MEDICINAL PROPERTIES IN THE DIET OF GORILLAS: AN ETHNO-PHARMACOLOGICAL EVALUATION

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ABSTRACT A growing body of literature in the behavioral, ecological and pharmacological sciences suggests that animals use certain plants for the control of parasite infection and related illnesses. It has also become increasingly apparent that chimpanzees in Africa and their human counterparts share strong similarities in the plants they use for the treatment of similar diseases. Little is yet known, however, of the other closest living ape relative in Africa, the gorilla. Here we review the ethnopharmacological literature to evaluate the possible role of plant secondary compounds in the diet of gorillas in the wild. A total of 118 medicinal plant species from 59 families are listed from an extensive review of the literature on gorilla diet in the wild. The major pharmacological activities of those plant foods, which are also used in traditional medicine include antiparasitic, antifungal, antibacterial, antiviral, cardiotonic, hallucinogenic, stimulatory and respiratory activities. A greater understanding of the role of such plants in the primate diet and how these plants can be used for health maintenance is a promising new avenue for expanding our understanding of the biological basis and origins of traditional human medicinal practices and for developing novel applications of ethnopharmacological knowledge for humans.

Key Words: Gorilla diet; Self-medication; Novel drug search; Ethnoveterinary medicine.

INTRODUCTION

In recent years a growing body of evidence has accumulated regarding the phenomena of self-medication in animals (see Huffman, 1997). A product of biological evolution, selective pressures have acted upon hosts and their pathogens in such a way that animals have adopted behavioral strategies to counteract the deleterious effects of these pathogens. One of the ultimate goals of research in animal self-medication is to shed light upon the evolution of medicinal practices in early humans and the ecological and biological forces that helped shape them. A comparative study of great ape self-medicative behavior and an understanding of the overall medicinal effects of the diet are important steps in understanding this process. The field of ethnopharmacology has much to offer and gain from this research.

A variety of non-nutritional plant secondary compounds are found in the great ape diet, but little is known about the possible medicinal consequences of their ingestion. One of the challenges of interpreting self-medication in animals is to distinguish between possible indirect medicinal benefits derived from secondary compound rich plants that are assumed to be ingested for their nutritional value versus

limited and situation specific ingestion of items that are processed solely for their curative value or other physiological effects. In traditional human societies too, the boundary between 'food' and 'medicine' is not always clear. Among the Hausa of Nigeria, over 80% of the plants used for the treatment of malaria and other dehabilitating ailments are also used as food (Etkin, 1996; Etkin & Ross, 1983). Over the last decade or more science has entered a renaissance in its view of food as evidenced by the increase in research and development of so called 'functional foods' or 'neutraceuticals' (e.g. Mazza, 1998; Ohigashi *et al*., 1997). Many of the traditional spices, condiments and vegetables used around the world are also important sources of anti-tumour agents or possess antioxidant, antibacterial, antiviral and antiparasitic activity (Billing & Sherman, 1998; Murakami *et al*., 1994; Sherman & Billing, 1999). Ethnopharmacology has played a leading role in documenting and evaluating many of these plants.

Parasites can cause a variety of diseases that affect the overall behavior and reproductive fitness of an individual making the need to counteract such pressures great. Among the recent advances in the study of primate self-medication is research into the behavioral adaptations for parasite control in wild chimpanzees (e.g. Huffman & Seifu, 1989; Huffman *et al*., 1993, 1997; Huffman, Page *et al*., 1996; Messer & Wrangham, 1995; Page *et al*., 1997; Wrangham, 1995). Two such proposed types of self-medicative behavior, bitter pith chewing and leaf-swallowing have been investigated in the most detail from an antiparasitic perspective (e.g. Huffman, 1997; Huffman, Page *et al*., 1996; Huffman & Caton, 2001). The likelihood of similar 'medicinal foods' in the diet of other great apes is quite high and warrants further extensive research.

It has become increasingly apparent that there are strong similarities in the plants used ethnomedicinally by humans and those exploited by chimpanzees for self-medication (Huffman, Koshimizu & Ohigashi, 1996). With respect to the medicinal properties of the African great ape diet, perhaps the least is known about gorillas. It is the purpose of this paper therefor to discuss some of the ethnomedical plants that form part of the natural diet of western lowland gorillas (*Gorilla gorilla gorilla*), eastern lowland gorillas (*Gorilla g. graueri*), and the mountain gorillas (*Gorilla g. beringei*). A greater understanding of the role of such plants in the primate diet and how these plants may be used for health maintenance is a promising new avenue for expanding our understanding of the biological basis and origins of traditional human medicinal practices and for developing novel applications of ethnopharmacological knowledge (e.g. Huffman, Koshimizu & Ohigashi, 1996; Huffman *et al*., 1998; Huffman, 2001).

PRIMATOLOGICAL AND ETHNOPHARMACOLOGICAL LITERATURE SURVEY

I. Central Nervous System (CNS) Stimulants, Cardiotonics and Hallucinogens

Appendices 1 and 2 list some particular ethnomedicinal plants found in the diet of lowland and mountain gorillas respectively. The wide variety of medicative proper-

ties listed within is a testament to the potential pharmacological diversity of their diet.

The African apes exploit a number of Kola (*Cola*) trees (Sterculiaceae), some species utilised by gorillas being *Cola gabonensis* (fruits), *C. nitida* (seeds), *C. pachycarpa* (seeds) and *C. rostrata* (seeds). It is interesting that in many of these species the gorillas prefer the seeds. Indeed, Raponda-Walker & Sillans (1961) state that the local people emphasize the preference gorillas show for seeds of *C. pachycarpa*, and even name the plant "cola of the gorillas". These seeds usually contain caffeine (between 2-2.5%) and theobromine. The amino acid content of Kola 'nuts' suggests that protein levels are weak (Outuga, 1975), and this in turn may indicate that gorillas eat the fruits and seeds primarily for their caffeine value.

Cola nuts are highly esteemed by people throughout tropical West Africa as charms and remedies, as amulets and as aphrodisiacs. White or light-coloured nuts effect love magic, while red has the opposite effect. Dried *Cola* fruits have also been used as currency and are given as tokens of friendship (Rätsch, 1992). Their reputation for suppressing fatigue and promoting endurance is legendary, and Russell (1995) claimed that the British Consul at Bahia, Brazil wrote a letter in 1890 suggesting that this powerful commodity should be brought to the attention of Her Majesty's War Office.

A curious relationship exists between a *Cola* species, *C. lizae* and gorillas in the Lopé region of Central Gabon. The plant itself is remarkable in that it was described just over a decade ago (Hallé, 1987) despite being the most dominant tree in the area, where its distribution is localised. The fruits of this plant are a major food source for gorillas for a part of each year, and the apes are the primary seed dispersers of the species. When gorillas build their nests in open areas of the forest and deposit their faeces near these nests, the seeds are provided with optimum conditions for germination (Tutin *et al*., 1991). The other seed disperser is the chimpanzee, but they are only a minor agent.

