IRD Éditions

Des sources du savoir aux médicaments du futur
| Jacques Fleurentin, Jean-Marie Pelt, Guy Mazars

Animal origins of herbal medicine

Michael A. Huffman

p. 31-42

Résumé

Parasites and pathogens cause a variety of diseases that affect the behavior and reproductive fitness of all animals. Because the need to counteract such pressure is great, anti-parasitic behaviors are predicted to occur throughout the animal kingdom. Early in the co-evolution of plant - animal relationships, some arthropod species began to utilize the chemical defenses of plants to protect themselves from their own predators and parasites. The origins of herbal medicine have their roots deep within the animal kingdom. From prehistoric times humans have looked to wild and domestic animals for sources of herbal remedies. Both folklore and more recent examples provide accounts of how the use of some medicinal plants are obtained by observing the behavior of animals. Animals too learn about the details of self-medication by watching each other. To date, perhaps the most striking scientific studies of self-medication have been made on the African great apes. The great ape diet is often rich in plants containing secondary compounds of non-nutritional, sometimes toxic, value that suggest medicinal benefit from their ingestion. Chimpanzees and humans co-existing in sub-Saharan Africa are known to use *Vernonia amygdalina* for the control of parasite infections. Phytochemical studies have demonstrated the wide array of biologically active properties in this plant species. In light of the growing resistance of parasites and pathogens to synthetic drugs, the study of animal self-medication offers a new line of investigation to provide ecologically sound methods for the treatment of parasites using plant-based medicines in people and their livestock living in the tropics.

Texte intégral

Animals in ethnomedecine

1 Throughout the history of humankind people have looked to animals for sources of herbal medicines and narcotic stimulation (Brander, 1931; Riesenberg, 1948). Anecdotal reports of the possible use of plants as medicine by wild animals such as the elephant, civet, jackal, and rhinoceros are abundant (Table I).

2 The Navajo living in the southwestern United States credit the bear for their knowledge of the antifungal, antiviral and antibacterial properties of the Umbelliferae *Ligusticum porteri* (Grasanzio, 1992; Moore, 1979).

3 *Tabernanth iboga* (Apocynacea) contains several indole alkaloids, and is used as a powerful stimulant and aphrodisiac in many secret religious societies in Gabon (Harrison, 1968). Harrison speculated that because of the wide spread reports from local people of bush pigs, porcupine and gorilla going into wild frenzies after digging up and ingesting the roots, they probably learned about these peculiar properties of the plant from watching the animals' behavior. The most active principle, found in the root, is called ibogaine and is shown to affect the central nervous system and the cardiovascular system. Two other active known compounds in the plant are tabernanthine and iboluteine. The stimulating effects are similar to caffeine (Dubois, 1955). The sloth bear and local people of central India are noted to become intoxicated from eating the fermented Madhuca flowers (Brander, 1931) and reindeer

and the indigenous Lapps consume fly agaric mushrooms known for their intoxicating effects (Phillips, 1981).

4 One version of the discovery of coffee is that the chance observation by a shepherd of goats becoming stimulated after grazing on the berries of wild coffee plants in the highlands of Ethiopia provided the clue for humans to exploit the plant as a stimulant. Dr. Jaquinto, the trusted physician to Queen Ann, wife of James I in 17th Century England, is said to have made systematic observations of domestic sheep foraging in the marshes of Essex which led to his discovery of a successful cure for consumption (Wilson, 1962).

5 My Tanzanian collaborator in research since 1987, Mohamedi S. Kalunde, a Tanzanian National Parks wildlife officer comes from a long line of traditional healers. He credits the discovery of at least two medicinal treatments passed down to him by his mother and late grandfather from their observations of animal behavior. One day, Mohamedi’s grandfather Babu Kalunde observed a young porcupine ingest the roots of a plant known locally as ‘mulengelele’ (yet unidentified species). Keeping it captive in the village compound for observation, he observed that it subsequently recovered from a severe case of diarrhea and malaise. Based on these observations, Babu Kalunde later successfully used the plant to treat a dysenterylike epidemic that broke out in his village. Mohamedi’s mother, Joha Kasante, discovered an antidote for snake bite by having Mohamedi follow the snake that bit his younger brother and bring back leaves of the plant that the snake subsequently chewed on. The leaves are said to prevent the snake’s poison from circulating throughout the body. In the foothills of the Himalayas near Mt. Everest the use of the roots of ‘chota-chand’ as a potent antidote for snake bite is said to have been learned by observing mongoose feeding on the plant before fighting with cobra (Balick & Cox, 1996). All of these examples suggest the occurrence of self-medication in a variety of animal species and ways that humans may learned about the medicinal value of plants from them.

6 Why should any of this really surprise us? After all, from an evolutionary standpoint, preservation of health is a basic

principle of survival and all species alive today can be expected to have evolved a variety of ways of protecting themselves from other organisms, large and small, in their environment.

7 Where did this all begin? In the plant world, a common line of defense is to produce a variety of toxic secondary compounds such as sesquiterpenes, alkaloids, and saponins which prevent predation by animals (Howe & Westley, 1988; Swain, 1978). At some point in their co-evolutionary history, likely starting with the arthropods, animals began to take advantage of the plant kingdom's protective chemical arsenal to protect themselves from predators and parasites and to enhance their own reproductive fitness (Blum, 1981). For example, adult danaine butterflies of both sexes utilize pyrrolizidine alkaloids for defense against predators and males have also been shown to depend on it as a precursor for the biosynthesis of a phe- romone component needed for courtship (Boppre, 1978; 1984). The monarch butterfly is reported to feed on *Asclepias* species containing cardiac glucosides which makes birds sick, conditioning them not to feed on the species (Brower, 1969). Such three-trophic level interactions are likely to have provided the foundation for the evolution of a more sophisticated level of self-medication seen in the higher vertebrates.

The impact of parasites on the evolution of self-medicative behaviour

8 Parasitism has played an important role in the evolution of host behavior throughout the animal kingdom (Anderson & May, 1982; Clayton & Moore, 1997; Futuyma & Slatkin, 1983). Co-evolution between host and parasite has resulted in the development of mechanisms by which the host limits parasitic infection and the parasite increases its chance of infecting the host (Toft *et al.*, 1991; Ewald, 1994). At the primary level, the host's immune response (innate & acquired) normally controls infections, however, some parasites invariably establish themselves by undergoing antigenic variation, thus disguising themselves with the

hosts antigens, or by interfering directly with the immune response (Cox, 1993; Wakelin, 1996) .

9 Where physiological adaptation is not enough, hosts have developed behavioral responses to avoid or limit contact with parasites and other pathogens. These behaviors, widespread among the vertebrates, include regular changing of sleeping or feeding sites, differential use of drinking sites, use of antiparasitic leaf material to line nests or dens occupied over long periods, and the application of aromatic substances to repel fur and feather infesting parasites (Baker, 1996; Clark, 1991; Freeland, 1980; Gompper & Holyman, 1993; Gresianzio, 1992; Hart, 1990; Hausfater & Meade, 1982; Kummer in Nelson, 1960; Seigstadt in Cowen, 1990; Sengputa, 1981). Learned aversion of foods or tastes associated with illness, parasite infection, and compensatory changes in host dietary preferences induced by parasites have been demonstrated in the laboratory and field for a wide range of vertebrates (Gustavson, 1977; Kyriazakis *et al.*, 1994; Keymer *et al.*, 1983). From what has been discovered about self-medication in the great apes over the last few years, parasites and gastrointestinal upset clearly appears to be a major focus of self-medication in non-human animals (Huffman, 1997).

