

A Review on Zoopharmacognosy

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ABSTRACT

Self medication is a specific therapeutic behavioral change in response to disease or parasitism. The empirical literature on self medication has so far focused on identifying cases of self medication in which particular behaviors are linked to therapeutic outcomes. The term "zoopharmacognosy" is relatively new to the field. The term is introduced in 1987 and it means animal self medication. It is the self medication process by an animal for any disease or wound by any animal or insect. The used plant or insect having the quality of curing the illness. Scientific investigation opened the doors for new medicines which are pointed out by the behavior of the animal towards self medication. Since the introduction of this study many new drugs are now in use which was found in the study of self medication behavior of an animal. So many new species are found which self medicate themselves for disease or other illness. The study will help us to increase our knowledge about the existence of the unknown drugs which are used by various animals.

Keywords: Zoopharmacognosy, antiparasitic, antibacterial, antimicrobial.

INTRODUCTION

Scientists from various disciplines are currently exploring the possibility that many species use plants, soils, insects, and fungi as 'medicines' in ways that guard against future illness (preventive medicine) and/or relieve unpleasant symptoms (curative or therapeutic medicine). Some species, particularly great apes, show an intention of purpose in their medication and in these cases the term zoopharmacognosy uses specific plants with medicinal properties for the treatment and prevention of disease.¹

Understanding the importance of Zoopharmacognosy and its benefits to animals and humans will help solidify the urgency in which mankind must conserve species rich habitat and preserve biodiversity. Only with future collaborative research initiatives will Zoopharmacognosy be able to unlock the many benefits to be shared by wildlife ecologists, public health professionals, pharmaceutical companies, conservationists, and the general public. Beyond Zoopharmacognosy's obvious benefits, the potential discovery of new medical cures, it also offers a whole realm of other possibilities

A review of literature

Zoopharmacognosy are based on well-developed sensory systems, in particular the olfactory (smell) system, because essential behaviours governing daily life, such as mate-seeking, environmental mapping, food locating and communication, are all dependent on

olfactory cues. When wild animals "self-medicate" with plants for example, they are detecting aromas of in the smell of these sources but are also known to utilize soil minerals and structural compounds naturally occurring in bark, grasses, minerals, algae and other organic sources in their environment. Plant Secondary Metabolites (PSM's) have a number of protective functions on the body, they can bolster the efficacy of their body's immune system which helps reduce vulnerability to infection or advanced disease states, offer protection from free radicals and effective against pathogenic bacteria, viruses, fungus and parasites.

So what are the implications and benefits of zoopharmacognosy? The potential and benefits of zoopharmacognosy are huge, particularly in sustaining and managing wildlife, agriculture, ecosystems, livestock and animal health and can help reduce the industrial impact on the environment, establishing a more synergistic relationship between humans and nature.

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Associations between animal species, and environmental sources for health maintenance,

is more in design with nature and other characteristics of the land for and offers huge potential in

- preserving biological diversity and environmental systems
- can be a valuable contribution towards creating stable agricultural ecosystems
- can contribute as indicators for ecological networks beyond that of food webs and environmental change assessments
- Offers another tool in restoring fragile or damaged habitats, helping the wilderness re-establish itself
- In sustaining the long term health of our livestock, in disease prevention by empowering the animals themselves to strengthen their immune systems and resisting disease in the first instance, as well as reducing the severity of symptoms should they occur.

Self medicative behaviour in African apes

Observations of the great apes provide the clearest scientific evidence to date for direct forms of self-medication in animals. The hypothesis I am currently developing is that these behaviors aid in the control of intestinal nematodes and tapeworms or provide relief from related gastrointestinal upset, or both. Perhaps because of their phylogenetic closeness and common neural pathways of chemosensory perception, humans and chimpanzees, when displaying similar symptoms of illness, learn to associate and select for similar properties in medicinal plants. Unquestionably, the evolution of medicinal habits from the great apes to early hominids and modern humans has important implications for modern medicine. Thus, this article reviews the evidence for self-medication as a form of parasite control in the African great apes, relates that information to the evolution of medicinal plant use in traditional human societies, and suggests how natural plant products might play a role in modern health care.^{2,3,4}