Although *C. lizae* is obviously an important food source for gorillas, it is not an exceptionally nutritious one. The mature fruits have high sugar content, but gorillas also consume unripe green fruits. The large seeds are swallowed individually and pass through the gastrointestinal (GI) tract unharmed.

Partnerships of this kind are usually to the benefit of both parties. It is clear what the plant gains, but less illuminating from the point of view of the gorilla: analysis showed no measurable alkaloids in the seeds or seed coating (Tutin *et al*., 1991). Yet one could expect a chemical benefit for the apes, particularly as gorillas seem to be attracted to caffeine and theobromine bearing plants. In Equatorial Guinea they eat the leaves of *Caffea liberica* (Rubiaceae) and the fruits of *Theobroma cacoa* (Sterculiaceae) (Sabater Pi, 1977).

Strophanthus spp. (Apocynaceae) are best known for the arrow poisons extracted from the crushed seeds, but this group of plants are extremely important ethnomedically throughout their distribution. The seeds contain a glucoside called strophanthin, which is a cardio-active agent. In some species the ground seeds are used for cardiac insufficiency, while the roots or leaves of other types (e.g. *S. hispidus, S. kombe, S. gratus, S. welwischii, S. preussii,* etc.) are utilised in preparations for venereal diseases, intestinal parasites and serious skin diseases such as scabies

(Burkill, 1985). In Gabon, gorillas are catalogued as eating the fruits of an unidentified species of *Strophanthus* (Tutin & Fernandez, 1985), and it will be interesting to see if future research reveals a greater exploitation of this species by gorilla and chimpanzee populations in other areas.

In Africa, hallucinogenic plants are either poorly represented or poorly recognised. The best documented is *Tabernanthe iboga*, (Apocynaceae), a shrub first described in 1889. The active principle in iboga is ibogaine, the highest concentration being found in the root. Ibogaine affects the CNS and cardiovascular system, along with tabernanthine and iboluteine, other active constituents in the plant. The stimulating effects are similar to caffeine, i.e. increasing stamina. The plant is employed in traditional African medicine, along with *Tabernaemontana* species, for manic depression, leprosy and as an aphrodisiac. In the former Belgian Congo (Democratic Republic of Congo) the sap is used in the treatment of pox, and the leaves for gum and tooth diseases (Dubois, 1955).

Ibogaine was the first indole to come into vogue in Europe, the extract being initially marketed in 1939 under the name 'Lambarene'. It stayed on the market until at least the mid-1960s, and was promoted as a cure for everything from neurasthenia to syphilis, but above all as an aphrodisiac. The tablets consisted of a dry pharmaceutical extract of the root of *Tabernanthe manii*, a related species to *T. iboga*, with a drug content of 0.20 g of extract per tablet (about 8 mg of ibogaine). Currently ibogaine is being heralded rather extravagantly as an interrupter for drug addiction, without withdrawal symptoms, and the University of Miami is to conduct human trials to demonstrate its properties. For a thorough overview of the discovery of ibogaine, its chemical structure, laboratory investigations and research into its therapeutic qualities and toxicity see De Rienzo & Beal (1997).

T. iboga is an essential component in African religious cults and rites, particularly in Bwiti. The Metsogho-Massango and Bapinzi peoples of southern Gabon practice Bwiti in its original form. The cult is male-orientated and initiation indispensable for social promotion within the tribe; any male unable to join is an outcast and considered feminine (Goutarel, 1997). The use of iboga is controlled in ceremonies, but when the Fang people adopted the cult they adulterated it, allowing women to join and being more reckless in the use of iboga, which they call 'eboka'. Initiates have been given massive doses of iboga to "open their heads" in order to effect contact with the ancestors through collapse and hallucination. One to three baskets full of the material would be consumed over an 8-24 hour period, representing an ingestion of 300-1,000 grams, or some forty to sixty times the threshold dose and close to toxicity. It is not surprising that some of these initiates died, and in a forty-year period a dozen cases of murder or manslaughter were brought against Bwiti cult leaders. The Fang also use the drug casually and regularly outside of Bwiti rituals (Fernandez, 1972, 1982).

In Bwiti legends the pygmies are said to have found iboga, but it is possible that the pygmies themselves discovered the properties of the plant by watching wild boars digging up and eating the roots, only to go into a wild frenzy, jumping around and fleeing from perhaps frightening images. Similar behaviour has been reported by indigenous peoples for porcupines and gorillas who are said to be fond of the roots (Pope, 1969; Raponda-Walker & Sillans, 1961). In south-eastern Cameroon

gorillas eat the flowers and branches of iboga (Bützler, 1980), while in Gabon they eat the fruits, stem and root of the plant (Valker, 1931). There is ample evidence that man globally has discovered the effects of drug plants by observing the behavior of animals (Siegel, 1979; Huffman, 2001).

Pharmacological tests have been carried out on animals by early French scientists (see Pope, 1969). Phisalix (1901) injected dogs with ibogaine, and the animals acted as if they were seeing frightening things; they would suddenly begin to bark loudly at nothing, leap backwards, or desperately try to hide in a corner. In 1905 Landrin (1905) experimented with frogs, guinea pigs and dogs. The effects were similar to a large dose of caffeine in all three species. Toxic doses sometimes produced convulsions, almost invariably paralysis, and finally an arrest of respiration. Fifty years later Schneider & Sigg (1957) did similar research on cats and dogs, confirming Landrin's findings. In these studies the animals exhibited ataxia, peculiar position of the legs, partial pilo-erection, pupil dilation, alertness, outstretched tails, and increased respiration—a picture of fear or rage (Pope, 1969).

The likelihood is that the exploitation of *Tabernanthe iboga* by gorillas is very localised. Valker (1931) made his observations within the environs of Sindara on the Ngounie river, south of Lambarene. Raponda-Walker lived at Sindara for five years, so it is conceivable that he also heard reports of gorillas eating iboga roots in this region. Bützler (1980) found his single piece of evidence in one small area of the Dja Reserve in the vicinity of Djoandjla, but never heard of the apes utilising the plant in any other area of Cameroon that he visited.

These accounts came not only from inland areas, however, but also from coastal regions. Pierre Henri Chanjon, a professional hunter and guide, and former official guardian of the Petit Loango Reserve in south-western Gabon for over a decade, is familiar with the root-eating of iboga by gorillas, but he believes that the apes are intelligent enough to be discriminatory in their consumption, possibly using the plant as a tonic (P.H. Chanjon, personal communication). This would make sense. The apparent "cultural" and infrequent employment of the plant by the pongids suggests a purely medicinal function. Although the fruit is said to be very palatable, and probably contains no active constituents (unlike the rest of the plant), it has not been identified as a food item in any of the diets of gorillas and chimpanzees so far recorded.