10 These learned aversions are another level at which the host avoids prolonged exposure to pathogens. Diet modification has also been proposed as a means of altering or controlling internal parasite load. A causal relationship between a sudden change in diet and reduced tapeworm load has been suggested for black bears (Rausch, 1954; 1961). Another example of this type of behavior involves the ingestion of specific plant parts, which have little or no nutritional value, for their antiparasitic qualities, which may be either pharmacological (Huffman *et al.*, 1 993; 1998; Ohigashi *et al.*, 1994) or physical (Huffman *et al.*, 1996).

Food as medicine

11 From an evolutionary perspective, it seems likely that the use of many medicinal plants may have derived from the ingestion of rarely eaten or fall-back foods (eaten in periods

of main food shortage) with supportive medicinal properties. One of the challenges and difficulties of interpreting self-medication is distinguishing 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 medicinal properties. In some cases it may not even be necessary to draw the distinction.

12 When consumed on a fairly regular basis year round in seasons of wide availability, food and medicine may be one in the same. Particularly in traditional human societies, the difference between food and medicine is not always clear. A case in point is the study by Etkin (1996) which found 30% of the plant foods used among the Hausa of Nigeria are also used as medicine. Furthermore, 89% of species used to treat symptoms of malaria were also eaten in a dietary context (Etkin & Ross, 1983). Etkin and Ross propose that many Hausa foods were originally acquired from non-cultivated plants first used as medicine. Similarly, many traditional spices, condiments and vegetables of Asian cuisine used today, such as ginger root, marine algae, and various herbs contain significant sources of anti-tumor agents (Murkami *et al.*, 1994; 1996; Ohigashi *et al.*, 1992) that may also have an active role in the suppression of parasitic and viral infections.

13 Many of these "food-medicines" are beneficial beyond their nutritional value because of the variety of plant secondary compounds contained within. As discussed above, these compounds are considered to be produced by the plant to deter herbivores from ingesting them (Ehrlich & Raven, 1964; Feney, 1976; Howe & Westley, 1988; Wink *et al.*, 1993), but in small amounts such compounds may be of some benefit to the consumer. A number of plant foods found in the diet of the great apes appear to share these properties and are worth mentioning here.

14 The berries of *Phytolacca dodecandra* L. Herit (Phytolaccaceae) are an abundant and frequently ingested food item of the Kanyawara group of chimpanzees in Kibale, western Uganda (Wrangham and Isabirye-Basuta, in

Huffman and Wrangham, 1994). These bitter tasting berries are a concentrated source of at least 4 toxic triterpenoid saponins (lemmatoxin, lemmatoxin-C, oleanoglycotoxin-A, phytolacca-dodecandra glycoside). Consumption of about 2 grams of the material is fatal in mice and rats. Other known properties of these triterpenoid saponins include antiviral, antibacterial, antifertility, spermicidal and embryotoxic activities (Kloos & Me Cillough, 1987).

15 Pith and fruit of *Afromomum* species (wild ginger family) are commonly ingested by chimpanzees, bonobos and gorillas across Africa (Idani *et al.*, 1994; Moutsambote *et al.*, 1994; Nishida & Uehara, 1983; Sugiyama & Koman, 1992; Tutin *et al.*, 1994; Wrangham *et al.*, 1993; Yumoto *et al.*, 1994). A study in progress of the chemical ecology of Bwindi gorilla (*Gorilla gorilla beringei)* diet by John Berry (Rodriquez Laboratory, Division of Biological Sciences, Cornell University) is investigating the bioactivity of the fruit of one of these wild ginger species, *Afromomum sanguineum* (K. Schum.) K. Schum. (Zingiberaceae). The fruits of this species, in particular, are also known to be ingested by gorillas in the Kahuzi- Biega National Park, Congo-Kinshasa (Yumoto *et al.*, 1994). Assays of homogenized fruit and seed extracts show significant antimicrobial activity (Berry, in prep.). The fruits are sold locally in market stalls and along the road in the Bwindi area for the treatment of bacterial and fungal infection and as an anthelmintic (John Berry, personal communication).

16 The tips of the young leaves of *Thomandersia laurifolia* (T. Anders, ex Benth.) Baill. (Acanthaceae) are on rare occasion chewed by western lowland gorillas *[G. g. gorilla*) in the Ndoki forest of northern Congo (Kuroda, Mokumu, Nishihara, in prep). According to Kuroda and colleagues, the local human inhabitants use these leaves as a treatment for parasites and fever. Weak anti-schisto-somal activity has also been found from crude leaf extracts (Ohigashi, 1995).

17 Bark and wood are characteristically highly fibrous, heavily lignified, sometimes toxic, relatively indigestible and nutrient poor (Waterman, 1984). Chimpanzees and gorillas are known to infrequently ingest the bark and wood of several plant species (Huffman & Wrangham, 1994).

18 While the list of plant species whose bark is ingested is long, little is actually known about the contribution of bark to the diet and general health. The literature on African ethnomedicine warrants mention of a few of these species. The bark of *Pycnanthus angolensis* (Welw.) Warb. (*Myristicaceae*) ingested by chimpanzees at Mahale in western Tanzania is used by West Africans as a purgative, laxative, digestive tonic, emetic and reliever of toothaches (ABBIW, 1990). Bark strips of *Grewia platyclada* K. Schum (Tiliaceae) are sometimes chewed for the relief of stomach aches by local residents at Mahale (Huffman, unpublished data, Mohamedi S Kalunde, personal communication about human uses). In 1992 one juvenile male suffering from diarrhea was observed chewing, but not swallowing, the fibers of the bark of this species at Mahale (Huffman, unpublished data). In Tanzania, the chimpanzees of Gombe National Park occasionally eat the bark of *Entada abyssinica* Steud. ex A. Rich. (Mimosaceae). In Ghana, the bark is used by humans for diarrhea and as an emetic (Abbiw, 1990). The bark of *Erythrina abyssinica* DC. (Papilionacea) is occassionally eaten by Mahale chimpanzees. Significant plasmodicidal and antischistosomal activities have been demonstrated from the bark of this species collected at Mahale (Ohigashi, 1995; Wright *et al.*, 1993). The bark of *Gongronema latifolium* Benth. (Asclepiadaceae) occasionally eaten by the chimpanzees of Bossou Guinea is extremely bitter, and the stems are used by humans in West Africa as a purge for colic, stomach pains and symptoms connected with intestinal parasite infection (Burkill, 1985).

19 The preceeding discussion of peculiar fruit, leaf, bark, and wood items ingested by the apes serve to demonstrate the diversity of secondary compounds or inferred pharmacological activity present in their diet. The total effect of ingesting these items is not clear, but it is unrealistic to assume nutritional gain where little is likely to be obtained.

Use of plants as medicine of plants by chimpanzees in the wild

20 Perhaps due to our phylogenetic closeness, humans and chimpanzees select some of the same plants when displaying similar symptoms of illness (Huffman *et al.*, 1996a). Recent evidence from the African great apes suggests that certain plants are ingested, not incidentally, but directly for their significant medicinal value. The hypothesis currently being developed is that the behaviors aid in the control of intestinal parasites and / or provide relief from related gastrointestinal upset (Huffman *et al.*, 1996a; Huffman, 1997).

21 These observations provide the clearest systematic evidence collected thus far for self-medication in animals. Unquestionably, these implications of self-medicative behavior are of extreme interest when considering the early emergence of medicinal habits from the great apes to early hominids and modern humans.

Vernonia amygdalina and bitter pith chewing behavior

22 The hypothesis that bitter pith chewing has medicinal value for chimpanzees was first proposed from detailed behavioral observations and parasitological and phytochemical analyses of patently ill chimpanzees' ingesting *Vernonia amygdalina* Del. (Compositae) at Mahale (Huffman & Seifu, 1989; Huffman *et al.*, 1993). These are the first reported observations to verify illness and apparent improvement thereafter of an animal ingesting putative medicinal plants.

