*Acacia nilotica* (L.) Del.	Fabaceae	2	1	1.0	yes	100 X
Ekara (l)	not collected	NI	1	1	0	yes	100 X
***Ekere* (l, s)**	***Harrisonia abyssinica* Oliv.**	Simaroubaceae	5	3	0.5	yes	60 I
Ekorete (l, fr)	*Balanites aegyptiaca* (L.) Del.	Balanitaceae	1	1	0	yes	100 X
***Ekosimabu* (wp)**	***Loudetia superba* De Not.**	Poaceae	9	5	0.5	no	43 I
Eligoi (wp-r)	*Euphorbia tirucalli* L.	Euphorbiaceae	2	2	0	yes	50 N, X
	Cissus spp.	Vitaceae					
Elira (l, b)	*Melia azedarach* Linn.	Meliaceae	1	1	0	yes	100 X
Eminit (l, b)	*Acacia gerradii* Beuth.	Fabaceae	1	1	0	yes	100 X
Epederu (l, fr)	*Tamarindus indica* L.	Fabaceae	1	1	0	yes	100 X
***Epeeru* (wp-r)**	***Cassia nigricans* Vahl.**	Fabaceae	5	1	1.0	yes	100 I
Epetet (l, b, fr)	*Acacia aerfote* (Forssk.) Schweinf.	Fabaceae	2	2	0	yes	50 I, J

(Continued)

Erogorowete (l, b)	*Capparis* spp.	Capparidaceae	2	2	0	yes	50 I, X
Eteteleit (l, b)	*Acalypha fruticosa* Forssk.	Euphorbiaceae	2	2	0	yes	100 X
Etirir (l, b)	*Acacia spirocarpa* Hochst. ex A. Rich.	Fabaceae	1	1	0	yes	100 X
Ewonokori (l, b)	*Capparis* spp.	Capparidaceae	2	1	1.0	yes	100 I
Eyelel (l, fr)	*Acacia drepanolobrium* Sjöstedt	Fabaceae	1	1	0	yes	100 X
Jokpolon (l)	*Hyparrhenia* spp.	Poaceae	1	1	0	no	100 I
Khat (l)	*Celastrus edulis* (Forssk.) Vahl	Celastraceae	1	1	0	yes	100 ID
***Loletio* (l)**	***Eragrostis pilosa* (L.) P. Beauv.**	Poaceae	7	4	0.5	no	57 N
Longarwe (l, b)	*Cissus* spp.	Vitaceae	1	1	0	yes	100 I
	Synadenium grantii Hook f.	Euphorbiaceae					
Losgirai (l)	*Amaranthus spinosus* L.	Amaranthaceae	1	1	0	yes	100 I
Mumwa (wp-r)	*Sorghum vulgare* Pers.	Poaceae	1	1	0	yes	100 X
water of *Ari Ekosimabu* (l)	***Ari* = bend in the river, lined with *L. superba***	Poaceae and 'water'	3	2	0.5	no	67 I
(b)							
Bad water	non-plant	'water'	1	1	0	no	100 ID
†Bitter, smelly plants (l, b)	**not specific**	NI	3	1	1.0	yes	100 X
Burnt grass and its ashes (wp)	not specific	Poaceae	3	3	0	yes	33
Good grass and water (l)	not specific	Poaceae and 'water'	1	1	0	no	100 X
Ninya (l)	not specific	Poaceae	1	1	0	no	100 D
Sour grass near clay soil (l)	not collected	Poaceae	3	3	0	no	33
Water	non-plant	'water'	1	1	0	yes	100 I
(c)							
Fence rubbing	not specific	'mineral'	3	3	0	no	100 I
Rain standing	non-plant	'water'	1	1	0	no	100 I
Rocky soil	non-plant	'mineral'	1	1	0	no	100 I
TOTALS			124	10		72%	

part used = plant part used; l = leaves, b = stem bark, fr = fruit, fl = flower, r = root bark, wp-r = whole plant, wp-r = wp without roots. If the remedy is not a plant or is not ingested – this is left blank

Obs = # of observations or use citations of this self-medicating remedy by informant groups

UC = # of Usage Category 'treated' by this remedy

ICF = Informant Consensus Factor (Equation 1)

PM = medicine is also prepared for human and/or veterinary use

FL = Fidelity Level% (Equation 2). With the highest UC noted, except if FL 33% - thus three UC, where D: digestive, I: infection/infestations, ID: ill-defined, J: injury, N: nutritional, P: pregnancy/birth/peurperium, R: respiratory, S; skin diseases, X: prophylaxis

NI = not identified

† = group of 3–8 plants

Those self-medicating behaviors that have high importance factors are bold.