The local human inhabitants of the Peti Loango region use *T. iboga* in their secret society Bouiti, and it is noteworthy that they share other medicinal plants with gorillas, including the fruit of the rubber liana *Landalphia mannii* (Aponcynaceae) to combat intestinal parasites, and the bark of *Annodium manni* (Annonaceae) for diarrhoea (P.H. Chanjon, personal communication)

Two other hallucinogenic plants ingested by gorillas and chimpanzees are *Alchornea floribunda* and *A. cordifolia* (Euphorbiaceae). Both contain the alkaloids alchornine and alchornidine. Gorillas have been documented to eat the fruits of both species in Equatorial Guinea (Sabater Pi, 1977), while chimpanzees consume the pith and fruit of *A. cordifolia* in the Republic of Guinea. Local human inhabitants in Guinea use the pith and leaf of this plant as an antiseptic and anti-cough agent (Sugiyama & Koman, 1992).

A. floribunda is used in the same manner as *T. iboga* in Gabonese cults. The root

has a reputation as an intoxicant and as an aphrodisiac. After reducing it to powder it is mixed in palm wine and left for several days before being consumed to provide energy for tribal festivities or warfare. It is said to provide a state of intense excitement followed by a deep, sometimes fatal depression (Rätsch, 1992).

The highest percentage of alkaloids in *A. cordifolia* is concentrated in the roots and in the bark, although the leaves are used medicinally for coughs, colds, pneumonia, bronchitis and tachycardia. Perera *et al*. (1991) pharmacologically screened the leaves of plants collected in Cameroon and found good results with jaundice, but a rather weak toxicity that would not be significant for traditional medical uses. However, a screening of leaves, stem and roots of specimens collected in former Zaire showed a broad spectrum of antibacterial activity (Muanza *et al*., 1993).

These indole drug plants, together with others (such as *Rauwolfia* spp.) suggest that Africa may not be so impoverished in psychotropic plants as is widely believed. It is a tantalising thought too that gorillas might be directly affected by these same properties.

II. Respiratory Ailments, High Altitude Living and the Virunga Mountain Gorilla Diet

The cold, wet and windy slopes of the Virunga volcano range is a unique and inhospitable environment for gorillas. Not surprisingly, the apes commonly suffer from coughs, colds, pleurisy, pneumonia and bronchitis. This habitat lacks the diversity of flora found in the humid lowland forests and consequently has a narrower range of medicinal plants. One important source of food for gorillas is *Vernonia adolfi-frederici* (Compositae), the gorillas eat the flowers, pith and rotten wood of the plants (Schaller, 1963; Fossey, 1983). This genus is very significant ethnomedically in many areas of Africa. At least seven species–*V. ambigua, V. amygdalina, V. cinerea, V. cistifolia, V. conferta, V. nigritiana* and *V. poskeana*–are used in the treatment of naso-pharyngeal illnesses, and at least two others (*V. adoensis* and *V. colorata*) are considered as cures for pulmonary infections (Burkill, 1985; Iwu, 1993).

One of the behavioral puzzles of the Virunga gorillas are their periodic migrations to the upper slopes 1,100-3,200 meters above sea level, to the giant senecio zone. Schaller (1963) followed a group of gorillas to an altitude of 4,100 meters on Mt. Mikeno. Here the animals fed infrequently on *Senecio alticola* (Compositae) and *S. erici-rosenii*, preferring to eat the pith. Senecio are also important in ethnomedicine. For example, *S. biafrae* is used in the treatment of pulmonary complaints, *S. petitianus* for head colds, *S. abyssinicus* for liver conditions, *S. baberka* and *S. manni* for venereal diseases, and *S. lyratipartus* as an emetic (Burkill, 1985; Iwu, 1993). Also at these high altitudes are the giant lobelias (Campanlaceae). All members of this genus contain a number of alkaloids (iobeline, iobelanidine and norlobelanidine), which have stimulating effects upon the entire body lasting a quarter of an hour. Higher doses may have narcotic effects, and New World Indians use many species of *Lobelia* as remedies and inebriates (Rätsch, 1992). It is also of interest that lobeline is a respiratory stimulant. Gorillas feed on *L. giberroa* and *L. wallastonii*. Schaller (1963) found *L. giberroa* to be very abundant at Kabara, but observed only five gorillas that briefly fed on these plants. Injured plants exude a sticky white

fluid that adheres to the skin, is extremely bitter to the taste, and is painful in the eyes. With *L. wollastonii*, the gorillas snapped the heads off young plants to eat the soft pulp at the base of the leaves. They also pulled up the root, which they peeled by biting off the bark (Schaller, 1963). Watts (1984) noted that they ate the ephelium from the roots of *S. johnstonii* and *L. wollastonii* in small quantities.

That these gorillas travel to the high escarpments rarely, expending a great deal of energy in the process, only to spend a few days in a zone presumably lacking in an abundance of nutritional food requires an explanation. The current evidence suggests that gorillas have a tendency to ingest some plants abundant in caffeine and other heart stimulating alkaloids. It is interesting to speculate as to why this should be. Gorillas, especially adult males, are large primates that lead fairly active lifestyles. In mountain forests, particularly the Virunga Volcanoes, gorillas traverse steep slopes in oxygen-thin atmospheres, so it is not difficult to surmise that under both these environmental conditions, that like humans, cardiac stimulants would not only be desirable, but highly adaptive.

The highland gorillas are apparently also fond of medicinal mushrooms. Fossey (1983: 52) wrote: "Still another special food is bracket fungus (*Ganoderma applanatum*), a parasitic tree growth resembling a large solidified mushroom. The shelf-like projection is difficult to break free from the tree; so younger animals often wrap their arms and legs awkwardly around a trunk and content themselves by only gnawing at the delicacy. Older animals who succeed in breaking the fungus loose have been observed carrying it several hundred feet from its source, all the while guarding it possessively from more dominant individuals' attempts to take it away. Both the scarcity of the fungus and the gorillas' liking of it cause many intragroup squabbles, a number of which are settled by the silverback, who simply takes the item of contention for himself."

Ganoderma applanatum (Polyporaceae), also known as "Artist's Conk" and "Red Mother Fungus", grows on a variety of hosts around the world. It has been found to contain various steroidal compounds, such as ergosterol, ergosta, fungisterol, alnusenone, friedelin and other triterpenes. The fungus has demonstrated immunostimulating properties in animal studies (Hobbs, 1995). Doses of nucleic acid isolated from the mycelium conferred protection against tick-borne encephalitis virus in mice, while polysaccharides (from 10-50 mg/kg) from the mushroom have been found to increase spleen cell proliferation in vitro and stimulate antitumour activity against sarcoma 180 in mice, as well as increase spleen cell primary antibody responses to sheep red blood cells. Single doses of polysaccharides (from 10-50 mg/kg) have produced a 100% tumour inhibition ratio (Hobbs, 1995). In China, *G. applanatom* is believed to be useful for rheumatic tuberculosis and oesophageal cancer. It also exhibits antibiotic properties and shows activity against other types of cancer (Hobbs, 1995). In neighbouring Bwindi's Impenetrable Forest *G. australe* is used medicinally by local people, and also ingested by gorillas (J. Berry, personal communication). Although no medicinal properties have yet been scientifically recorded for this species, the genus *Ganoderma* generally includes a number of species that have been used medicinally, or may prove useful in the future, such as *G. lucidum, G. capense, G. japonicum, G. sinense* and *G. tsugae* (Hobbs, 1995).

