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The science of zoopharmacognosy: what do we know about animal self-medication?

Tedje van Asseldonk
(mrs drs A.G.M. van Asseldonk),
Institute for Ethnobotany and Zoopharmacognosy (IEZ),
Rijksstraatweg 158, 6573 DG Beek-Ubbergen, the Netherlands.
Tel. +31.2468.44301; fax 2468.43939.
www.ethnobotany.nl ; info@ethnobotany.nl

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Introduction

This morning I will try to teach you something about the rather new science of zoopharmacognosy. I will give a global introduction showing several examples.
Let my introduce our small institute first.
About 10 years ago my colleague Arend de Haas and I founded our institute the IEZ in the Netherlands, because we thought these two important issues received too little attention in Dutch universities. *Ethnobotany* is the study of traditional herbalism, and *Zoopharmacognosy* is our subject of today. There are some ethnobotany students in our universities, but they always work abroad, mostly in the third world. However important this work is, we believe that we also need to turn back to our own historical and folkloric herbal tradition, we will have to study that carefully, and we will need to re-evaluate and *revalue* both the concepts and remedies of that tradition with our modern knowledge. Only by doing so we can hope to communicate on a basis of mutual equality with the people in the third world. Then we can really learn form each other and help each other. So we concentrate on researching all these things in the Netherlands. Today we will concentrate on our zoopharmacognosy work.

The outline of my presentation will be as follows:
- After a short Introduction I will give some quotations from old books about animal selfmedication.
- I will continue with an overview of the work by Huffman and others on primates;
- Then I will discuss our own research on primates; and explain how we are setting the first steps on research on cattle.
- Very briefly I will touch the subject of zoopharmacognosy in other animal species and give some anecdotical reports about pets.
- In the end we can maybe have some discussion about: What can we learn from this? How do we proceed to extend our knowledge?

To finish my short introduction I will show you our ongoing projects. I will only talk about zoopharmacognosy now; but I will refer to the other projects when appropriate.
So now we start with our first issue, being European history.

History
Here we have an example of a poem of the famous Dutchman Jacob Cats, he is also named Father Cats, because he has teached to a lot of Dutch people about the moral values they had to cherish. He wrote more than one poem about the wisdom that animals have about herbal healing, but this *emblema* is also in English, and therefore most suitable for this occasion.
It is called: *No help for the lover*, and it says:

The hert that wounded is, knows how to fiend relief
And makes by dictamon the arrow out to fall
And with the selfsame herb hee cures his wound withall
But love no herb can fynd to cure his inward grief!
(as we can see on this picture of amor)!

It is an interesting reference that he makes to this plant *Dictamnus;* it was in fact Dioskorides, the Greek author of the most authorative herbal in Europe, written in the 1st century A.D., who already stated that chamois (mountain goat), when they are wounded by an arrow, eat from this herb to expel the remnants.

Let's look at some more examples. Plinius (the Roman author, in his book on Natural History about 77 A.D.) also mentions this *Dictamnus* story and tells us that much knowledge stems from the observation of animals. For example he states that the clystre (enema) was an invention of the Egyptian Ibis birds; they use their bills to squirt water in their ass to clean their body's. I would not know if this is the case, but he states this observation and many more. When harts are stung by a poisonous spider, they eat fresh water crabbes to cure from it. If by accendent they eat poisonous weed, they cure themselves with Artichokes (as we now know: this is good help fro the liver). When a scorpion is poisoned by touching *Aconitum*, he uses *Helleborus* to heal. And the swallows use the orange colored (bitter) juice of the plant *Chelidonium* for the eyes of their young. The weasel uses *Ruta* as a preservative when he goes on a rat hunting mission. The snake uses the juice of Fennel by rubbing herself with it; both for skin change and for better eye sight after the winter. The dragon (whatever he means by that!) when overloaded its stomach with meat finds relief in the juice of the wild Lettuce. Storks use *Oregano* when they are ill, and bears use *Hedera helix (ivy)* and Crabfishes, and Plinius gives a detailed account of several plants used by several animals for purging and cleansing the intestines.

