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Ethnomedicinal and bioactive properties of plants ingested by wild chimpanzees in Uganda

Sabrina Krief, Claude Marcel Hladik, Claudie Haxaire

Abstract

Several plant species claimed by healers to cure diseases are also eaten by wild chimpanzees. However, the behaviour leading apes to ingest these peculiar species is not clearly understood. Some of the items consumed by chimpanzees have low nutritional value, and there is a growing body of evidence suggesting that health might be improved or regulated by such ingestion. Observations concerning the diet and the health condition of wild chimpanzees in the Kibale National Park (Uganda) are discussed in relation to the ethnomedicinal utilization of plant species reviewed in literature. Among the 163 plant parts known to be eaten by these chimpanzees, at least 35 are used in traditional medicine as treatment for intestinal parasites, skin infections, reproduction and respiratory diseases. Relationships with pharmacological properties are presented, taking into account the difficulties of interpreting ethnomedicinal data. In conclusion, a greater knowledge of ape’s behaviour and health may provide a new complementary method to select plants for biomedical research.

1. Introduction

Chemicals present in wild plants may often result from the pressure of selection exerted by insects and microbes, but also herbivores (Janzen, 1978). Ironically these products, generally toxic to animals, actually provide benefits to sick animals and humans.

The interactions between plants and animals were thoroughly investigated, during the last decades, after detailed information about plants eaten by great apes have been obtained (e.g. Schaller, 1963; Reynolds and Reynolds, 1965; Hladik, 1977; Wrangham, 1977; Rodman, 1978; Tutin and Fernandez, 1993). The ingestion of non-nutritional plant parts such as bark, and some unusual behaviours associated with biological activities of the plants consumed was also observed (e.g. Huffman and Seifu, 1989; Ohijashi et al., 1994; Wrangham, 1995), supporting the hypothesis suggested by Janzen (1978), that plant secondary compounds actually help animals to combat or control diseases.

Concerning human health and medicine, the empirically deeply rooted knowledge and wisdom of native people was considered, after the Bureau of American Ethnology, started the investigations on medicinal ethnobotany, as a useful pre-screen in the search of plants of pharmacological interest. Farnsworth, in 1990, emphasized the importance of higher plants as source of drugs: in our pharmacopoeia, 119 drugs are still extracted from 90 species of plants, and about 75% of these were discovered by chemists attempting to identify the active compounds in relation to ethnomedicinal uses. In 1985, it has been estimated that about 64% of the world population utilizes plants as medicine (Farnsworth et al., 1985). However, a drug, according to the concept prevailing in our industrialized western societies, differs from that of food, although ethnological data show large differences, in various ethnic groups, in the definition of these two categories. For instance, the “drugs” such as the powder of Erythroxylum coca, used in Amazonia (Hugh-Jones, 1993), or the fruits of Cola nitida eaten in tropical Africa (Haxaire, 1996) might be considered closer to the food category by the consumers. In such contexts, the notions of illness and medication are ambiguous for a biologist who attempts to reach physical efficiency. Moreover, some ethnobotanical/ethnopharmacological categories have been observed that overlap food and drug categories. For instance Etkin (1983), who highlighted the actual existence of such categories after taking into account the indigenous knowledge, wrote «We draw inspiration from the Haussa term for medecine ‘magani’, a concept so inclusive that it signifies ‘plants administred to cure fever’ as well as ‘foods used to remedy hunger’». In such cases medicinal properties are socially recognised to the wild cooked leaves eaten during the main food shortage periods, corresponding to the major period of malaria prevalence. It was further demonstrated by Etkin and Ross (1983) that this type of food provides a certain protection against malaria.
Could the observation of the feeding behaviour of a close relative of Homo sapiens living in a natural setting provide a complementary approach? Some striking similarities between plants ingested by chimpanzees and used in ethnomedicine are presented here, suggesting that the study of animal behaviour might be a promising lead for identification of potentially bioactive plants.