III. Antiparasitic, Antifungal, Antibacterial, and Antiviral Properties of *Aframomum* spp. (Zingiberaceae)

Several species from the genus *Aframomum* are major food plants for gorillas and chimpanzees throughout the lowland rainforests and in many montane areas (Appendix 3). There appears to be regional preferences. In the coastal forests of southern Cameroon and Equatorial Guinea *A. hanburyi* and *A. subsericeum* are heavily utilised by gorillas, while *A. giganteum* is rarely eaten (Bullock, 1981). Gorillas in south-eastern Cameroon favour *A. danielli*, and it is part of their stable diet (Merfield, 1954). Bioassays of the extract of *A. danielli* have been made by Adegoke and Skura (1994), revealing active growth inhibitors of *Salmonella enteriditis, Pseudomonas fragi, P. flourescens, Proteus vulgaris, Streptococcus pyogens, Staphylococcus aureus, Aspergillus flavus, A. parasiticus, A. ochraceus* and *A. niger*.

In other parts of Equatorial Guinea and in parts of Gabon *A. giganteum* takes precedence as favourite with gorilla populations. The Eschira people of Gabon use the seeds of the fruit as an anthelmintic, the fruit pulp as a light laxative and the macerated roots for treatment against dental decay (Raponda-Walker & Sillans, 1961). Also in Gabon, the Basango pound the stem in water and the liquid is then consumed to counteract intestinal worms.

A. giganteum has been shown to contain quercetin and kaempferol, both possessing antibacterial activities which inhibits the growth of fungi and yeast. They also display potent antiviral responses and are anti-inflammatory. Another agent is syringic acid which has been shown to be a significant local anaesthetic and to have specific anti-Parkinson action (Neuwinger, 1996).

Gorillas living in the Mamfe region of West Cameroon eat the fruits of *A. melegueta* (Migeod, 1925). Bioassays on the fruit and seeds have been tested against several bacterial and fungal strains (Oloke *et al*., 1988). The crude extracts revealed potent bactericidal activities against *Escheria coli, Pseudomonas aeruginosa, Yersinia entercolitica, Bacillus subtilis, Proteus vulgaris, Klebsiella pneumoniae* and *Serratia marcescens*. Fungicidal activities inhibited *Candida albicans, Trichophyton mentagrophytes, Aspergillus niger, Botryodiplodis theobromae* and species of *Cladasporium* cladosporiodes. Ethnic groups use different parts of the plants for the preparation of folk remedies. In southern Nigeria the fresh fruit is used as an aphrodisiac, the leaf for measles and externally for leprosy, and the root decoction is taken by nursing mothers to reduce excessive lactation (Iwu, 1993).

There are some fifty species of *Aframomum* in Africa, about half of them in the Cameroon-Gabon region. They are closely allied to the *Amomum* of Asia, and indeed some species of *Amomum* are used ethnomedicinally in south-east Asia (Perry, 1980). During low fruiting seasons orangutans (*Pongo pygmaeus pygmaeus*) living in the Gunung Palung National Park, Borneo eat the stems of *Amomum* (Knott, 1998).

A full list of all *Aframomum* spp. exploited by the African apes has yet to be catalogued; present knowledge suggests that *A. sanguineum* is the most popular with gorillas in at least 5 distinct regions spanning Cameroon, Gabon, Congo-Brazzaville, Central African Republic, Congo-Kinshasa, and Uganda (e.g. Calvert,

1985; Tutin & Fernandez, 1985; Sabater Pi, 1977; Yamagiwa *et al*., 1994; Goodall, 1979; Schaller, 1963). Dr. J.M. Lock, an authority on the taxonomy of the genus *Aframomum* regards *A. sanguineum* as a synonym of *A. angustifolium* (J.M. Lock, personal communication). It is used as an anthelmintic in East Africa, where the seeds are ground with finger millet to make a paste that is stirred in water, making gruel. It is also considered to be a reliable remedy for stomach-ache, while a decoction of the root is taken for dysentery (Kokwaro, 1976).

Bioassays of *A. sanguineum* conducted by John Berry of Cornell University (unpublished data) demonstrated that the flesh and seeds of the fruits contained powerful inhibitors of bacterial growth, acting against *Bacillus cereus, Staphylococcus aureus, Escherichia coli* and *Pseudomonas aeruginosa*. The fruits of *A. milbraedii*, a species sympatric with *A. sanguineum*, revealed no similar antibacterial agents. It is possible that toxins in this species could be sited in other parts of the plant.

Owing to the fact that a number of *Aframomum* species exploited by the great apes demonstrate a wide range of antibacterial and antifungal activities, it is possible that the herbs are as much a source of preventative medicine as they are considered an important source of food (Wrangham *et al.*, 1991; Kuroda *et al*., 1996). In fact, some species may be so strongly antibiotic that young apes have to regulate their intake. Blancou (1955) observed that captive infant gorillas avidly ate the plants on certain days, but stubbornly refused them on others. Even a captured adult male suffered from diarrhoea when it ate more than five or six *Aframomum* fruits at a time (Schaller, 1963).

THE ACQUISITION OF MEDICINAL PLANT USE IN APES AND HUMANS

Primates acquire knowledge of food plants early on in life, and at a few years of age are already confident at selecting favoured items. Each day confiscated gorilla infants at the Brazzaville orphanage were allowed to forage in a remnant patch of forest nearby. They deliberately choose certain plants, with the youngest animals following the example of the senior ones. Abel M'Passi, a Congolese botany student from Brazzaville University, collected samples of everything the gorillas consumed, eventually identifying 57 plant foods. He suggested that the young gorillas were eating certain plants appropriately when suffering from diarrhoea and/or parasitosis by utilising plant species known locally for their medicinal properties. Among the plants listed were *Alloyphyllus africanas, Caloncoba welwitschii, Costus afer, Elaeis guineensis, Musa sapientum, Palisota hirsuta* and *Solanum torvum* (Attwater, 1999; Mark Attwater, personal communication)

Bitter taste is a reliable signal for toxicity and a number of secondary compounds ubiquitous in nature taste bitter (e.g. saponins, alkaloids, terpenoids, steroid glycosides and some sesquiterpenoids). Many also possess important pharmacological activity. Selective association between taste and gastrointestinal illness is a widely accepted principal of taste aversion learning among mammals (cf. Revusky, 1984) and the learning mechanism of food aversion in response to induced sickness has been well documented in a number of animal species (see Zahorik & Houpt, 1977).