Great ape self-meditative behavior and parasite infection

A longitudinal investigation showed that Mahale chimpanzees are naturally infected by numerous parasite species. The species found were three nematodes, *Strongyloides fuelleborni* (thread worm), *Trichuris trichiura* (whip worm), and *Oesophagostomum stephanostomum* (nodular worm); one trematode, *Dicrocoelium lanceatum* (lancet

flake); three protozoan, *Entamoeba coli*, *Endolimax nana*, and *Iodamoeba buetschlii* (all of which are amoebas); and one flagellate, *Giardia Lamblia*. *Oesophagostomum stephanostomum* infections were associated significantly more frequently with bitter-pith chewing and leaf swallowing (in 14 out of 15 cases, or 93%) than any of the other parasite species (Huffman et al. 1997). The evidence from Mahale points to this parasite as the stimulus for, and the only parasite directly affected by, self-medication. The nematode parasites of the genus *Oesophagostomum* (Strongyloidea) called nodular worms, because they encapsulate themselves in nodules in the intestinal wall during their development—are common parasites in the proximal hindgut of rodents, pigs, ruminants, nonhuman primates, and humans. Several species are found in gorillas and chimpanzees and occasionally in humans (Brack 1987, Polderman and Blotkamp 1995). Some of these nodular worm species are significant pathogens in domestic livestock and in primates. Symptoms of moderate to heavy infections of *O. stephanostomum*, *O. bifurcum*, and *O. aculeatum* found in apes range from anorexia, weight loss, enteritis, diarrhoea, anaemia, and lethargy to intense pain that simulates appendicitis. The direct economic loss caused by *Oesophagostomum* species in animal husbandry and the hazards it presents to human health have stimulated much research on their biology and control.⁴

The behavioral ecology of bitter-pith chewing

Detailed plant chemistry, behavioral observations, and parasitological surveys of patently ill chimpanzees at Mahale led to the hypothesis that bitter-pith chewing has medicinal value. Very much a collaboration of scientific method and traditional knowledge, these were the first reported observations to verify illness and obvious improvements in health after chimpanzees ingested *Vernonia amygdalina* Del. (Compositae), a putative medicinal plant.

Impact of bitter-pith chewing on parasite load

In general, when an individual chews the bitter pith of *V. amygdalina*, that individual is in ill health, as evidenced by diarrhoea, lethargy, weight loss, and nematode infection. In two cases recorded in detail, recovery from such symptoms was evident 20–24 hours after the individuals chewed the bitter pith. In one of these cases, the eggs per gram (EPG) of faeces level of an *O. stephanostomum*

infection could be measured; it was found to have dropped from 130 to 15 in 20 hours.

Chimpanzees' acquisition of self medicative behaviors and the evolution of medicine in traditional human societies

The way in which proposed self-medicative behaviors are individually acquired by the African great apes is a challenging topic for investigation. To suggest that self-medication is a behavioral tradition leaves open questions about how the behavior started and how individuals become predisposed to ingest medicinal plants. At one extreme, animals may have an innate tendency to select appropriate plants when ill, so that the role of tradition is reduced to local enhancement (i.e., native individuals have their attention drawn to plant species used by others; Huffman and Wrangham 1994). However, with leaf swallowing and bitter-pith chewing, the species being ingested is not the only question to be resolved; what parts of the plant are ingested and how must also be learned for the behavior to be effective. Given the high degree of conservatism in chimpanzee feeding habits (Nishida 1987), random sampling of novel food items, especially when ill, does not occur frequently. Perhaps the traditional behavior began during a period of extreme food scarcity, when ill and hungry apes who were forced to try new foods recovered their health and associated their recovery with the new food.