2. Materials and methods

2.1. Study site

The observations were conducted in the Kibale National Park, located in Uganda, between 0°13' to 0°41'N and 30°19' to 30°22'E. The elevation is between 800 and 1500 m, and the rainfall averages 1700 mm per year. Vegetation of this mid-altitude moist forest also includes secondary forest, grassland, swamps and plantations of Eucalyptus and pines, and elements of lowland tropical rainforest.

2.2. Behavioral and veterinary observations of chimpanzees

The habituated community of chimpanzees (Pan troglodytes schweinfurthii), including about 50 individuals, was observed between December 2000 and March 2001, and in October 2001. Data on feeding behavior were previously recorded by R.W. Wrangham and his assistants of the “Kibale Chimpanzee Project”, and a list of food plants was kindly provided at the beginning of this survey (Krief, 2003).

Feeding data were obtained from 10-min focal-animal sessions and ad libitum observations. Health state was monitored daily with non invasive methods (Krief, 2003). Behavioural observations were focused on ill chimpanzees and on the foods that appeared most likely to have medicinal effects.

2.3. Plant collection, bioassays, and ethnomedicinal data

Specimens of the plants included in the diet of Kibale chimpanzees were identified first with the help of the field assistants, then compared to specimens and identified in the herbarium of the Laboratoire de Phanérogamie at the Museum National d'Histoire Naturelle (Paris, France). Plant material was also collected for further analysis, and air-dried in the field, sheltered from the sun.

Dried extracts were assessed for in vitro activities against the following parasites Leishmania donovani, Trypanosoma brucei brucei, Plasmodium falciparum and a free-living worm Rhabditis pseudolongata with almost the same sensibility to Ivermectin as a parasite worm. Antitumor activities were assayed by measuring the cytotoxicity against KB cells from human tumor tissue. Extracts were also tested against bacteria (Staphylococcus aureus, Escherichia coli) and fungi (Candida tropicalis, Penicillium crustosum). For detailed description of the protocols, see Krief (2003).

For the ethnomedicinal data concerning the plants eaten by chimpanzees, the web site ‘Prelude’ constructed by Baerts and Lehmann (2002), a source of ancient and up-to-date documentation on both traditional human and veterinary medicine, was used in parallel with the search of conventional sources of bibliography.

3. Results

As shown in Table I, plant parts from 27 species — belonging to the group of 163 food items included in the 117 plant species from the chimpanzee diet at Kibale — are used as traditional medicine in Africa. Among these plants, eleven species have been tested for pharmacological activities, showing actual activities in seven plant parts. These last species are listed in Table II, together with other species used by chimpanzees, for which we found bibliographical records showing actual activities. Most of these plants with bioactive compounds have a traditional medicinal utilization, although the bioactivity is not necessarily linked to the traditional utilization.

According to a classification following the criteria of western medicine, we can observe that ten of these plants are used to cure skin diseases or infections, fifteen of them are for digestive disorders. Thirteen species have ethnomedicinal properties in reproductive functions, and in respiratory diseases. Finally, twelve species are used to relieve pain or fever.

According to such criteria in veterinary medicine, most of the chimpanzees observed were in good
health during the study periods. However, at least 10 cases of obviously ill chimpanzees were diagnosed. Bacterial infections were diagnosed in two instances, including one wounded individual and another one suffering from tooth abscess. An old female with an important abdominal distension also had a left hand defect, the swollen hand being not used for tree climbing. Two chimpanzees were detected suffering from gastrointestinal disorders. Five cases were respiratory infections with nasal discharge, sneezing, cough, including two severe cases with lethargy, dyspnea and anorexia.

These wounded or sick chimpanzees were followed carefully in the field. Since the symptoms were totally absent after one week, we consider that all of them had recovered from their respective diseases. The three following examples illustrate utilization of plants with putative activity, according to the ethnomedical records reported in Table I.

(1) An adult male chimpanzee whose toe was severely cut after a fight was observed during the week following the injury, ingesting:
   • Acanthus pubescens stems, which are used in Burundi against skin infections and dermatosis,
   • Ficus capensis fruits, which are used to cure abscess and edema,
   • Ficus exasperata leaves, also used as treatment against abscess, edema, and against ulcer. (this antiulcerogenic property has been confirmed by in vivo bioassays; see Table II).