While the highly adaptive significance of the reversed process, i.e., being able to associate improved health with the ingestion of novel plants having medicinal properties, seems self-evident, such learning mechanisms have received little attention (cf. Zahorik, 1977) and is an area greatly in need of further research.

In non-human primates, important benefits also come from social learning, which allow naive individuals to acquire information through the experience of others, and over time to perfect the behavior themselves. Although infant apes almost certainly learn about medicinal plants, just as they do about food plants, from their elders, the question remains as to how this knowledge was acquired in the first place. It is not simply a question of which plant to use, but the exact part of the plant and how to ingest it, at the same time avoiding the dangers of toxicity. What is almost certain is that if great apes can overcome such complexities, then surely the ancestors of man must have had the same capacity (Huffman, 2001). It is most likely that many plant foods of the early hominids, like those of modern apes, contained secondary compounds that were inhibitory agents to pathogens, thus aiding to preserve the health of the ingestor.

Our earliest hominid ancestors can be predicted to have exhibited some similarities in plant selection criteria with both extant apes and modern humans. The fossil record provides no direct evidence for the finer subtleties of feeding behavior and diet, but it seems reasonable to hypothesize that early hominids would have displayed at least the range of extant ape self-medicative behaviours. A major turn of events in the evolution of medicine is likely to have come about in early humans with the advent of language to share and pass on detailed experiences about plant properties and their effect against disease.

It is also likely that humans watching the behaviour of sick animals discovered the medicinal properties of many plants early on in our history (Huffman, 2001). Hallucinatory-type behavior has also been demonstrated in mammals and birds under controlled laboratory conditions, while erratic behaviour has been observed in various species in the field after they had been affected by drug plants (Siegel & Jarvik, 1975). As early as 1888, it was postulated that medicinal plants have outstanding peculiarities of taste, usually bitter, pungent, aromatic, astringent or acidic, (which effectively covers most plants), and frequently a peculiar smell as well (Smith, 1888). He suggested that by these notable qualities two to three hundred species could be selected from the nine thousand South African plants, thus greatly narrowing the field of experiment by trial and error.

The strong similarities in plant selection criteria among the African great apes in response to parasite infection and gastrointestinal upset and the common use of some plants by chimpanzees and humans for treating such illnesses is tantalising evidence for the evolution of medicine and the impact made by parasite infection. The survey presented in this paper also points to several possibilities among the gorillas.

FUTURE PROSPECTS FOR MULTIDISCIPLINARY RESEARCH IN ETHNOPHARMACOLOGY AND ANIMAL BEHAVIOR

It is possible that some *Aframomum* species could be a key factor in modulating parasite loads via chemical action, particularly the nematode *O. stephanostomum*. In the past, wild-caught infant gorillas have suffered massive infections, although free-living animals have not appeared to suffer unduly from the worms. At the Ikunde Centre, a former arm of the Barcelona Zoo situated at Bata, Rio Muni (now Equatorial Guinea), all gorillas that were taking milk were infected with this strongyle nematode. The celebrated white gorilla, "Copito de Nieve", showed an abundance of *Oesophagostomum* eggs when he arrived at the centre (Sabater Pi, 1967). During this time 80% of all captured infant gorillas succumbed to *oesophagostomiasis*. Rousselot & Pellissier (1952) describe *O. stephanostomum* in nine wild-caught gorillas (ages ranged from 18 months to 3 years) in the Brazzaville Zoo. Symptoms began 30 to 40 days (equal to the parasites' prepatent period) after capture, and at autopsy all exhibited intestinal nodules ranging in number from 7 to 60.

Oesophagostomum spp. infections are common in non-human primates, pigs, sheep, cattle and occasionally humans, and are considered significant pathogens (cf. Polderman *et al*., 1991). *O. stephanostomum* has been identified as a major parasite linked to and effectively controlled by self-medicative behavior in chimpanzees in the Mahale Mountains of western Tanzania (Huffman *et al*., 1993, 1997; Huffman, Page *et al*., 1996; Huffman & Caton, 2001).

While a number of broad spectrum anthelmintics are currently available for the treatment of livestock, growing chemoresistance to these anthelmintics and the prohibitive costs of such drugs to developing African nations make their use impractical if not at times impossible (Jackson, 1993; Mathias *et al*., 1996; Roepstorff *et al*., 1987). Recently, great interest has been taken in ethnoveterinary research and development, a fast growing field which is looking for new ways of treatment using natural plant products derived from ethnomedicine (cf. Mathias *et al*., 1996). Combined, ethnopharmacology and the emerging field of animal self-medication have the potential to evaluate evolutionary strategies of health maintenance and contribute to the development of biologically sound health care strategies in the 21st Century (Huffman *et al*., 1998). We hope that this paper will stimulate such research by others in this ripe new field.

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Appendix 1. Some Ethnomedical Plants in the Diets of *Gorilla g. gorilla* and *Gorilla g. graueri*.

Family	Species	Ethnomedical uses	Plant parts eaten by gorillas
Acanthaceae	*Crossandra guineensis*	Leaves used for diarrhoea and skin diseases. [1]	Leaves [2]
	Thomandersia laurifolia	Leaves and roots used for coughs, fevers, asthma, dysentery, fatigue, vaginal infection and anthelmintic. [1]	Leaves [2]
Aniosophylleaceae	*Poga oleosa*	Kernel and leaves used as emollient, laxative and for skin diseases. [3]	Fruits [4]
Annonaceae	*Annodium manni*	Bark used as sedative and dysentery and gastro-enteritis. [1]	Fruits, Bark [5, 6]
	Polyalthia suaveolens	Fruits, roots and leaves used as aphrodisiac, deparasitant, rheumatism, and toothache and as an anti-inflammatory. [1]	Fruits [2, 5, 6]
	Xylopia aethiopica	Fruits and whole plant used as carmanative and analgesic. [3, 7, 8]	Leaves [9]
Araceae	*Anchomanes difformis*	Roots and leaves used for constipation and coughs. [1, 3, 7, 10]	Leaves [9, 11]
	Colocasia esculenta	Tubers and leaves used for whitlow and potherb. [3, 7, 10]	Roots [4]
	Cyrtosperma senegalense	Roots used as sedative, analgesic and purgative. [1]	Roots [2]
Apocynaceae	*Landolphia owariensis*	Twigs, leaves and stem used for colic, venereal diseases. [1, 3, 7, 10]	Leaves, Bark [6]
	Pycnobotrya nitida	Leaves and fruits used for bronchopneumonia, dysentery [1]	Pith [6]
	Rauwolfia macrophylla	Intestinal complaints, syphilis. [12]	Fruits [4]
	Saba comorensis (var. florida)	Flowers used for jaundice, haemoglobin. [1]	Fruits [2]
	Tabernaemontana crassa	Bark used as anthelmintic, skin diseases, leprosy. [1, 8, 10]	Fruits [2]
	Tabernanthe iboga	Roots, stem and bark used for debilitating illness of unknown origin, aphrodisiac, hallucinogen and tonic. [1, 10, 12]	Fruits, Leaves, Roots [12, 13, 14]
Asclepiadaceae	*Tylophora syvatica*	Dermatitis, ovarian problems and coughs. [1]	Leaves, Bark [4]
Bromeliaceae	*Ananas comosus*	Fruits and leaves used for arthritis, venereal diseases and skin eruptions, laxative. [1, 3, 7]	Fruits, Bark [4]
Burseraceae	*Canarium schweinfurthii*	Fruits, stems and barks used for coughs, venereal diseases and as exudate. [1, 3, 10]	Fruits [6]