23 *V. amygdalina* occurs throughout tropical sub-Saharan Africa (Watt & Breyer-Brandwijk, 1962). Bitter pith chewing of other *Vernonia* species has been observed at Gombe, Tanzania (V *colorata* (Willde.) Drake: Huffman & Wrangham, 1994; Hilali, unpublished data as personal communication from J. Wallis) and Kahuzi-Biega, Congo-Kinshasa (V *hochstetteri* Schi-Bip., *V. kirungae* Rob. E. Fries: Yumoto *et al.*, 1994; A.K. Basabose, personal communication). At Tai, Ivory Coast, the bitter piths of *Paliosota hirsuta* (Thunb.) K. Schum. (Commelinacea) and *Eremospath macrocarpa* (Mann & Wendl.) Wendl. (Palmae) are chewed (C. Boesch, personal communication in Huffman, 1997).

24 When ingesting the pith from young shoots of *V. amygdalina,* chimpanzees meticulously remove the outer bark and leaves to chew on the exposed pith, from which they extract the extremely bitter juice and residual amounts of fiber. The amount of pith ingested in a single bout is relatively small, ranging from portions of 5 to 120 cm X 1 cm. The entire process, depending on the amount ingested takes anywhere from less that one to 8 minutes. Mature conspecifics in proximity to an individual chewing *Vernonia* bitter pith or leaf swallowing show no interest in ingesting the pith (Huffman & Seifu, 1989; Huffman *et al.*, 1997). Infants of ill mothers, however, have been observed on occasion to taste the pith discarded by their ill mothers. In this way, group individuals are exposed to both the behavior and the extremely bitter taste of the pith at a very young age.

25 At Mahale, use of *V. amygdalina* has been recorded in all months except June and October (late dry season), demonstrating its year-round availability (Nishida & Uehara, 1983). However, use by chimpanzees is highly seasonal despite its year round availability. It is most often used during the rainy season months of December and January, the time parasite re-infection by nematodes is at their peak in some species (Huffamn *et al.*, 1997).

The ethnomedicine and phytochemistry of bitter pith chewing

26 *V. amygdalina* is used by numerous African ethnic groups across the continent as medicine (Table II). A concoction made from this species is prescribed treatment for malarial fever, schistosomiasis, amoebic dysentery, several other intestinal parasites and stomachaches (Burkill, 1985; Dalziel, 1937; Huffman *et al.*, 1996a; Watt & Breyer-Brandwijk, 1962). The Tongwe of Mahale use this plant as a treatment for intestinal parasites, diarrhea and stomach upset.

27 Phytochemical analysis of *V. amygdalina* samples collected at Mahale from plants known to be used by chimpanzees reveal the presence of two major classes of bioactive compounds. From this work, a total of 4 known sesquiterpene lactones, 7 new stigmastane-type steroid glucosides and 2 freely occurring aglycones of these

glucosides have been isolated (Ohigashi *et al.*, 1991; Jisaka *et al.*, 1992a, b; Jisaka *et al.*, 1993 a, b). The sesquiterpene lactones present in *V. amygdalina,* also found in *V. colorata* and a number of other *Vernonia* spp, are well known for their anthelmintic, antiamoebic, antitumor, and antibiotic properties (Asaka *et al.*, 1977; Gasquet *et al.*, 1985; Jisaka *et al.*, 1992a; Jisaka *et al.*, 1993 b; Kupchan *et al.*, 1969; Toubiana & Gaudemer, 1967). From crude methanol extracts of the leaves, Koshimizu *et al.* (1993) also found inhibition of tumor promotion and immunosupressive activities.

28 *In vitro* tests on the antischistosomal activity of the pith's most abundant steroid glucoside, vernonioside B1, and sesquiterpene lactone, vernodaline (Figure 1), showed significant inhibition of movement of the adult parasites and adult females' egg-laying capacity (Jisaka *et al.*, 1992b). These findings are consistent with the observed decline in nodular worm (*Oesophagostomum stephanostomum*) EPG level 20 hours after an adult female chimpanzee 1993). The sesquiterpene lactones showed significant *in vivo* plasmodicidal activity, while that of the steroid glucosides was weaker (Ohigashi *et al.*, 1994).

29 Some of the species with bitter piths ingested by chimpanzees at Gombe, Kahuzi-Biega, and Tai also have a number of ethnomedicinal and pharmacological properties. V. *colorata* and *V. amygdalina* are not distinguished from each other ethnomedicinaly with regard to their medicinal properties and folk classification (Burkill, 1985). Alkaloids occur in the pith, as well as flower and leaf of *V. hochstetteri* (Smolenski *et al.*, 1974). *P. hirsuta* and *E. macrocarpa* are used in west African ethnomedicine for the treatment of upset stomachs, colic, as an antiseptic and analgesic and for venereal disease (Abbiw, 1990; Neuwinger, 1996). Moluscicidal activity has also been reported for *P. hirsuta* (Okunji and Iwu, 1988).

A link between animal self-medication and ethnomedicine

30 The ethnomedicinal uses of *V. amygdalina* and the conditions under which ill chimpanzees have been observed

to ingest this species are similar in many respects. In the two documented cases of use by chimpanzees described above, the rate of recovery (20-24 hr) was comparable to that of local human inhabitants at Mahale, the Watongwe (within 24 hr), who use *V. amygdalina* for the treatment of parasitosis and gastrointestinal upset.

31 This preparation is typically made by the Watongwe from a cold water decoction of 2-3 crushed fresh leaves (approximately 10-15 g f. w.) in 300-400 ml of water. Due to the plant's toxic effect on the patient, this is usually only a one-dose treatment (M.S. Kalunde, personal communication). An analysis replicating this traditional method (3 trials) yielded 3.3-5.0 mg of vernonioside B1 (Figure 1; Huffman *et al.*, 1993 a). This was directly compared by quantitative analysis of pith collected from the plant used by the adult female chimpanzee that experienced a drop in parasite load 20 hr after its ingestion. The amount of pith she ingested (60 cm, approximately 50-100 g f. w.) was found to contain approximately 3.8-7.6 mg of vernonioside B1, or roughly an equal amount to that normally obtained by a Tongwe patient (Hufman *et al.*, 1993 a).

32 We are intrigued by this close similarity in use by humans and chimpanzees. Both humans and chimpanzees appear to have recognized the important physiological activity of this plant, and evidence suggests that chimpanzees ingest *V. amygdalina* when they experience some of the same symptoms.

33 From an ethnobotanical viewpoint, the greater number of different cultures that recognize a single plant species as having some kind of medicinal property, the more likely that species is to contain significant physiological activity. The example of *V. amygdalina* with its widely recognized medicinal value in Africa takes this one step further by bridging the gap between apes and humans (Table II).

Self-medication as a learned behavioral tradition

34 How do animals learn to medicate themselves? In non-human primates important benefits come from social learning which allow naive individuals to acquire information through the experience of others, and over time to perfect the behavior themselves. Once an effective self-medicative behavior is recognized, it will likely spread through the group, first slowly, but after a time increasingly faster as it is passed onto the youngest members. At Mahale, and presumably elsewhere, initial exposure to self-medicative behaviors take place by individuals at an early age, not when ill themselves, but by observing the behavior and tasting the items used by others that are ill- often their mothers.