Chiov. or *Bothriochloa insculpta* (A. Rich.) A. Camus), EDOOT soils, and LOLETIO (*Eragrostis pilosa* P. Beauv.). Two species had six observations: ECUCUKWA (*Aloe tweediae* Christian or *A. dawei* Berger) and EKAPANGITENG (*Albizia anthelmintica*). Note that both AKAWOO and ECUCUKWA are ethnospecies with more than one scientific name.

Forty-seven of the 50 self-medicating behaviors, or 94%, were taken orally (part a and b in Table 2). Only three behaviors had no oral component (part c, Table 2). Forty-two, or 84%, of the self-medicating behaviors documented here involved plants. Five had a water component, and six had a mineral component. Three behaviors spanned two of the above categories.

Table 3 lists families associated with livestock self-medication, in decreasing frequency of observations. The Poaceae family was represented by 10 species, whereas Fabaceae had eight and Euphorbiaceae had five species that livestock had been observed to graze or browse when ill. A general category of 'mineral' was designated for geophagia (soil eating) and behaviors such as walking on rocks or rubbing against fences. This category had five remedies.

The Poaceae family also had the most observations, with 36 citations in six different usage categories. This included seven citations for EKICUYAN, a common but somewhat vague nutritional ailment described below. The Fabaceae family had 19 use reports for four usage categories, six of these reports involved internal parasites (part of infection/infestation usage category). The mineral group had 18 observations for six usage categories, including five for EKICUYAN.

MOST COMMONLY OBSERVED DISEASES, PROCESSES, AND DISORDERS

Table 4 lists the 35 different disease conditions grouped according to usage category (Cook 1995), in decreasing frequency. In order to protect Karamojong intellectual property rights, the specific medicinal applications of each plant are not given at this instance, although the most common remedy for each category is highlighted in table 4. Furthermore, the discussion will raise one example, *Albizia anthelmintica* for internal parasitism, as the plant and its use are widely distributed public knowledge and the NGO and CBO partners felt comfortable with this decision. Internal parasitism was the most common condition addressed by self-medicating behaviors. This condition was observed 13 times, with eight different self-medicating behaviors. Twelve observations each for disease prevention and health were noted, while EKICUYAN had 11 observations with eight different remedies. EKICUYAN, a culturally bound syndrome, can refer to human or veterinary disease and is described by pastoralists as heartburn or AKICWE, anthropomorphically described as 'salt-craving' or 'meat-deficiency.'

USAGE GROUPS

Table 4 lists the usage categories in decreasing order of user citations. Infections/infestations had the most individual diseases, processes or disorders and the most user citations with 49, or 39.5% of total. Following this were the prophylaxis group with 31, 18 in nutritional disorders, and eight for milk production, which was the sole process mentioned in the pregnancy/birth/puerperium disorders category.

TABLE 3. FAMILIES ASSOCIATED WITH KARAMOJONG LIVESTOCK ZOOPHARMACOGNOSY.

Family	# species mentioned	Obs	UC	ICF	most common UC observed
Poaceae	10	36	6	0.86	Infection
Fabaceae	8	19	4	0.83	Infection
'Mineral'[1]	5	18	6	0.71	Nutrition
Euphorbiaceae	5	8	4	0.57	Infection
Capparidaceae	3	7	2	0.83	Infection
Vitaceae	3	5	4	0.25	Infection
Aloaceae	2	6	4	0.4	Infection
Other (13 families)	1	1	1	0	

UC = # of different usage categories 'treated' by this family
Obs = # of observations or events of particular family by informant/group
ICF = Informant Consensus Factor (Equation 1)
[1] = Mineral group was included as a common category, not as a botanical family

TABLE 4. USAGE CATEGORIES IN DECREASING ORDER OF OBSERVATIONS (OBS), LISTED WITH INDIVIDUAL DISEASES, PROCESSES AND DISORDERS (DPD) IN DECREASING ORDER, NUMBER OF UNIQUE SELF-MEDICATING BEHAVIORS (SM) FOR EACH USAGE CATEGORY AND INFORMANT CONSENSUS FACTOR (ICF).