(2) Parasitism and digestive disorders were diagnosed in a 6 yr-old female. The chimpanzee was the only individual of the group observed ingesting Albizia grandibracteata bark, that was never observed eaten by the other chimpanzees of the group. The bark of this species is used in Uganda and in the Democratic Republic of Congo to alleviate digestive disorder and parasitism. (as shown in Table II, the anthelmintic activities of the A. grandibracteata bark extract was confirmed by bioassays, and saponins present in the extract are responsible of such properties).

(3) A 17-year old male, was observed frequently coughing, looking weak and lethargic. Sneezing was frequent and discharge was thick with mucous. Feces samples were rich in parasites. This chimpanzee was the only individual from the party to feed on the immature fruits of Ficus capensis. In Ivory Coast, these fruits are selected when unripe as traditional veterinary medicine.

Most of the species used as traditional medicine are rarely (even exceptionally) eaten by chimpanzees, except four of them, more commonly ingested in the field (R.W. Wrangham pers. comm.): Phytolacca dodecandra fruits, Celtis africana leaves, Pennisetum purpureum stems, Monodora myristica seeds. Nevertheless, all chimpanzees regularly ingest a great variety of food plants (i.e. 46 items corresponding to 35 species in four months), and, in the long term, the diet includes most of the plants with bioactive properties, although some of them are ingested in very small quantity (Krief, 2003).

4. Discussion

4.1. Medicines for chimpanzees?

Globally, the diet of the chimpanzees of Kibale includes several plant species with actual or putative bioactivities, likely to offer medicinal benefits. A low parasitical load has been observed in all the individuals of this group (Krief et al., 2003), that could be related to anti-parasite properties. The permanent access to small amounts of various plants is likely to play a role of ‘preventive medication’, maintaining a low level of pathogens and a subclinical health status. This global activity of the diet of the chimpanzees may provide a balance beneficent to health, that might be homologous to the ‘mediterranean diet’ (Hill & Giacosa, 1992) recommended for human after epidemiological surveys.

The ‘curative medication’ is another aspect that can be inferred from the data presented in this paper, and from previous studies such as the ingestion of bitter pith of Vernonia amygdalina first observed by Huffman and Seifu (1989). Although case studies are uncommon, the evidence that sick chimpanzees eat peculiar food items that are not eaten by the healthy individuals of the group rises the issue of specific medication. What could determine such a complex behaviour? Food intake is generally mediated by unconscious conditioning mechanisms (Hladik and Simmen, 1996). What has been called ‘chimpanzee cultures’ (Wrangham et al., 1994) includes many skills such as termites fishing, nut breaking that are learned by a young individual in the context of a social group. Is there, for such specific food choices, a different way of learning including individual or group memories?
4.2. What can be learned from the ethnomedical data?

Traditional medicines are based on a non-dualistic perception of human being and each of them has its own semiology. In other words, for each traditional medicine, the activity of a remedy is understood, in the cultural context, according to specific alteration of body and soul which characterizes the illness. Even though the practical result of medication is biologically demonstrated, remedies, from the lay people point of view, are necessarily linked to endogenous cultural significance (Augé, 1986). These interpretations obviously never correspond what is implied in the practice of the western medicine (or biomedicine).

Furthermore, since botanists are the main providers of ethnomedical information, the ethnomedical literature is not abstracted in a systematic manner for both medicinal and botanical aspects, as stated by Farnsworth (1990). This author also reports the lack of information about the diseases treated, the quantities of materials used and the type of preparation (decoction, infusion, paste...). In addition, crucial information, as for instance the cultural construction of efficacy (Etkin, 1988), diet prescribed with specific medication, complex mixture, etc., are very rarely reported. Most investigators in ethnomedicine tend to distinguish the ‘magico-religious’ dimension of the empirical aspects of traditional practices, which has resulted in an incomplete exploration of the traditional pharmacopoeia.