35 In the case of *Vernonia amygdalina,* it is not just what species is used and the context of use, but also the appropriate plant part and in what amounts it is ingested that must be learned for the plant to be used effectively and safely. Avoidance of bitter tasting things has evolved as a means of avoiding toxic substances. This innate tendency must be learned to be ignored if the medicinal benefits of these substances are to be gained. Humans often end up having to put sugar coatings on medicines to convince others to ingest them. For chimpanzees the observational learning process is undoubtedly an important component. Given the high degree of conservatism in chimpanzee feeding habits the random sampling of new plants, especially when ill, does not seem likely to occur very frequently. If so, traditions must have started rarely, perhaps as a result of ill, hungry chimpanzees trying new foods during periods of extreme food scarcity, recovering their health, and associating their improvement with the new item.

36 Chimpanzees have a strong capacity for empathy and good longterm memory. Any associations made between the change in a sick individual’s feeding habits and subsequent recovery are likely to reinforce the learning of both context and the details of plant use. On numerous occasions ill chimpanzees’ travel companions have been observed to co-ordinate their activities to be near the ill and thus had ample opportunity to observe their self-medicative behavior in its proper context. This probably worksstrongest on naive

dependent offspring who follow closely and mimic the behavior of their mothers. Newly immigrant females have also shown intense interest in individuals while ingesting the bitter pith of this plant. While all of the adults in M group have been observed to self- medicate at some time or another, they rarely if ever show interest in plants used for this simply because they come across them along a trail or because somebody else is using them.

37 Taste perception and physiological feedback in response to the ingestion of bitter plants are likely to play a supportive role in the learning process. Historically, herbalists have emphasized the importance of taste and smell in the evaluation of plant medicinal properties. In a study of the criteria of medicinal plant selection by the Tzeltal Mayans of Highland Chiapas in Mexico, John Brett noted that taste and smell were consistently used to select or evaluate a plant to treat related illnesse (Brett, 1994). Regardless of taxonomy, bitter tasting plants were selected and predominantly used to treat gastrointestinal upsets, parasites and stomach pains.

38 This close correspondence between bitter taste and pharmacological activity may also aid chimpanzees in their selection of plants for treating parasite infection and related gastrointestinal illness based on previous experiences. This would be particularly adaptive for immigrating females when they move to new areas where the vegetation is different but similar pharmacologically active bitter plants may be available.

39 Selective association between taste and gastrointestinal illness is a widely accepted principal of taste aversion learning among mammals and the learning mechanism of food aversion in response to induced sickness has been well documented in a number of animal species. The capacity to associate improved health after eating novel plants having medicinal properties has received less attention but the highly adaptive significance of this process is self-evident. Such biological and psychological processes in conjunction with observational learning are proposed to constitute the core of nonhuman primate self-medicative behavior and if so are at the roots of the human cultural practice of medicine.

Evolution of medicinal plant use and the future

40 These 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 tantalizing evidence for the evolution of medicine and the impact made by parasite infection. Our earliest hominid ancestors can be predicted to have exhibited some similarities in plant selection criteria with both existing apes and modern humans. The early 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 behaviors.

41 The fundamentals of associating the medicinal properties of a plant by its taste, smell and texture have their roots deep in our primate history. 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. Another major event in human history is considered to have been the attainment of food preparation and detoxification technologies which allowed humans to exploit a wider range of plant life as food. Johns (1990) argues that it was this turning point that may actually have increased our dependence on plant secondary compounds because of their disappearance from the daily diet. In this way, perhaps a greater specialization of plant use specifically as medicine came about. Furthermore, with the skilled use of fire to boil, steam, vaporize, condense or otherwise extract useful secondary plant compounds from plants, a greater variety of uses for these compounds were developed.

42 The current level of sophisticated medicinal practices in traditional humans societies may be the product of the greater variety of diseases and stress brought about by a subsistence revolution from hunting and gathering to a greater dependence on domestic crops and livestock in a sedentary setting (Johns, 1990). In this light, our early

modern human ancestors may have had a smaller pharmacopoeia, but this was not because of any lack of technical sophistication. More likely it was because of less diseases and stress to respond to (Cohen and Armelagos, 1984). Thanks to the technological advancement of modern medicine, the lives of millions of people in the so called civilized world are saved or prolonged every year. Yet, it is also technological advancement that brings about the changes in our diets (preservatives, additives, genetic engineering) and lifestyles responsible for the modern diseases which nations spend fortunes every year trying to find cures for.

43 We do not have to turn back the clock of time or abandon civilization to regain a piece of that paradise lost. We may have much to re-learn and gain from the "ancient wisdom" of our primate cousins and the wealth of traditional medicine still being practiced today by a large majority of the world's population.

44 Further field and laboratory research into self-medicative behavior in other animal species is strongly encouraged. As this review has shown, answers to a few questions invariably lead to more questions. As more researchers in the field begin to look for similar types of behavior, they will be found and more answers will be provided. Because of the obvious adaptive significance of self-medication, its existence is predicted to be wide-spread. Self-medicative behaviors are predicted to occur in all animal species.

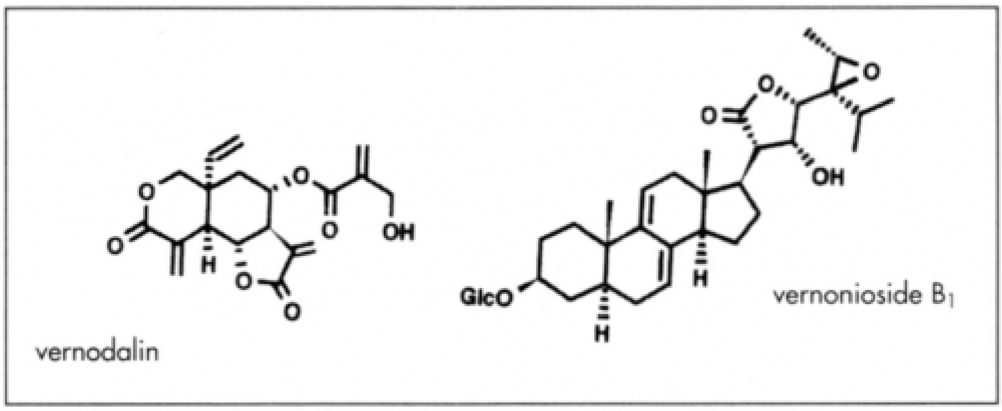


Figure 1

The most abundant constituents isolated from the pith of Vernonia Amygdalina, a steroid glucoside (versonioside bj) and a sesquiterpene lactone (vernodaline)