The famous blood pressure-lowering plant *Rauwolfia serpentina* had come into use for snakebites, because people in India saw the Egyptian mongoose (*Herpestes ichneumon*) eat this root before it was attacking a cobra. The rise of the Christian religion may have put these type of observations more to the background. In Europe views were modified because the Christian God was sometimes seen as the inspiring entity for the use of medicinal plants, or greek/roman era physicians, but certainly not animals. Also disease was sent by God and therefore sick people needed care, not cure.
In in the Renaissance period in Europe the older zoopharmacognosy observations were again recognized, for example by Brunfels (1532) who writes that the leaves of *Laurus nobilis* are used by pigeons and chickens to cure constipation, an example that was also given by Plinius. Erasmus wrote in the *Colloquia* that he had observed a toad, who, after he was bitten by a spider, took instantly a leave of plantain (*Plantago*). (Noordhuis 2005).
Many examples were given by Gianbattist de la Porta (1558), who was one of these allround scientists that were physician and alchemist amongst other things. For example, says Porta: the elephant, having eaten a chameleon, eats wild olive against its poison (the same thing is mentioned by Plinius). For wounds it would use *Aloe*.
The mainstream mechanistic approach in the European science of the 17th, 18th en 19th century however described animals as machines without any thinking or feeling and so the zoopharmacognostic lines of thought became obsolete in science.

But in the 20th century two lines of research came together. Ethnobotanists, working in several countries, noticed that the indigenous people in

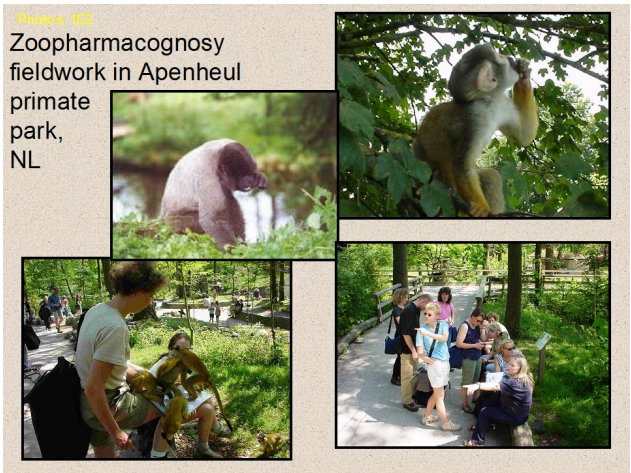
other continents often pointed to the animals (for example primates in the Amazon region) as the source of their herbal knowledge. Again it was remembered that the North American Indians, when asked where their herbal knowledge came from,.had pointed to the bears. Indeed several medicinal herbs are named after bears like *Allium ursinum*, *Arctostaphylus uva ursi* etc.
The folk animal herbalist Julliette de Bairacli wrote about some examples of animal self medication in her books. It was Jane Goodall who reported, together with Richard Wrangham, some actual cases of self medication by chimps in Tanzania, that got to the media and raised public interest.

Huffman et al. on primates
The ethologist Huffman of Kyoto University in Japan took up this type of research very diligently. He took several samples of plants to the pharmacognosy laboratory, plants that were apparently used by chimps for self medication There the existence of medicinal compounds in these plants was confirmed. Other examples of this research in the end of the 20th century include a report from Washington university biologists about zoo capuchin monkey Alice. She applied several times corn syrup with a stick on her wounds.

The new science, a combination of ethological (animal behavior) and phytochemical (pharmacognostical) research was named zoopharmacognosy by Eloy Rodriguez. Research by Huffman, Sauther, Carrai, Kriege and others showed the phenomena to be rather complicated. According to Huffman (2005) not only chemical strategies but also physical (mechanical) effects of plant parts may play a role in their usefulness to combat parasites.