Appendix 1. (continued)

Family	Species	Ethnomedical uses	Plant parts eaten by gorillas
Caesalpiniaceae	*Anthonotha gilletii*	Diuretic, oedema [8]	Fruits [6]
	Brachystegia eurycoma	Seeds and leaves used as anthelmintic. [3]	Leaves [9]
	Detarium macrocarpum	Fruits and leaves used for dysentery and syphilis. [3]	Fruits [2, 9]
	Dialium dinklagei	Fruits and leaves used as anti-tussle, anti-infective. [6]	Fruits [3]
	Dialium pachyphyllum	Leaves and bark used for pain relief and coughs. [1]	Fruits [2]
	Gilbertiodendron dewevrei	Used for dysentery. [1]	Seeds [2]
Capparidaceae	*Bucholzia coriacea*	Fruit and seed used for purgative and anthelmintic. [7, 10, 12]	Fruit [12]
Caricaceae	*Carica papaya*	Leaves and fruits used for fever malaria. Roots used for yaws. [3, 7, 8]	Trunk [4]
Cecropriaceae	*Myrianthus arboreus*	Leaves, roots and stem used for dysentery, skin infections and as anthelmintic. [7]	Fruits [6]
Chrysobalanaceae	*Parinari excelsa*	Fruit and stem used for diarrhoea, dysentery and as tonic. [3]	Fruits [2]
Combretaceae	*Quisqualis latiolata*	Used for diarrhoea, dysentery and haemorrhoids. [1, 7]	Bark [4]
Commelinaceae	*Palisota hirsuta*	Stems and leaves used for sore throat, coughs, and toothache. Sap used as anthelmintic. [3, 10]	Fruits [4, 5, 6]
Compositae	*Gynura scandens*	Crushed leaves used for fevers. [15]	Bark [16]
	Vernonia conferta	Leaves, stems and roots used for coughs, stomach ache and yaws and as anthelmintic. [1, 3, 7]	Fruit, Pith [4]
Cucurbitaceae	*Cucumeropsis edulis*	Seeds used as vermifuge and purgative. [3]	Buds, Pith [4]
Ebenaceae	*Diospyros crassiflora*	Used for ovarian problems and eye complaints. [1]	Fruits [2]
Euphorbiaceae	*Alchornia cordfolia*	Leaves, stem, bark and roots used for malaria, urinary, respiratory and gastrointestinal disorders, skin infections and as a purgative. [1, 3]	Fruits [4, 6]
	Alchornia floribunda	Roots and fruits as hallucinogen aphrodisiac and for urinary, respiratory and intestinal disorders. [1]	Fruits, Bark [4, 6]

Appendix 1. (continued)

Family	Species	Ethnomedical uses	Plant parts eaten by gorillas
	Macaranga kilimandscharica	Root extract used for bilharzia. Decoction of roots and leaves for stomach problems. [15]	Bark [16]
	Manihot esculenta	Leaves and tubers used for diabetes. [3, 8]	Tubers [5]
	Manniophytum fulvum	Stem, bark and twigs used for dental caries, leprosy, venereal diseases, and skin infections and as anthelmintic. [1, 3]	Leaves [4]
Flacourtiaceae	*Caloncoba glauca*	Seeds used for migraine, leprosy and as aphrodisiac. [1, 8, 10]	Fruits [2]
	Caloncoba welwitschii	Used for bronchitis, rheumatism and headache and as anthelmintic. [1, 8]	Fruits, Bark [2]
	Oncoba spinosa	Fruits and leaves used for colds, fevers and female infertility. [1, 3]	Leaves [9]
Gentianaceae	*Gentium africanum*	Leaves and stems used as purgative and tonic. [3]	Leaves [2]
Gramineae	*Pennisetum purpureum*	Leaves used for mouth infections, gingivitis, and thrush. Mild laxative. [3, 12]	Leaves [16]
	Saccharum officinarum	Stem and leaves used as laxative. [3]	Fruits [4]
	Zea mays	Diuretic and for urinary infections. [12]	Roots [4, 16]
Guttiferae	*Garcinia kola*	Seeds, stems, roots and bark used for coughs, inflammation of respiratory tract, poison, antidote and as an aphrodisiac. [1, 3]	Fruits [2]
	Mammea africana	Fruits, leaves and bark used for fevers, skin infections, diarrhoea and bronchitis. [1, 3]	Fruits [2, 4, 9]
Humiraceae	*Saccoglottis gabonensis*	Fruits, leaves and stems used for fevers and emetic. [1, 3]	Fruits [4]
Icacinaceae	*Iodes africana*	Leaves used as decongestant for respiratory complaints, sinusitis, bronchitis and diarrhoea. [1]	Leaves [6]
Irvingiaceae	*Irvingia gabonensis*	Fruit rind, roots and bark used for fevers. [1, 3]	Fruits [2, 5, 9]
Leguminosae	*Albizia gummifera*	Crushed pods taken for stomach pains. Pounded roots in water for skin conditions, bark decoction for malaria. [15]	Roots, Bark [6]

Appendix 1. (continued)