Future directions

As was true for Babu Kalunde almost a century ago, the study of animal self-medication and ethno medicinal practices may provide important leads to future sources of medicine. A closer look into the manner in which animals use natural plant products

Really Wild Remedies—Medicinal Plant Use by Animals

Pausing only to wipe the feverish sweat from her brow, the WaTongwe woman finishes crushing a few leaves and stems a fellow tribe member brought her from the mujonso, or "bitter leaf," tree. She soaks them in a bowl of cold water while her stomach aches with a dull pain. Closing her eyes and grimacing in anticipation of the liquid's foul taste, she holds her nose and gulps down the bitter elixir, hoping this reliable remedy will rid her of the intestinal pain that's plagued her for days.

Nearby, in Tanzania's Mahale Mountains National Park, a lethargic chimpanzee suffering from diarrhoea and malaise slowly

pulls a young shoot off a small tree called *Vernonia amygdalina*. She peels away the shoot's bark and leaves with her teeth, and begins chewing on the succulent pith. Swallowing the juice, she spits out most of the fibres, and then continues to chew and swallow a few more stalks for half an hour.

Recovered within 24 hours, both of these females resume business as usual. They were both suffering the effects of an intestinal parasite infection. And, in case you haven't guessed, they both ate from the same tree.

Eating bacteria for digestion

The folivorous, or leaf-eating, hoatzin, however, uses specialized bacteria in the crop to break down hard-to-digest leafy plant material. Research indicates that the bird's gut bacteria also neutralize toxic secondary compounds found in the plants it eats.

Antimicrobial property of plant

According to biologist John Berry at Cornell University, sweet red fruits of *Aframomum angustifolium*, having antimicrobial properties actually pose a digestive threat to the normal, healthy population of microorganisms found in the gorilla's gut. After eating fruits of this wild ginger, antibacterial compounds in the plant can temporarily damage these microbes, in turn upsetting the gorilla's digestive system if they aren't already a regular part of the diet. Evidence shows that the gorilla's micro biota has developed resistance to the biologically active components of the plant in areas where it is commonly eaten--an adaptation.

Consumption of soil

'Geophagy' is an act of deliberately consuming soil, stones and rock by herbivorous and omnivorous mammals, birds, reptiles and insects. This behaviour is observed and studied in the context of self-medication in Japanese macaques (*Macaca mulatta*), mountain gorillas (*Gorilla gorilla*), chimpanzees (*Pan troglodytes*) and African elephants. Geophagy is suggested as a means to maintain gut pH, to meet nutritional requirements for traces minerals, to satisfy hunger for sodium to detoxify previously consumed plant secondary metabolites and to combat intestinal problems like diarrhea.^{5,6}

The Importance of Being the Fittest

In biology, 'fitness' is measures of an individual's ability to survive and reproduce. It is measured by the number of viable offspring an animal can produce compared to other individuals in the same population. A wild animal has to be healthy and fit in order to

compete successfully with others to reproduce. Parasites play a crucial role in mate-selection by directly affecting host fitness. Recent studies on mate-selection in birds and mammals have evidently shown that females preferred non-parasitized male over the parasitized one. Choosy females may indirectly use secondary sexual characters as an indicator for the presence of effective genes. In mammals, many empirical studies have evidently shown that females can discriminate between healthy and diseased males on the basis of their odour and it has also been demonstrated that females prefer the odour of non-parasitized males. It has been believed that females could avoid infection and gain genetic benefits in terms of more viable offspring by mating with non-parasitized males. Therefore, being the fittest is vital in the life time of any organism that competes for mate populations. Thus, parasites can affect host fitness and may eventually have an influence on the evolution of overall life history strategies in animal societies. Therefore, one of the main selective pressures which would have led the animals to use medicinal plants is believed to be parasitic pressure. To overcome the fitness loss due to parasitism, animals have evolved a variety of anatomical, physiological and behavioural adaptations. In addition to the immunological defense, avoidance and removal of parasites are the two behavioural strategies animals use to reduce parasites. Other behavioural adaptations evolved against parasites may also include the avoidance of food materials which are potential sources of parasites, the use of prophylactic substances and the consumption of therapeutic substances. In general, animal self-medication has been categorized into two types – preventative (prophylactic – act of using medicinal plants without any symptoms of infection or before infection) and curative (therapeutic – act of using medicinal plants only after infection or illness).^{7,8,9}