	Usage category	Individual diseases, processes and disorders*			Obs	SM	ICF	most common remedy
I	Infections/ infestations	Internal parasitism (13) Tick infestation (6) Heartwater (5) LOKIT - ECF (4) EMITINA - goat mange (3)	EBAIBAI - FMD EYALIYAL ~ tetany Lice LOLEO - rinderpest LOKECUMAN - black quarter	LOPID - anaplasmosis MALARIA fever EKORE - chest pain LOUKOI - CBPP Scabies	48	22	0.55	***A. anthelmintica*** and ***C. nigricans***
X	Prophylaxis	Disease prevention (12)	Health (12)	Non specific-health (7)	31	25	0.59	*A. nilotica* and ***C. tomentosa***
N	Nutritional Disorders	EKICUYAN ~'heartburn' (11)	Thin (low BCS) (5)	Anorexia (not eating)	18	8	0.2	***E. pilosa***
P	Pregnancy/Birth/ Puerperium	Milk production (8)			8	8	0	
D	Digestive System Disorders	EKITUBON - bloat Diarrhea	Constipation	Nausea	6	5	0.2	***L. superba***
ID	Ill-Defined Symptoms	Ill-defined	Lethargy	Weak calves	4	4	0	
R	Respiratory System Disorder	Coughing	Difficulty breathing		3	3	0	
S	Skin/Subcutaneous Cellular Tissue Disorders	Poor coat			3	3	0	
J	Injuries	Snake bite	Wound		2	2	0	
M	Muscular-Skeletal System Disorders	Headache			1	1	0	
	TOTALS				124	50	0.6	

* = # observations (Obs) listed with individual DPD when ≥3
SM = # of self-medicating remedies used for usage category
FMD = Foot and Mouth Disease
ECF = East Coast Fever
CBPP = Contagious Bovine Pleuropneumonia
BCS = Body Condition Score
ICF = Informant Consensus Factor (~Equation 1) $ICF = \frac{obs - SM}{obs - 1}$
The most frequently used remedy for each category is listed, in bold if it had high importance.

Self-medication Indices

As stated in the methods section, we estimated plant/material importance with following criteria: three use citations, ICF >0.4, FL >40% and presence of the treatment in the local pharmacopoeia.

ICF (Equation 1) was used to measure the level of consensus in individual self-medicating behaviors (Table 2), families (Table 3) and usage categories (Table 4, ICF = obs-SM/obs -1). Fourteen of the 50 identified self-medicating behaviors, or 30%, had an ICF >0.4. Four remedies had the highest possible ICF of 1.0. When considering remedy use at the individual ailment level, vs. the more general, grouped ailment usage level used in this study, *Albizia anthelmintica* has the highest ICF, 0.8. All but one of its observations was for internal parasitism (infections/infestations category); the other observation was under the prophylaxis category. The mineral group had an ICF of 0.71. Only two of the 10 usage categories (Table 4) had ICF >0.4: prophylaxis (ICF = 0.59) and infection/infestation (ICF = 0.55), whereas nutritional disorders and digestive system disorders both had low positive ICF of 0.2.

Table 2 shows the fidelity levels (last column) for each self-medicating remedy according to usage category. The infection category had the highest fidelity level. Not including those behaviors with only one user citation (which yields 100% FL by default); six remedies had perfect fidelity levels. There were 14 self-medicating behaviors with more than three use citations and a FL >40%.