Family	Species	Ethnomedical uses	Plant parts eaten by gorillas
Loganiaceae	*Anthocleista vogelli*	Stem, bark and leaves used as anti-inflammatory, anti-diabetes and for venereal diseases. [1), 3)]	Leaves [9)]
Marantaceae	*Haumania danckelmaniana*	Roots used as anthelmintic. [1)]	Shoots [2), 4), 11)]
	Marantochloa congensis	Roots used as purgative. [1)]	Pith [2)]
	Thaumatococcus danielli	Fruit and leaves used for liver disorder and as laxative. [1), 3)]	Fruits, Pith [6)]
Meliaceae	*Trichilia heudelottii*	Stem, roots and leaves used as anthelmintic, diuretic and aphrodisiac. [1), 3)]	Flowers [2)]
Menispermaceae	*Triclisia dictyophylla*	Roots used for malaria and anticonvulsant. [1), 8)]	Fruits [2)]
	Triclisia patens	Roots used for oedema, rheumatism and arthritis. [1), 8)]	Fruits [2)]
Mimosoideae	*Parkia filicoldea*	Fruits and leaves used for inflammation. [3)]	Fruit, Pulp [9)]
	Pentaclethra macrophylla	Bark, fruits and leaves used as anthelmintic and as analgesic. [1), 3)]	Leaves [9)]
	Tetrapleura tetraptera	Fruits and whole plant used for flatulence, jaundice, fevers and convulsions. [1)]	Fruits, Seeds [2), 11)]
	Piptadeniastrum africanum	Stem, bark and roots used for oedema, constipation, dropsy and as anthelmintic. [1), 10)]	Leaves, Bark [9)]
Moraceae	*Chlorophora excelsa*	Roots, leaves and fruits used as tonic and for inflammation. [1), 3)]	Leaves [2), 4), 6), 9)]
	Ficus exasperata	Leaves used for coughs and venereal diseases. [1), 3)]	Fruits [2)]
	Ficus mucuso	Used for bronchitis, otitis, convulsions and as analgesic. [1)]	Leaves, Pulp [4)]
	Ficus natalensis	Fruits and leaves used for pains and venereal diseases. [15)]	Leaves, Fruits [6)]
	Ficus thonningii	Leaves and fruits used for bronchitis and urinary tract infection. [1), 3)]	Fruit, Pulp [9)]
	Musanga cecropioides	Leaves and stem used for fevers and as emmenagogue. [3)]	Roots [2)]

Appendix 1. (continued)

Family	Species	Ethnomedical uses	Plant parts eaten by gorillas
	Musanga smithii	Fruits, leaves, bark and sap used for broncho-pneumonia, leprosy, gonorrhoea, rheumatism and as an anthelmintic. [1)]	Fruits [17)]
	Treculia africana	Fruits and leaves used for chronic coughs, skin infections and as anthelmintic. [1), 3)]	Fruits [2), 3), 6), 9)]
Musaceae	*Musa paradisiaca*	Fruits and leaves used as potent astringent, hemostatic and for indolent ulcers. [3)]	Leaves, Fruit [3), 11)]
	Musa sapientium	Fruit rind and leaves used as anthelmintic aphrodisiac and for high blood pressure. [3)]	Fruits [4)]
Myrisinaceae	*Maesa lanceolata*	Fruits used as anthelmintic and purgative and for sore throat. [1)]	Bark [16)]
	Pycnanthus angolensis	Seeds and stem bark used for skin diseases, mouth sores, fevers, asthma and whooping cough. [1), 3)]	Leaves, Fruit [2), 4), 5), 6)]
Ochnaceae	*Lophira alata*	Bark used for visceral pains, toothache, convulsions, and epilepsy. [7)]	Leaves [9)]
Olacaceae	*Strombosiopsis tetandra*	Fruits, roots and leaves used for ovulation problems, rheumatism and epilepsy. [1)]	Fruits [2)]
Palmae	*Ancistrophyllum secudiflorum*	Shoots and sap used as vermifuge, tonic and for fever and dysentery. [3)]	Pith [5)]
	Elaeis guineensis	Leaves, fruit and roots used as analgesic, antibacterial and poison antidote. [1), 3)]	Fruits, Pith [6)]
	Eremospatha haubevilleana	Leaves and roots used for hernia, otitis and as anthelmintic. [1)]	Pith [6)]
Papilionoideae	*Pterocarpus soyauxi*	Leaves, stem, bark used for fever. [3)]	Bark, Leaves, Seeds, Buds [4), 8)]
Passifloraceae	*Adenia cissampeloides*	Roots and stem used as anthelmintic and poison antidote. [15)]	Bark [16)]
	Barteria nigritiana	Fruits and leaves used for fevers, aches and stomach disorders. [1), 3)]	Fruits [2)]
	Passiflora foetida	Leaves used for anxiety and sleeplessness. [1), 3)]	Fruits [3)]
Rubiaceae	*Nauclea didrichii*	Roots and stem used for malaria and as febrifuge. [3)]	Fruits [9)]
	Porterandia cladantha	Leaves used as aphrodisiac and for eczema, diarrhoea and local pain relief. [1), 3)]	Leaves [2)]

Appendix 1. (continued)

Family	Species	Ethnomedical uses	Plant parts eaten by gorillas
Sapotaceae	*Baillonella toxisperma*	Fruits, medullas and leaves used for vaginal infections, epilepsy, rheumatism and gingivitis. [1)]	Medullas, Fruit [5)]
	Gambeya lacourtiana	Fruits used for vaginal infections, rheumatism and uterine haemorrhage. [1)]	Fruits [2)]
Sapindaceae	*Allophyllus africanus*	Fruits, leaves and roots used for diarrhoea, arthritis, headache, nasal congestion, colic and as anthelmintic. [3)]	Fruits [2)]
	Lecaniodiscus cupanoides	Stem, bark and leaves used for abdominal swelling caused by liver abscess and for fevers. [1), 3)]	Fruits [9)]
Selaginellaceae	*Selaginella myosurus*	Used for asthma, fever and defatigant. [1)]	Leaves [4)]
Smilacaceae	*Smilax kraussiana*	Roots used for venereal diseases, fevers and as tonic. [3), 10)]	Leaves, Flowers, Pith [4), 16)]
Solanaceae	*Solanum torvum*	Leaves used for epilepsy. [1), 3), 10)]	Leaves, Pith [4), 16)]
Sterculiaceae	*Cola gabonensis*	Roots, fruits and leaves used for migraine, scabies and as aphrodisiac. [1)]	Fruits [2)]
	Cola nitida	Fruits used as stimulant and in healing rituals. [3), 8), 12)]	Seeds [2)]
	Cola pachycarpa	Fruits and leaves used for coughs internal heat. [3)]	Seeds [12)]
	Theobroma cacao	Fruit pods and leaves used for lactation and as stimulant and emollient. [12)]	Fruits [4)]
Tiliaceae	*Duboscia macrocarpa*	Fruits used for tuberculosis and dental problems. [1)]	Fruits [2), 8)]
Ulmaceae	*Celtis adlofi-friderici*	Fruits used for tuberculosis. [1)]	Fruits [2)]
	Celtis brieyi	Leaves, fruits and roots used for dysentery, rheumatism and as antianaemic. [1)]	Leaves, Fruit, Bark [6)]
Urticaceae	*Urera hypselodendron*	Leaves in water given to sick children. Decoction of stems mixed with milk for abdominal pains in pregnant women. [15)]	Bark [6), 16)]
Verbenaceae	*Vitex doniana*	Roots and leaves used for nausea, colic and epilepsy. [1), 3)]	Leaves [2), 9)]
Zingiberaceae	*Costus afer*	Stem and rhizomes used for coughs, hypertension, arthritis, skin diseases and as an aphrodisiac. [3), 8), 12)]	Leaves [6), 9)]
	Costus lucanusianus	Used to control filarial worms, ulcers and bronchitis. [12)]	Fruit, Stem [4)]