Table I: Some anecdotal evidence for self-medication in animals

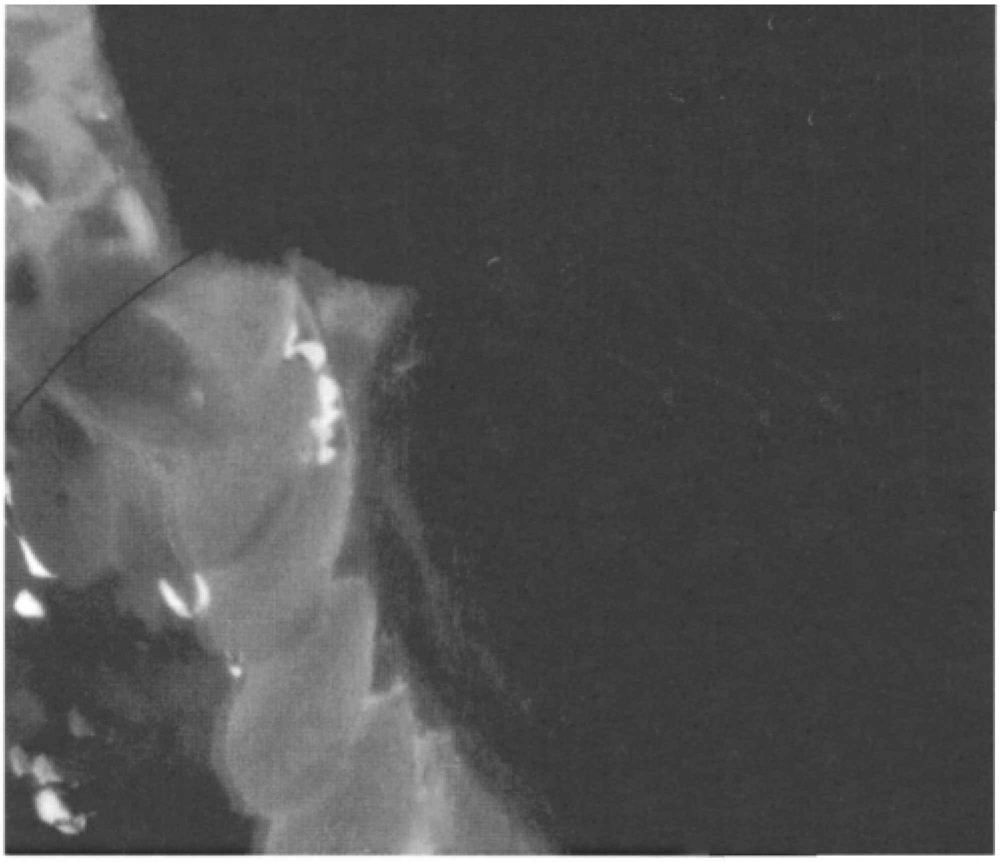
Species	Plant (chemical evidence)	References
Malay elephant	*Entada schefferi* (Leguminosae): for stamina before long walk, possible pain killer?	Hubback, 1941, Janzen, 1978
African elephant	Boraginaceae sp.: induce labor; used by Kenyan ethnic group to induce labor and abortion. Similar story related to Huffman about observations made in Tanzania	Cowen, 1990 M.S. Kalunde, pers. comm.
Indian bison	*Holarrhena antidysenterica* (Apocynaceae): bark regularly consumed. Species name suggests antidysentaric action.	Oglivie, 1929
Wild Indian boar	*Boerhavia diffusa* (Nyctaginaceae): called pig weed. Roots are selectively eaten by boar and is a traditional Indian antihelmintic.	Janzen,1978, Dharmkumarsinhji, 1960
Pigs	*Punicum granatum* (Punicaceae) pomegranate: root sought after by pigs in Mexico. Alkaloid in roots toxic to tapeworms.	Janzen, 1978, McCann, 1932 Caius, 1940
Indian tigers wild dogs, bears civets, jackals	*Careya arborea* (Barringtonaeaceae), *Dalbergia latifolia* (Leguminosae) etc.: fruits of various species eaten by large carnivores. Possibly helps in elimination of parasites ingested along with contents of intestines of herbivore prey	McCann, 1958, Burton, 1952 Janzen, 1978
S. American wolf	*Solanum lycocarpon* (Solanaceae): rotting fruit said to be eaten to cure stomach or intestinal upset	D.A.O. Courtnay, G.C. Kirby pers. comm.
Asiatic two-horned Rhinoceros	*Ceriops candoleana* (Rhizophoraceae): tannin rich bark eaten in large amounts enough to turn urine bright orange. Possible use in control of bladder and urinary tract parasites.	Hubback, 1939
Black howler monkey Spider monkey	Indigenous peoples living in primate habitats of the Neotropics claim that some monkey species are parasite-free because of the plants they eat.	S. Vitazkova, M. Pavelka pers.. Comm.

Table II: Ethnomedicinal uses of *Vernonia amygdalina* in Africa

Application	Plant part used	Region used, comments
General intestinal upsets		
enteritis	root, seeds	Nigeria
constipation	leaves, sap	Nigeria, Tanzania, Ethiopia: as a laxative
diarrhoea	stem, root-bark, leaves	W. Africa, Zaire
stomach upset	stem, root-bark, leaves	Angola, Ethiopia
Parasitosis		
schistosomiasis	root, bark, fruit	Zimbabwe, Mozambique, Nigeria: sometimes mixed with *Vigna sinensis*
malaria	root, stem-bark, leaves	E. Africa, Angola, Guinea, Nigeria, Ethiopia: a quinine substitute
trematode infection	root, leaves	E. Africa: treatment for children used as a suppository
amoebic dysentary	root-bark	S. Africa
ringworm	leaves	Nigeria: ringworm and other unidentified epidermal infections
unspecified	leaves	Nigeria: prophylactic treatment for nursing infants, passed through mother's milk
	root, seeds	Nigeria: worms
	leaves	W. Africa: crushed in water and given to horses as a vermifuge, livestock fodder supplement for treating worms
	leaves	Ghana: purgative
Tonic food	leaves	Cameroon, Nigeria: boiled or soaked in cold water prepared as soup or as a vegetable fried with meat ; "n'dole", "fatefate", "mayemaye", leaves sold in markets and cultivated in home gardens
Other ailments		
amenorrhoea	root	Zimbabwe
coughing	leaf	Ghana, Nigeria, Tanzania
diabetes	all bitter parts	Nigeria
fever	leaves	Tanzania, Kenya, Uganda, Congo-Kinshasa: leaves squeezed and juice taken
gonorrhoea	roots	Ivory Coast: taken with *Rauwolfa vomitoria*
"heart weakness"	root	W. Africa: vernonine is a cardiotonic glycoside comparable to digitalin
lack of appetite	leaf	W. Africa: leaves soaked in cold water to remove bitter and then boiled in soup
pneumonia	leaf	Ivory Coast: taken with Argemone maxicana or used in a bath
rheumatism	stem, root-bark	Nigeria
scurvy	leaves	Sierra Leone, Nigeria, W. Cameroon: leaves sold in markets and cultivated in home gardens
General hygiene		
dentrifice	twig, stick	Nigeria: chew stick for cleansing and dental caries
disinfectant	not given	Ethiopia
soap	stems	Uganda

Sources: Abebe, 1987; Akah and Okafor, 1990; Burkill, 1985; Dalziel 1937; Irvine, 1961, Kokworo, 1976; Muanzo, *et al.*, 1993; Nyazema, 1987; Palgrave. 1983; Watt and Breyer-Branwijk, 1962; Huffman, personal unpublished data from interviews in Uganda and Tanzania.

Aspilia massambicensis (Oliv.) Asteracea
Mahale National Park (Tanzania) 1996



Adult male Jilda swallowing leaf of *Aspilia massambicensis* (Oliv.) Asteracea
Mahale National Park (Tanzania) 1993

M.A. Huffman

Vernonia amygdalina Del. Compositae Mahale National Park (Tanzania) 1996

Adult male Jilba chewing bitter pith of *Vernonia amygdalina* (Compositae)
Mahale National Park (Tanzania) 1993

Bibliographie

Des DOI sont automatiquement ajoutés aux références par Bilbo, l'outil d'annotation bibliographique d'OpenEdition.
Les utilisateurs des institutions qui sont abonnées à un des programmes freemium d'OpenEdition peuvent télécharger les références bibliographiques pour lequelles Bilbo a trouvé un DOI.
Format
APA
MLA
Chicago
Le service d'export bibliographique est disponible aux institutions qui ont souscrit à un des programmes freemium d'OpenEdition.
Si vous souhaitez que votre institution souscrive à l'un des programmes freemium d'OpenEdition et bénéficie de ses services, écrivez à : contact@openedition.org

References

Format
APA

ABBIW D.K. (1990) *Useful Plants of Ghana,* Kew, Intermediate Technology Publications and Royal Botanic Gardens.
DOI : 10.3362/9781780443737

ABEBE D. (1987) Plants in the health care delivery system of Africa, in A.J.M. LEEUWENBURG (Compiler), *Medicinal and poisonous plants of the tropics,* Wageninigen, Pudoc Wageninigen, 79-87.