Self medicative mosquitos' behaviour

According to the World Health Organization (1996), 30 new diseases have emerged in the past 20 year. In addition; there has been resurgence and a redistribution of old diseases on a global scale. Diseases such as malaria and dengue ("breakbone") fever, carried by (vectored by) mosquitoes, are among those undergoing resurgence and redistribution (Gubler and Kuno 1997). Arthropods are exquisitely sensitive to climate. Throughout this century public health researchers have understood that climate

circumscribes the distribution of mosquito-borne diseases, while weather affects the timing and intensity of outbreaks (Gill 1920a,b; Dobson and Carper 1993). Paleoclimatic data (Elias 1994) demonstrate that geographic shifts of beetles have been closely associated with changes in climate. Their distribution—using the mutual climatic range (MCR) method to map fossilized species assemblages—is particularly sensitive to changes in minimum temperatures (TMINs or night time and winter temperatures), as illustrated by shifts in species accompanying the Younger Dryers and those at the end of the last glacial maximum. Indeed, the battle between insects and plants may have been key to climate control during the carboniferous period: by developing and coevolving multiple means of defending against herbivores, woody terrestrial plants may have thrived, drawing down atmospheric carbon and cooling the biosphere (Retallack 1997). A growing number of investigators propose that vector-borne diseases (VBDs), (e.g., involving insects and snails as carriers), could shift their range in response to climate change 1996; Carcavallo and de Casas 1996). Models, incorporating vectorial capacity (temperature-dependent insect reproductive and biting rates and microorganism reproductive rates), uniformly indicate the potential for spread of the geographic areas that could sustain VBD transmission to higher elevations and higher latitudes under global warming (2 ° CO₂) scenarios (Matsuoka and Kai 1994; Martin and Lefebvre 1995). The transmission season may also be extended in the United States indicate a potential for the northern movement of mosquito-borne encephalitis (e.g., western equine encephalomyelitis and St. Louis encephalitis) within the continental United States and Canada. Simulations of the changes in malaria virulence due to global temperature increases during the past several decades show patterns strikingly similar to those found in the double CO₂ simulations (N. Graham 1998, unpublished manuscript). This article examines recent evidence that indicates upward movements in disease-carrying insects, upward plant migration, the retreat of tropical glaciers, and the upward shift in the freezing isotherm in the Tropics, all suggesting the possibility of climatic changes in recent decades. We will focus here on mosquito-borne diseases and the implications for human health and human activities.

The most recent and relevant data from the physical and biological sciences indicate a significant warming trend this century [Intergovernmental Panel on Climate Change

Moreover, Diaz and Graham (1996) report that, since 1970, the elevation of the freezing level (0°C isotherm) in tropical latitudes (30°N–30°S) has shifted upward approximately 150 m (equivalent to about 1°C of local warming). The rise in tropospheres temperatures is reflected in the mass balance of many glaciers, and ice caps from the Tropics to the midlatitudes are currently retreating, many at rates that continue to accelerate (Kaser and Noggler 1991; Hastenrath and Kruss 1992; Thompson et al. 1993; Haeberli 1995; IPCC 1996). For example, the edge of the Qori Kalis glacier that flows off the Quelccaya ice cap high in the Peruvian Andes Mountains was retreating at a rate of 4 m (13 ft) annually between 1963 and 1978. By 1995, that rate had. Many of the smaller ice fields may soon disappear, potentially jeopardizing local water supplies that are critical for human consumption, regional agriculture, and generation of hydroelectric power.