Appendix 1. (continued)

Family	Species	Ethnomedical uses	Plant parts eaten by gorillas
	Renealmia africana	Leaves and fruit used for medicinal purposes. [1), 12)]	Fruit [4)]

[1)] Bouquet *et al*., 1971; [2)] Nishihara, 1995; [3)] Iwu, 1993; [4)] Sabater Pi, 1977; [5)] Tutin & Fernandez, 1985; [6)] Yamagiwa *et al*., 1994; [7)] Burkill, 1985; [8)] Oliver-Bever, 1986; [9)] Rogers *et al*., 1990; [10)] Neuwinger, 1996; [11)] Calvert, 1985; [12)] Raponda-Walker & Sillans, 1961; [13)] Bützler, 1980; [14)] Valker, 1931; [15)] Kokwaro, 1976; [16)] Schaller, 1963; [17)] Merfield, 1954

Appendix 2. Some Ethnomedical Plants in the Diets of *Gorilla g. beringei* in the Virunga Volcanoes.

Family	Species	Ethnomedical uses	Plant parts eaten by gorillas
Boraginaceae	*Cynoglossum geometricum*	Crushed leaves inhaled for treatment against fever and influenza. [1), 2)]	Roots, Leaves, Part of stem [3), 4), 5)]
	Cynoglossum lanceolatum	Diaphoretic and expectorant. [6)]	Shoots, Root [5)]
Compositae	*Crassocephalum bojeri*	Crushed leaves and juice drunk for colds and as an antidote for fever and rheumatism. [2)]	Bark [3), 4)]
	Mikania cordata	Decoction of leaves used for headaches. [1), 2)]	Leaves [3), 4)]
	Senecio maraguensis	Leaves used for yaws, syphilis, and gonorrhoea. [6)]	Roots [3), 5)]
Gramineae	*Pennisetum purpureum*	Mild laxative, mouth infections, gingivitis, thrush. [1)]	Leaves [3)]
Menispermaceae	*Stephania abyssinica*	Leaves used as purgative, roots used as aphrodisiac and for roundworm, stem juice used as an emetic. [1)]	Fruits [3), 4)]
Monimiaceae	*Xymalos monospora*	Softened leaves used for sores, dried roots for cuts and aches. [2)]	Fruits, Bark [3), 4)]
Myrsinaceae	*Rapenea pulchra*	Fruits used as anthelmintic. [2)]	Bark [4), 5)]
Piperaceae	*Piper capense*	Seeds used as cough medicine, roots used as anthelmintic. [2)]	Bark, Stem [3), 4)]
Polygonaceae	*Rumex usambarensis*	Leaves used for liver and stomach conditions for constipation in children and for abdominal pain during pregnancy. [2)]	Stem [4)]
Ranunculaceae	*Clematis simensis*	Leaves chewed and juice swallowed as cure for headache and colds. Root decoction drunk for treatment of malaria and as purgative. [2)]	Bark [4)]
Rosaceae	*Hagenia abyssinica*	Roots used for general illness and malaria. Flowers used for intestinal worms, especially tapeworm. Bark for diarrhoea and stomach-ache. [1), 2)]	Pit Bark, Roots [4), 5)]
	Pygium (Prunuus) africanum	Leaves inhaled for fever. Bark for stomach-ache. [1)]	Bark, Fruits [3), 4), 5)]
Urticaceae	*Urera hypselodendron*	Decoction of stems mixed with milk given to pregnant women for abdominal pains. [2)]	Bark [3), 4)]

[1)] Iwu, 1993; [2)] Kokwaro, 1976; [3)] Fossey, 1983; [4)] Schaller, 1963; [5)] Watts, 1984; [6)] Watt & Breyer-Brandwijk, 1962

Appendix 3. *Aframomum* spp. Utilised by *Gorilla spp.*

Location	Species	Parts eaten	Reference
S.W. Cameroon			Calvert, 1985
(Campo Reserve)	*A. danielli*	Shoots	
	A. giganteum	Shoots	
	A. hanburyi	Shoots	
	A. subsericeum	Shoots	
S.E. Cameroon			Merfield, 1954
	A. danielli	Pulp, Pith	
	A. albo-violaceum (syn. *A. stipulatum*)	Fruit	
W. Cameroon			Migeod, 1925
(Mamfe region)	*A. melegueta*	Fruit	
Gabon			Tutin & Fernandez, 1985
	A. danielli	Fruit, Pith	
	A. giganteum	Fruit, Pith	
	A. leptolepsis	Fruit, Pith	
	A. letestuanum	Fruit, Pith	
	A. limbatum	Pith	
	A. polyanthum	Fruit	
	A. subsericeum	Fruit, Pith	
Central Gabon			Rogers *et al*., 1990
(Lope Reserve)	*A. longipetiolatum*	Pulp, Stem	
	A. leptolepsis	Pulp, Stem	
S.W. Gabon			P.H. Chanjou,
(Petit Loango Reserve)	*A. citratum*	?	(personal
	A. giganteum	?	communication)
Equatorial Guinea			Sabater Pi, 1977
	A. giganteum	Fruits, Medullas, Leaves, Buds	
	A. sanguineum	Leaf Buds	
	A. danielli	Leaf Buds	
	A. subsericeum	Terminal Buds	
	A. limbatum	Fruit	
Northern Congo-Brazzaville			
(Ndoki Forest)	*A. citratum*	Fruit	Nishihara, 1995
(Likouala Basin)	*A. angustifolium*	Leaves, Pith	Fay *et al*., 1989
S.W. Congo-Brazaville			M.D. Gouya,
(Koulilou Basin	*A. stipulatum*	?	(personal
Conkouti)	*A. sanquineum*	?	communication)
	A. leptolepsis	?	M. Vacher, (personal communication)

Appendix 3. (continued)

Location	Species	Parts eaten	Reference
S.W. Central African Republic (Dzanga Sangha)	*A. sulcatum*	Pith	Carroll, 1986
Congo-Kinshasa (Itebero)			Yamagiwa *et al*., 1994
	A. laurentii	Fruit, Pith	
	A. sanguineum	Fruit	
(Kahuzi-Biega)			Goodall, 1979
	A. sanguineum	?	
(Mwenga-Fizi)			Schaller, 1963
	A. sanguineum	Pith	
Uganda			Schaller, 1963
(Bwindi Forest)	*A. milbraedi*i	Fruit	D. Tukahabwa, (personal
	A. sanguineum	Fruit	communication)