AKAH P.A., OKAFOR C.L.(1990) Blood sugar lowering effects of *Vernonia amydgalina* in experimental rabbit model, in A. SOFOWORA (ed), *The state of medicinal plant research in Nigeria,* Abstract volume for “Integrative seminar on natural products research and development of plant based drugs”, University of Science and Technology, Kumani, Ghana, 23-30 September, 1990, 27.

ANDERSON R.M., MAY R.M. (1982) *Population Biology of Infectious Diseases,* Berlin, Springer-Verlag.
DOI : 10.1007/978-3-642-68635-1

ASAKA Y., KUBOTA T., KULKARNI A.B. (1977) Studies on a bitter principle from *Vernonia anthelmintica, Phytochemistry,* 16, 1838-1839.

BAER M. (1996) Fur rubbing. Use of medicinal plants by capuchin monkeys *[Cebus capucinus), American Journal of Primatology,* 38, 263-270.

Format
APA
MLA
Chicago
Le service d'export bibliographique est disponible aux institutions qui ont souscrit à un des programmes freemium d'OpenEdition.
Si vous souhaitez que votre institution souscrive à l'un des programmes freemium d'OpenEdition et bénéficie de ses services, écrivez à : contact@openedition.org

BALICK M.J., COX P. A. (1996) *Plants, people, and culture,* New York, Scientific American Library, W. H. Freeman and Company.
DOI : 10.1201/9781003049074

BLIM M.S. (1981) *Chemical defenses of arthropods,* New York, Academic Press.

Format
APA
MLA
Chicago
Le service d'export bibliographique est disponible aux institutions qui ont souscrit à un des programmes freemium d'OpenEdition.
Si vous souhaitez que votre institution souscrive à l'un des programmes freemium d'OpenEdition et bénéficie de ses services, écrivez à : contact@openedition.org

BOPPRE M. (1978) Chemical communication, plant relationships, and mimicry in the evolution of danaid

butterflies, *Entomol. Exp. Appl.,* 24, 264- 277.
DOI : 10.1111/j.1570-7458.1978.tb02782.x

BOPPRE M. (1984) Redifining “Pharmacophagy”, *Journal of Chemical Ecology,* 10(7), 1151-1154.

BRANDER A.A.D. (1931) *Wild Animals in Central India. London,* Edward Arnold.

BRETT J. A. (1994) *Medicinal plant selection criteria among the Tzeltal Maya of Highland Chiapas, Mexico,* PhD Dissertation, San Francisco, University of California.

BROWER L. P. (1969) Ecological chemistry, *Scientific American,* 22 (2), 22- 29.
DOI : 10.1038/scientificamerican0269-22

BURKILL H.M. (1985) *The Useful Plants of West Tropical Africa,* 2nd ed., Vol. 1, Kew, Royal Botanical Gardens.

BURTON R.W. (1952) The tiger as fruit eater, *Journal of the Bombay Natural History Society,* 50, 649.

CLAYTON D.H., MOORE J. (1997) Host-Parasite evolution. General Principles & Avian Models, Oxford, Oxford Unviversity Press.

CLARK C.C. (1991) The nest protection hypothesis: the adaptive use of plant secondary compounds by European starlings, in LOYE J.E. and ZUK M. (eds.), *Bird-parasite* *intearctions: ecology, evolution, and behaviour,* Oxford, Oxford Unviersity Press, 205-221.

COHEN M.A, ARMELAGOS G. J. (eds) (1984) *Paleopathology and the origins of agriculture,* Orlando, Florida, Academic Press.

Format
APA
MLA
Chicago
Le service d'export bibliographique est disponible aux institutions qui ont souscrit à un des programmes freemium d'OpenEdition.
Si vous souhaitez que votre institution souscrive à l'un des programmes freemium d'OpenEdition et bénéficie de ses services, écrivez à : contact@openedition.org

COWEN R. (1990) Medicine on the wild side, *Science News,* 138, 280-282.
DOI : 10.2307/3974722

COX F.E.G. (1993) *Modern Parasitology,* 2nd edition, Oxford, Blackwell Scientific Press.

DALZIEL J. M. (1937) The Useful Plants of West Tropical Africa in Hutchinson J. & Dalziel J.M. (eds.), *Appendix to Flora of West Tropical Africa,* London, Whitefriars Press.

DHARMAKUMARSINHJI R. S. (1960) Indian wild boar (Sus *scrofa cristatus* Wagner) feeding on *Boerhavia diffusa* Linn., *Journal of the Bombay Natural History Society, 57,* 654-655.

DUBOIS L. (1955) *Tabernanthe iboga* Baillon, *Bull. Agric. Congo Beige,* 46, 805-829.

Format
APA
MLA
Chicago

EHRLICH P., RAVEN P. H. (1964) Butterflies and plants: A study in coevolution, *Evolution,* 18, 586-608.
DOI : 10.2307/2406212

ETKIN N.L. (1996) Medicinal cuisines: diet and ethnopharmacology, *International Journal of Pharmacology,* 34 (5), 313-326.
DOI : 10.1076/phbi.34.5.313.13246

ETKIN N.L., ROSS P.J. (1983) Malaria, Medicine, and Meals: Plant use among the Hausa and its impact on disease, in ROMANUCCI-ROSS L., MOERMAN D.E. and TANCREDI L.R. (eds), *The Anthropology of Medicine: From Culture to Method,* New York, Praeger, 231-259

EWALD PW. (1994) *Evolution of Infectious Disease,* Oxford, Oxford University Press.

FEENY P. (1976) Plant apparency and chemical defense, *Recent advances in phytochemistry,* 10, 1 -40.

FREELAND W. F. (1980) Mangaby (*Cercocebus albigena)* movement patterns in relation to food availability and fecal contamination, *Ecology,* 61 (6), 1297-1303.

FUTUYMA D.J., SLATKIN M. (1983) *Coevolution,* Sunderland, MA, Sinauer Associates Inc.
DOI : 10.1006/rwgn.2001.0239

GASQUET M., BAMBA D., BABADJAMIAN A., BALANSARD G., TIMON- DAVID P., METZGER J. (1985) Action amoebicide et anthelminthique du ver- nolide et de I'hydroxyvernolide isoles des feuilles de *Vernonia colorata* (Willd.) Drake, *European Journal of Medical Chemical Theory,* 2, 111-115.

GOMPPER M.E., HOLYMAN A.M. (1993) Grooming with Trattinnickia resin: possible pharmaceutical plant use by coatis in Panama, *Journal of Tropical Ecolology,* 9, 533-540.
DOI : 10.1017/S0266467400007616

GRISANZIO J.A. (1992) Fur-bearing pharmacists, *Animals,* September/October, 26-30.

GUSTAVSON C.R. (1977) Comparative and field aspects of learned food aversions, in BARKER L.M., BEST M.R. and DOMJAN M. (eds.), *Learning mechanisms in food selection,* Baylor (Texas), Baylor University Press, 23- 43.

HARBORNE J.B. (1978) Biochemical aspects of plant and animal coevolution, London. (Academic Press.Phytochemical Society of Europe Symposia, Series No.l5)

HARRISON G. P. (1968) *Tabernanthe iboga:* an African narcotic plant of social importance, *Economic Botany,* 23, 174-184.

HART B.L. (1990) Behavioral adaptations to pathogens and parasites. Five strategies, *Neuroscience and Biobehavioral Review,* 14, 273-294.
DOI : 10.1016/S0149-7634(05)80038-7

HAUSFATER G., MEADE B.J. (1982) Alternation of sleeping groves by yellow baboons *(Papio cynocepahalus)* as a strategy for parasite avoidance, *Primates,* 23, 287-297.