Thirty-six of the 50 remedies, or 72%, were also used as a prepared medication by the informants to treat their animals and/or their families (Table 2). Thirty-six, or 76.6%, of the 47 orally applied self-medicating remedies are also prepared medications. If the prophylaxis category is removed (in other words, counting only observations in apparently sick or weak animals), the overlap is 65.8% or 25 of 38; if we only include oral treatments, the overlap increases to 71% (25 of 35).

Table 2 sets the most important remedies in boldface. Four importance factors were considered, eight self-medicating remedies fulfilled all of these factors, and 12 had at least three factors.

Indigenous Knowledge Origin

When asked to free-list the sources of their indigenous knowledge (IK), informants identified three main sources: 1) Creator-God; 2) people, both dead and living; and 3) animals. All 12 participant groups reported receiving IK from the first two categories through dreams, visions, oral traditions, personal observation, and study of tradition. Only two informant groups noted obtaining IK from animals by observing the animals' behavior; furthermore, it was only one or two individuals that admitted this – much to the laughter of others.

Discussion

Importance Factors

Although there are no universally agreed upon criteria for distinguishing self-medication (SM) from routine eating or other non-self-medicating activities, several tools have been proposed, such as evaluating plant parts bioactivities of chimpanzee diets (Krief et al. 2006), Huffman's steps (Huffman and Seifu 1989) and comparisons of what chimps eat as to what local people use medicinally (Huffman et al. 1996; Krief et al. 2005). The importance factors used in this paper drew on Krief et al.'s (2005) work comparing chimpanzees' diets with the pharmacopoeia of people throughout the world. We also relied on the field of ethnobotany, which has developed methods for studying consensus between cultures (Phillips 1996). Any individual observation of a SM may be important and relevant to the argument that animals self-medicate. However, a SM that is reported more often (in this study, we set three use citations as an *a priori* minimum), we believe is more likely to represent a true SM. The self-medication hypothesis is further supported in this study by similarity in SM and Karamojong pharmacopoeia, >0.4 ICF, and >40% FL. Therefore the self-medication hypothesis is especially supported by those boldfaced remedies in Table 2, as they fulfill the above criteria.

Our results show that most self-medicating behaviors were orally, and that most were plant-based. Both of these findings are consistent with the existing zoopharmacognosy literature (Clayton and Wolfe 1993; Engel 2002; Huffman 2003; Krief, Hladik, and Haxaire 2005; Lozano 1998; Nègre et al. 2006). Fur rubbing has also been observed in black lemurs and capuchins with millipedes, in several bird species with ants, other non-human primates with plant resins and leaves

(Birkinshaw 1999). However, in our study, the informants did not specify which tree species the livestock rubbed upon.

Small sample size is a possible limitation of this study, as it may not have been adequate to distinguish some valid self-medicating activities from background noise; therefore we set three use citations as a minimum for importance. Indeed, the sample size of this study is notably smaller than in other research involving ICF, which may involve thousands of user citations (Heinrich 2000; Heinrich et al. 1998). On the other hand, zoopharmacognosy research has generally been anecdotal, following one animal or a small group of animals with much fewer use citations, in the range of one to 30 (Huffman and Seifu 1989; Krief et al. 2005; Wrangham and Nishida 1983). However, due to the innovative style of this study, recording every observation supposed to be a self-medicating activity is important in that it would support the self-medication hypothesis.

One might assume that the more abundant a particular plant, the more commonly animals graze it. However, pastoralists did not remark on what their livestock typically ate, but rather what they specifically ate while visibly displaying an illness. Goats were the exception, as they routinely browse on bitter plants. Informants thought many of these remedies 'strengthened their animals and kept them from falling ill' which we etically translated to mean disease prevention, and overall health promotion. This is shown in the prophylaxis usage category which had 26 of the 50 different self-medicating remedies. This indicates that pastoralists associate more than half of their livestock's self-medicating behaviors as routine ways to enhance their health without shepherds' involvement. Prophylaxis is a difficult concept. Many of the observations appearing in this category, are those when the individual informant could not ascertain the animal's illness or why the animal they observed was acting 'queerly' or eating something that would be out-of-the-ordinary. So they in turn presumed that the animals' behavior was to strengthen it or prevent it from falling ill. However, one might suspect that observers are anthropomorphizing: if they consider a plant to be medicinal-only or unpalatable as food, they may assume that their animals perceive it the same way, and thus attribute a medicinal purpose to use by a healthy animal that may well not exist. Or, they might follow the line of reasoning, because they collect and prepare the same plant as medicine – the animal might be doing the same thing. However, Karamojong pastoralists do understand that diseases spread, from animal to animal, through vectors (animate and inanimate). They will separate and quarantine those animals that are ill, or keep their healthy animals from mingling with others they perceive as ill. They will lead their animals to certain grazing areas or natural salt-licks when the suspect illness or force-feed minerals or medicines to keep a new dam healthy or to 'strengthen' her (Gradé personal observations).