Past and potential displacements of plant distributions in response to climate change has received considerable attention (Jacobson et al. 1987; Davis 1989; Davis and Zabinski 1992; Billings 1995). From a climatic perspective, a small displacement of plant distribution corresponds to a much larger latitudinal displacement. To accommodate to a 2°C rise in temperature in the Northern Hemisphere, for example, plant distributions may rise 500 m in elevation or shift 300 km poleward (MacArthur 1972; Peters 1991). Upward displacements of plant distributions have been documented on 26 alpine peaks recently updated to 30. Maximum upward displacement rates of plant distributions approach 4 m per decade. In extra tropical latitudes the evidence is more complex and the influence of changes in storm tracks associated displacement of plant distribution corresponds to a much larger latitudinal displacement. To accommodate to a 2°C rise in temperature in the Northern Hemisphere, for example, plant distributions may rise 500 m in elevation or shift 300 km poleward (MacArthur 1972; Peters 1991). Upward displacements of plant distributions have been documented on 26 alpine peaks recently updated to 30. Maximum upward displacement rates of plant distributions approach 4 m per decade. In extra tropical latitudes the evidence is more complex and the influence of changes in storm tracks associated with changes in the westerlies dominates the signal (Hurrell 1995; Hurrell and van Loon 1997). Insects may also prove to be useful indicator species. Parmesan (1996) found that the distribution of Edith's Checker

spot butterflies (order Lepidoptera) has shifted northward. Population extinctions are four times greater at the far southern end of its range (in Mexico) than at the far northern end of its range (in Canada), and about two and one-half times as great at lower elevations as compared to populations above 8000 feet. Similar changes in range are being observed for other butterfly species in Europe (C. Parmesan 1997, personal communication).¹⁰

Biodiversity and conservation implications

Regrettably the species-rich tropics are also not immune to large-scale farming and ranching. The world recently has seen a growing trend of large scale operations in the tropics, thus threatening the stability of the world's tropical rainforests. Although tropical rainforests do not cover much of the earth's surface, they are home to most of the earth's species. Yet, as slash and burn agriculture, legal and illegal logging, cattle ranching, mining and climate change pose serious threats to the tropical rainforests, humans must make an effort to conserve or at least better manage what's left of our planet's most diverse ecosystems. Since research shows that plants provide medicinal benefits, it is imperative that we conserve and study as many as possible before they and their benefits are lost forever. Climate change especially raises a threat to preserving tropical plant species, since the tropics fluctuate relatively little in temperature, the species that live there have evolved to survive in very specific temperature conditions. Yet, as the climate changes, and the Earth heats up a few degrees, these species with lower survival threshold, will be unable to cope with the changes and thus will go extinct. Plants that are able to survive the change in temperature will emit stronger aromas due to the warmer climate, which can confuse animals that rely on those plants for self-medication. This is due to the positive correlation between increased concentrations of plant secondary metabolites and warmer temperatures. Although climate change may be out of our control, Zoopharmacognosy researchers can work together with conservationists to help preserve the habitat of biodiversity in the tropics. Through studying animal self-medication and plant secondary metabolites, researchers and conservationists can help maintain healthy and holistic ecosystems, while also sharing their knowledge to help local forest-dwelling and farming communities benefit from Zoopharmacognosy and conservation.

Unfortunately for conservation efforts, lack of international cooperation, greed and conversely poverty drive people to use natural resources carelessly, without fear of consequences or simply out of sheer desperation. For these reasons, as humans we must overcome our own selfish ambitions and act quickly to halt the destruction of vital ecosystems, such as the tropical rainforests, before it is too late for the species and communities, who rely on them.

Zoopharmacognosy may be ideally suited to promote conservation efforts for both the sake of ensuring continued animal-self medication in the wild as well as supporting the discovery of human cures. Although we should try to preserve species their intrinsic value alone, there is also a huge monetary gain to be had if pharmaceutical companies and agricultural industry could better understand nature's remedies. Not only would it generate profits for major pharmaceutical companies, it would also generate income for rural communities, and allow people to better understand animal needs and thus encourage more humane treatment of animals.