HOWE H.F., WESTLEY L.C. (1988) *Ecological relationships of plants and animals,* Oxford, Oxford University Press.

HUBBACK T.B. (1939) The two-horned Asiatic rhinoceros (*Dicerorhinus sumatrensis), Journal of the Bombay Natural History Society,* 40, 594-617.

HUBBACK T.B. (1941) The Malay Elephant, *Journal of the Bombay Natural History Society,* 42, 483-509.

HUFFMAN M.A., GOTOH S., IZUTSU D., KOSHIMIZU K., KALUNDE M. S. (1993) Further observations on the use of *Vernonia amygdalina* by a wild chimpanzee, its possible effect on parasite load, and its phytochemistry, *African Study Monographs,* 14 (4), 227-240.

HUFFMAN M.A., GOTOH S., TURNER L.A., HAMAI M. and YOSHIDA K. (1997) Seasonal trends in intestinal nematode infection and medicinal plant use among chimpanzees in the Mahale Mountains, Tanzania, *Primates,* 38 (2), 111-125.
DOI : 10.1007/BF02382002

HUFFMAN M.A., KOSHIMIZU K., OHIGASHI H. (1996a) Ethnobotany and zoopharmacognosy of *Vernonia amygdalina,* a medicinal plant used by humans and chimpanzees, in CALIGARI P.D.S., HIND D.J.N. (eds.) *Compositae: Biology & Utilization,* Vol. 2., Kew, The Royal Botanical Gardens, 351-360.

HUFFMAN M.A., & SEIFU M. (1989) Observations on the illness and consumption of a possibly medicinal plant *Vernonia amygdalina* (Del.), by a wild chimpanzee in the Mahale Mountains National Park, Tanzania, *Primates,* 30, 51-63.

HUFFMAN M.A., WRANGHAM R.W. (1994) The diversity of medicinal plant use by chimpanzees in the wild, in

WRANGHAM R.W., MC GREW W.C., de WAAL F.B., HELTNE P.G. (eds.), *Chimpanzee Cultures,* Cambridge, Harvard University Press, 129-148.

IDANI G., KURODA S., KANO T., ASATO R. (1994) Flora and vegetation of Wamba Forest, Central Zaire with reference to Bonobo (Pan *paniscus*) foods, *Tropics,* 3 (3/4), 309-332.

IRVINE F. R. (1961) *Woody plants of Ghana. London,* Oxford University Fress.

JANZEN D. H. (1978) Complications in interpreting the chemical defenses of tree against tropical arboreal plant-eating vertebrates, in G.G. MONTGOMERY (ed.), *The ecology of arboreal folivores,* Washington D.C., Smithosonian Institute Press, 73-84.

JISAKA M., KAWANAKA M., SUGIYAMA H., TAKEGAWA K., HUFFMAN M.A., OHIGASHI H., KOSHIMIZU K. (1992a) Antischistosomal activities of sesquiterpene lactones and steroid glucosides from *Vernonia amygdalina,* possibly used by wild chimpanzees against parasite-related diseases, *Bioscience, Biotechnology and Biochemistry,* 56 (5), 845-846.

JISAKA M., OHIGASHI H., TAKAGAKI T., NOZAKI H., TADA T., HIROTA M., IRIE R., HUFFMAN M.A., NISHIDAT., KAJI M., KOSHIMIZU K. (1992b) Bitter steroid glucosides, vernoniosides Al, A2, and A3 and related B1 from a possible medicinal plant *Vernonia amygdalina,* used by wild chimpanzees, *Tetrahedron,* 48, 625-632.

JISAKA M., OHIGASHI H., TAKEGAWA K., HIROTA M., IRIE R., HUFFMAN M.A., KOSHIMIZU K. (1993a) Steroid glucosides from *Vernonia amygdalina,* a possible chimpanzee medicinal plant, *Phytochemistry,* 34, 409-413.

JISAKA M., OHIGASHI H., TAKEGAWA K., HUFFMAN M.A., KOSHIMIZU K. (1993b) Antitumor and antimicrobial activities of bitter sesquiterpene lactones of *Vernonia amygdalina,* a possible medicinal plant used by wild chimpanzees, *Bioscience, Biotechnology, Biochemistry,* 57 (5), 833-834.

JOHNS T. (1990) *With bitter herbs they shall eat it,* Tucson, The University of Arizona Press.

JOHNS T. (1994) Ambivalence to the palatability factors in wild food plants, in ETKINS N.L., *Eating on the Wild Side,* Tucson, The University of Arizona Press , 46-61.

KEYMER A., CROMPTON D.W.T., SAHAKIAN B.J. (1983) Parasite induced learned aversion involving Nippostrongylus in rats, *Parasitology,* 86, 455-460.
DOI : 10.1017/S0031182000050642

KLOOS H., MC CULLOUGH F.S. (1987) Plants with recognized mollusci- cidal activity, in MOTT K.E. (ed.), *Plant Molluscicides,* New York, John Wiley & Sons Ltd., 45-108.

KOKWARO J.O. (1976) *Medicinal Plants of East Africa,* Nairobi, General Printers Ltd.

KOSHIMIZU K., OHIGASHI H., HUFFMAN M.A., NISIHDA T., TAKASAKI H. (1993) Physiological activities and the active constituents of potentially medicinal plants used by wild chimpanzees of the Mahale Mountains, Tanzania, *International Journal of Primatology,* 14 (2), 345-356.
DOI : 10.1007/BF02192637

KUPCHAN S.M., HEMINGWAY R.J., KARIM A., WERNER D. (1969) Tumor Inhibitors XLVII. vernodalin and vernomygdin, two new cytotoxic sesquiterpene lactones from *Vernonia amygdalina* Del., *Journal of Organic Chemistry,* 34, 3908-3911.
DOI : 10.1021/j001264a035

KYRIAZAKIS I., OLDHAM J. D., COOP R.L., JACKSON F. (1994) The effect of subclinical intestinal nematode infection on the diet selection of growing sheep, British Journal of Nutrition, 72, 665-677.

McCANN C. (1932) A cure for tapeworm, *Journal of the Bombay Natural History Society,* 36, 282-284.

MOORE M. (1979) *Medicinal plants of the mountain west,* Santa Fe, Museum of New Mexico Press.

MOUTSAMBOTÉ J., YUMOTO T., MITANI M., NISHIHARA T., SUZUKI S., KURODA S. (1994) Vegetation and list of plant species identified in the Nouabale-Ndoki Forest, Congo, *Tropics,* 3 (3/4), 277-293.

MUANZA D.N., DANGALA N.L., MPAY O. (1993) Zairean medicinal plants as diarrhea remedies and their antibacterial activities, African Study Monographs, 14 (1), 53-63.

MURAKAMI A., OHIGASHI H., KOSHIMIZU K. (1994) Possible anti-tumor promoting properties of traditional Thai foods and some of their active constituents, *Asia Pacific Journal of Clinical Nutrition,* 3, 185-191.

MURAKAMI A., OHIGASHI H., KOSHIMIZU K. (1996) Anti-tumor promotion with food phytochemicals. A strategy for cancer chemoprevention, *Bioscience, Biotechnology Biochemistry,* 60 (1), 1-8.
DOI : 10.1271/bbb.60.1

NELSON G.S. (1960) Schistosome infections as zoonoses in Africa, *Tanscripts of the Royal Society of Tropical Medicine and Hygiene,* 54, 301-314.

NEUWINGER H.D. (1996) *African Ethnobotany. Chemistry, pharmacology, toxicology,* London, Chapman & Hill.