Parasitic diseases, overall, are the most common ailment which livestock self-medicate as recognized by Karamojong pastoralists. Thirty-seven, or 29.8%, of the 124 self-medicating observations were for internal or external parasites and the diseases they transmit. This is consistent with existing zoopharmacognosy literature: the most studied plants, *Vernonia amygdalina* and *Aspilia* spp., act against internal parasites (Lozano 1998) and parasitism is the most common ailment that has been noted in zoopharmacognosy (Engel 2002; Huffman 2003), additionally Clark and Mason (1985) reported on external parasites, i.e. nesting behavior in birds. The most commonly mentioned dewormer for livestock and humans in our study was *Albizia anthelmintica*, which was also the remedy with the highest importance factors. Even using the more stringent usage level, ICF is 0.8 (i.e. internal parasitism vs. general usage category infection/infestation) and its FL (83%) was the highest for a remedy with >6 observations. FL was used to quantify importance of species for a given purpose (usage category).

The idea that pastoralists experimented with the relevant remedy as a prepared medicine is supported by the observation some respondents claimed part of their IK came from animal observation, and is further addressed with 72% self-med to prepared med overlap. The overlap was higher than the 36% that Krief et al. (2005) found in comparing ethnobotanical uses to typical chimpanzee diets in Kibale, Uganda. Our higher levels could be that our study focused on self-medicating activities whereas their chimpanzee study examined the entire diet. Additionally, our study looked only at the local pharmacopoeia whereas theirs used a world-wide ethnobotanical database. In this instance, our higher level self-to-prepared med overlap suggests that some of

Karamoja's ethnomedicine origins were derived from animal observations.

Future objective and quantifiable research in this area should include:

a) Objective diagnosis and documentation of animals' disease condition with laboratory analysis.
b) Documentation of the frequency of behavior that is absent or rare when healthy, such as grazing an unpalatable plant part.
c) Documentation of resolution or improvement in disease condition, through standardized observation and/or laboratory means.
d) Documentation of cessation of the unusual behavior after improvement in symptoms.
e) Finally, reproduction of the beneficial effect in other diseased animals following administration of the relevant self-medicating behavior.

Trained behaviorists would more objectively evaluate steps b, c, and d. Villalba et al. (2006) essentially performed the last step in their sheep study by proving that animals choose appropriate plants to ameliorate their illness as a learned behavior.

Objective monitoring that are scientifically quantifiable and verifiable (steps a, c, and e), make internal parasitism attractive for further research. Much like *Aspilia* spp. and *Vernonia amygdalina* have drawn primatologists' attention (Lozano 1998), *Albizia anthelmintica* is a particularly good candidate for further exploration of livestock pharmacognosy. In addition to its high importance factors in this study, *A. anthelmintica* has shown anthelmintic activity in several studies (Gathuma et al. 2004; Githiori et al. 2003; Gradé et al. 2007; Koko et al. 2000).

To the knowledge of the authors, this is the first time that pastoralists' wealth of knowledge has been utilized as part of self-medicating behavior research, or that ICF and FL have been used to objectively evaluate the zoopharmacognosy hypothesis. Our results indicate that animals display multiple behaviors consistent with self-medication. There is also reason to suggest that pastoralists have developed some of their ethnopharmacological knowledge from careful animal observation. Finally, high importance species merit further investigations; identification/isolation of biologically active compounds (in particular those that are in the infection/infestations category), promotion at the local level, and perhaps drug development and primary health care.

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