Plants might be used by local peoples following the properties in relation to health, but the aspect of the plant may also play an important role in the symbolic properties; for instance Watt and Breyer-Brenwick (1962) show that: “Among widely separate tribes in Africa, the abundant clustered fruits suggest the notion of fertility (mimetic magic) and they are used in various ways as a charm to promote conception and to ensure an abundant crop”. But not only the aspect of the plant is pertinent to understand the diversity of uses of a same plant or even of the same part of a plant species. In current ethnobotanical literature, many plants seem ‘universal’, and this may explain the case of Ficus exasperata leaves (Table I) used to cure diseases from the four classes defined previously, in countries from West to East Africa. This result from the indigenous semiology which implies that various symptoms (that western researchers attribute to various diseases) are all disturbance of one single body and/or mind of a human being (Haxaire, 1996). In this context, food and medicine often overlap in traditional societies (Hugh-Jones, 1993; Motte-Florac et al., 1996) or at least health benefits are supposed for various food, herbs and spices.

Even though the organoleptic characteristic of a plant are culturally interpreted, taste perception may be a major clue for specific choice. For instance, treatments based on bitter substances are known in many traditional medicines, and appear to have a peculiar therapeutic relevance. The ancient Mexican Aztecs applied them upon the body against the fear caused by the lighting, and in enema to cure diarrhoea. In India, bitter substances are externally applied on ulcerations. In the popular medicine of Neaples (Italy), urination diseases are treated with the administration of substances that must usually be only just bitter, independently from their real or alleged pharmacological action (Scarpa, 1969). The possible rationale between these practices may reside in the fact that ‘bitter’ substances are usually rich in alkaloids (Bruneton, 1993). These have a number of applications against dyspepsia, anemia and poor nutritional conditions, such as those found in drug-addicts; moreover, alkaloids may also have an emetic, purgative, tonic and leukocytopoietic action.

4.3. How and why zoopharmacognosy based on great apes may provide an original help in drugs discovery?

Given the large number of known higher plant species (between 250,000 and 500,000), of which only 5% to 15% have been systematically investigated for the presence of bioactive compounds (Cragg et al., 1997), there is a need to elaborate an efficient strategy for a successful screening. Ethnomedicinal studies provide information to test plants likely to contain active secondary compounds, and there is growing evidence that this approach is an efficient source of new pharmaceuticals (Farnsworth, 1990; Fellows, 1992).

Taste perception might be an important factor in the variation of the plants selected by chimpanzees in relation to physiological condition (Krief, 2003). Biological properties have been demonstrated for plant parts eaten by chimpanzees (Table II), such as the antiulcerogenic and digestive effects of Ficus exasperata also shown in vivo (Akah et al., 1998). This item is used against stomach-aches and digestive troubles in five countries and for its roughness in three African countries.

The issue concerning the relationships between individuals cannot be neglected among the factors determining food choices and the actual activity of the compounds ingested. Since each chimpanzee have an
accurate perception of the other individuals of the group and is able to understand their purposes (de Waal, 1982), unconscious signals between various individuals (especially between a young chimpanzee and its mother) might influence either the pleasantness of the taste, or the activity of the compounds ingested in a similar way that, for humans, the relationships between a doctor and his patient can improve the efficiency of a medicine, not so different from the effect, described as the ‘placebo’ factor (Lachaux and Lemoine, 1988). Finally, although the observer of chimpanzees needs to categorize an individual as sick according to symptoms defined by western veterinary medicine, observations of the chimpanzees in the field may avoid some bias of interpretations from various investigators in ethnopharmacology. Chimpanzees are a good model for human pathology and physiology, but, for obvious ethical reasons, they could not be used for medical research and experimentation. Presently, their natural setting, where observations are carried on, can be considered as a kind of ‘open laboratory’: whatever the mechanism involved in the selection of food plants with bioactive properties by a great ape, further studies in this field appear as a new leading thread, completing the other approaches in the selection of plants for biomedical research.

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