NISHIDA T., UEHARA S. (1983) Natural diet of chimpanzees (*Pan troglodytes schweinfurthii).* Long term record from the Mahale Mountains, Tanzania, *African Study Monographs,* 3, 109-130.

NYAZEMA N.Z. (1987) Medicinal plants of wide use in Zimbabwe, in A.J.M. LEEUWENBURG (Compiler), *Medicinal and poisonous plants of the tropics,* Wageningen, Pudoc Wageningen, pp. 36-43.

OGILVIE G.H. (1929) Bison eating bark, *Journal of the Bombay Natural History Society,* 33, 706-707.

OHIGASHI H. (1995) *Plants used medicinaly by primates in the wild and their physiologically active constituents,* Report to the Minestry of Science, Education and Culture for 1994 Grant-in-Aid for Scientitific Research (n° 06303012).

OHIGASHI H., HUFFMAN M.A., IZUTSU D., KOSHIMIZU K., KAWANAKA M., SUGIYAMA H., KIRBY G.C., WARHURST D.C., ALLEN D., WRIGHT C.W., PHILLIPSON J.D., TIMMON-DAVID P., DELNAS F., ELIAS R., BALANSARD G. (1994) Toward the chemical ecology of medicinal plant-use in chimpanzees. The case of *Vernonia amygdalina* Del.. A plant used by wild chimpanzees possibly for parasite-related diseases, *Journal of Chemical Ecology,* 20, 541-553.

OHIGASHI H., JISAKA M., TAKAGAKI T., NOZAKI H., TADA T., HUFFMAN M.A., NISHIDA T., KAJI M., KOSHIMIZU K. (1991) Bitter principle and a related steroid glucoside from *Vernonia amygdalina,* a possible medicinal plant for wild chimpanzees, *Agricultural and Biological Chemistry,* 55, 1201-1203.

OHIGASHI H., SAKAI Y., YAMAGUCHI K., UMEZAKI I., KOSHIMIZU K. (1992) Possible anti-tumor promoting properties of marine algae and in vitro activity of wakame seaweed extract, Bioscience Biotechnology and Biochemistry, 56 (6), 994-995.

OKUNJI C. O., IWU M. M. (1988) Control of schistosomiasis using Nigerian medicinal molluscicides, *International J. Crude Drug Research, 26* (4), 246-252.
DOI : 10.3109/13880208809053927

PALGRAVE K.C. (1983) *Trees of Southern Africa,* 2nd revised edition, Cape Town, Struik Publisher.

PHILLIPS R. (1981) Mushrooms and other fungi of great britain and Europe, London, Pan.

RAUCH R. (1954) Studies on the helminth fauna of Alaska. XXI. Taxonomy, morphological variation, and ecology of *Diphyllobothirium ursi* n. sp. *provis.* on Kodiak Island, *Journal of Parasitology,* 40, 540-563.

RAUCH R. (1961) Notes on the black bear, *Ursus americanus Pallas,* in Alaska with particular reference to dentition and growth, *Z. Saugetierk,* 26, 77-107.

RIESENBERG S.H. (1948) Magic and medicine in Ponape, Southwest, *Journal of Anthropology,* 4, 406-429.
DOI : 10.1086/soutjanth.4.4.3628587

SENGPUTA S. (1981) Adaptive significance of the use of margosa leaves in nests of house sparrows Passer domesticus, *Emu,* 81, 114-115.
DOI : 10.1071/MU9810114

SMOLENSKI S.J., SILINIS H., FARNSWORTH N. R. (1974) Alkaloid screening. V, *Lloydia,* 37 (3), 506-536.

SUGIYAMA Y., KOMAN J. (1992) The flora of Bossou: Its utilization by chimpanzees and humans. African Studies Monographs 13(3): 127-169.

TOFT, C.A., AESCHLIMANN, A., BOLIS, L. (1991) Parasite-Host Associations; Coexistence or Conflict? Oxford, Oxford Science Publications.

TOUBIANA, R., GAUDEMER, A. (1967) Structure du vernolide, nouvel ester sesquiterpique isole de *Vernonia colorata, Tetrahedron Letters,* 14, 1333- 1336.

TUTIN C.E.G., WHITE L.J.T., WILLIAMSON E.A., FERNANDEZ M., Me PHERSON. G. (1994) *List of plant species identified in the northern part of the Lope Reserve,* Gabon, Tropics, 3 (3/4), 249-276.

WAKELIN D. (1996) Immunity to parasites - How parasitic infections are controlled, 2nd edition, Cambridge, Cambridge University Press.

WATERMAN P.G. (1984) Food acquisition and processing as a function of plant chemistry, in CHIVERS D. J., WOOD BN. A., BILSBOROUGH A (eds.), Food Acquisition and Processing in Primates, New York, Plenum Press, 177-211.

WATT J. M., BREYER-BRANDWINJK M.G. (1962) *The Medicinal and Poisonous Plants of Southern and East Africa,* Edinburgh, E. and S. Livingstone Ltd.

WILSON E. (1962) Aubrey's brief lives edited edition by O.L. Dick, Ann Arbor, Ann Arbor Paperbacks, p. xix.

WINK M., HOFER A., BILFINGER M., ENGLERT E., MARTIN M., SCHNEIDER D. (1993) Geese and dietary allelochemicals- food palatability and geophag,. Chemoecology, 4, 93-107.

WRANGHAM R.W., ROGERS M.E., ISABIRYE-BASUTA G. (1993) Ape food density in the ground layer in Kibale Forest, Uganda, *African Journal of Ecology,* 31, 49-57.
DOI : 10.1111/j.1365-2028.1993.tb00517.x

WRIGHT C., PHILLIPSON C., KIRBY D.V., HUFFMAN M.A., OHIGASHI H. (1993) Do *chimpanzees know how to treat protozoal diseases*? Paper presentation at the 5th British Society for Parasitology Malaria Meeting, September, 1993: Oxford.

YUMOTO T., YAMAGIWA J., MWANZA N., MARUHASHI T. (1994) *List of plant species identified in Kahuzi-Biega National Park,* Zaire, Tropics, 3 (3/4), 295-308.

Auteur

Michael A. Huffman

Center for Human Evolution Modeling Research, Primate Research Institute, Kyoto University 41-2 Kanrin Inuyama Aichi 484-8506 - Japan Huffman@pri.kyoto-u.ac.jp

Du même auteur

Origines animales de la médecine par les plantes *in Des sources du savoir aux médicaments du futur*, IRD Éditions, 2002

Référence électronique du chapitre

HUFFMAN, Michael A. *Animal origins of herbal medicine* In : *Des sources du savoir aux médicaments du futur* [en ligne]. Marseille : IRD Éditions, 2002 (généré le 06 avril 2021). Disponible sur Internet : <http://books.openedition.org/irdeditions/7199>. ISBN : 9782709917803. DOI : https://doi.org/10.4000/books.irdeditions.7199.

Référence électronique du livre

FLEURENTIN, Jacques (dir.) ; PELT, Jean-Marie (dir.) ; et MAZARS, Guy (dir.). *Des sources du savoir aux médicaments du futur*. Nouvelle édition [en ligne]. Marseille : IRD Éditions, 2002 (généré le 06 avril 2021). Disponible sur Internet : <http://books.openedition.org/irdeditions/7187>. ISBN : 9782709917803. DOI : https://doi.org/10.4000/books.irdeditions.7187.

Des sources du savoir aux médicaments du futur

Ce livre est cité par

Desclaux, Alice. Lévy, Joseph-Josy. (2003) Présentation. *Anthropologie et Sociétés*, 27. DOI: 10.7202/007443ar