There is no doubt that the earth's climate has fluctuated over time and will continue changing; species have gone extinct and will continue disappearing; ecosystems have deteriorated and will continue to crumble in the future, regardless of human interference, and beyond our own extinction. The current environmental concern and apprehension however, lies not in the fear that we are causing change in our natural world, but in the fact that the rate of these changes has been dramatically hastened by human activity and far exceeds the environment's ability to recover. Our never-ending appetite for natural resources, physical space, energy, and our lack of concern for anything other than our own species, have resulted in an alarming rate of habitat destruction and loss of species, putting both biodiversity and humans at risk. Human intelligence and the capacity to problem-solve have hindered our conservation efforts of natural resources and species, simply because we think we will be able to come up with a quick fix in the future. Yet, undeniably, the human community has overcome tremendous hurdles when faced with worldwide dilemmas.¹¹

CONCLUSION

In the twentieth century scientists discovered and mastered such medical miracles as Penicillin and Immunizations for Tuberculosis, Measles, Mumps and many others. Although

we may have duped ourselves into thinking we must have all the answers and therefore the ability, and right, to treat our planet as we see fit, in reality we do not. Oddly enough, today we feel as desperate and helpless as people did a hundred years ago, before antibiotics and mass immunizations. Despite our exceptional achievements, we still find ourselves asking: How will we solve the AIDS crisis? Treat the increasing numbers of cancer patients? Halt soil erosion? Save the rainforest? Yet, despite all the doom and gloom, we must not despair and must simply seek new opportunities, beyond our anthropocentric outlook, to solve the Earth's and our own calamities.

Zoopharmacognosy will shed light on new solutions for our ever-expanding medicinal needs. Through observation and understanding of animals' self-medication behavior, we can find new cures for our world's medical needs. The only way to do this is to conserve habitats since we do not understand fully the consequences of destroying countless ecosystems and species. However, if we continue to observe and learn from animal behavior we can understand what constitutes a holistic environment for them as well as ourselves. After all, we are also trying to survive on this self-contained bio-dome known as Earth. Everything we have ever concocted to benefit mankind has been found right here in our own world.

As humans we have the capacity to digest knowledge, develop the most incredible technologies, and discover vital medical cures. Yet, despite our abilities, we are limited. The human mind is an incredible instrument, which has the power to change the world. But, no matter how many unimaginable and daring feats we have accomplished and how advanced our technology might be, we still must admit we do not have all the answers. We do not have all the solutions to our problems, all the cures to our ailments, and we never will, but all we can do is to keep searching.

Maybe it's time to look beyond ourselves, beyond our incredible, but limited capacities, to find the answers to our problems before there is nowhere left to look. Maybe Zoopharmacognosy can show us the solutions quicker. We must now take responsibility of our mismanagement, overuse and disregard of the species of this world. Once we are able to unlock all the potential benefits of Zoopharmacognosy and its positive implications for conservation, then and only then, can we revolutionize our

world. John Muir, a Scottish-American preservationist, once wisely said, "One learns, that the world, though made, is yet being made. That this is still the morning of creation." One would only hope we create a world, which we and all other species can thrive.¹²

FUTURE PERSPECTIVE

As was true for Babu Kalunde almost a century ago, the study of animal self-medication and ethno medicinal practices may provide important leads to future sources of medicine. A closer look into the manner in which animals use natural plant products may, for example, provide novel insights into viable new strategies for suppressing or slowing down the rate of acquisition of chemo resistance by parasites that infect livestock and humans. A strong movement is under way in many African nations to evaluate and integrate those traditional medicines shown to be effective into modern health care programs. My collaborators and I in Africa and elsewhere realize the importance and urgency of such efforts. Our multidisciplinary approach to this research, wherein the biological activity of novel plant-derived compounds is assessed against parasite species found across a wide range of hosts, the chances of success. At the same time we recognize the importance of preserving the intellectual property rights of individuals, regions, and countries to any new discoveries derived from indigenous plant material. One objective of this research is to integrate our results into local health care and livestock management systems so that locally available plants can be properly used to the benefit of all. Recently, Mohamedi said that he had heard of a traditional healer located east of Mahale who was using mulengelele to treat AIDS patients. He cautioned that he had not tried it on patients himself, so he could not verify its effectiveness. My colleagues and I were investigating the properties of mulengelele root, in the laboratory as this article was being prepared. Our primate ancestors and the wealth of traditional medicine. Africa, the birthplace of humankind, may also have been the starting point for the evolution of modern medicine. That continent too has an important role to play in the world's future.¹³

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