Two phenomena Huffman reported were "*bitter pith* chewing" and "*leaf swallowing*".
November 1987 Huffman noticed a female chimp, of a group that he had followed for several months, was feeling weak, she hardly left her bed and took no care of her young. Later she went to and sat down in front of a shrub and pulled down several new growth branches. She placed them all on her lap and removed the bark and leaves of the first branch to expose the succulent inner pith. She bit off small portions and chewed on each for several seconds at a time. By doing this, she made a conspicuous sucking sound as she extracted and swallowed the juice, spitting out most of the remaining fiber. This continued for 17 minutes, with short breaks as she consumed the pith of each branch in the same manner. This plant was *Vernonia amygdalina*, and it was obviously not a regular part of the chimps diet. Huffmans local assistant Mohamedi was from a healer's family and knew this plant was considered a strong medicine against malaria-fever, stomach-ache and intestinal parasites. Within a day the chimp recovered from her illness. After this event Huffman looked for and found other examples.
A particularly interesting phenomenon was that he saw chimps swallow whole leaves of *Aspilia* plants. The leaves are folded between tongue and palate and pass visibly unchanged through the gastrointestinal tract. This is often done as the first, or one of the first, food items in the morning. Although laboratory analyses found chemicals with potential antibiotic and nematocidal properties in the plant (findings that were later challenged) clearly they could not play a large role, given the fact the leaves left the body undamaged. Several field observations could link this behaviour to the expulsion of parasites. These kind of activities are also reported for other animals. And moreover it appeared that in the rainy season, when parasite loads are heavy, this behaviour increased. So it must be a kind of purging therapy, for which the animas choose specific plants, plants with a rough or hairy surface. They take the worms with them on the way through the intestines. Although some chemicals may be involved, this mainly is a *physical* strategy against worms.
So Huffman mentioned several strategies for plant use, and also he introduced the link to ethnobotany, local herbal knowledge. He and others have also looked for herb use in specific conditions like pregnancy, I will talk about that later.

Research by the Institute for Ethnobotany and Zoopharmacognosy (IEZ)



In 1995 several articles in Dutch newspapers had been discussing the knowledge that woolly monkeys (*Lagothrix lagothricha*) appear to have on the medicinal plants, growing in their outdoor enclosure in the zoo Apenheul. Therefore the IEZ instigated field studies in this zoo during 1996 and 1997. During the years 1998-2002 we observed the foraging behavior of Bolivian squirrel monkeys (*Saimiri boliviensis*), both in Apenheul and in the French zoo "Vallée des Singes".

Study groups

Preliminary studies included an inventory of the vegetation and an estimate of the bite size for *Lagothrix lagothricha* and several observational ad libitum and scan sampling studies (Altman 1974). The woolly monkeys (*Lagothrix lagothricha*) we studied in Apenheul Primate Park were part of a group of 18 females, some juveniles and two babies that was free ranging between visitors. In the spring of 1996 we observed 8 adult females for ten days by focal animal sampling (8x10 observer days). We observed 4 individuals in a 20x4 days spread through the opening season in 1997. The Bolivian squirrel monkey (*Saimiri boliviensis*) groups in Apenheul primate park (NL) and Vallée des Singes (Fr) consisted of about 100 (NL) respect. 50 (F) free ranging individuals. The monkey enclosures that we studied are each about 10,000 m^2, several vegetable plots divided by asphalt walking roads.

Methods

An inventory of the vegetation was made in order to compare it to the consumption. To study the foraging behavior for *Lagothrix lagothricha* focal (continuous) sampling was used (Altman 1974). For *Saimiri boliviensis* we applied ad libitum (continuous and location fixed) sampling. The statistics we used were summarizing and descriptive.

Results

In the woolly monkeys (*Lagothrix lagothricha*) area we found 123 different plant species (some could not be specified beyond genus level) belonging to 53 plant families. To make this quantitative, and comparable to the consumption, we estimated of all plants present the amount of bites that were available for eating. To estimate the size of a bite three observers imitated the monkeys foraging behavior, carrying out 10x10 samples for each item. So a bite of a herb was estimated to be 2,3 (+/- 0,8) gram; a tree or shrub leaf bite was smaller; a bite of grass was 3,9 (+/- 1,8) gram. The total amount of available bites present for *Lagothrix lagothricha* in the enclosure we estimated to be a total of 25,215,468 bites (6090 kg).

I like to add that this was an early season inventory. Probably in summer more bites were available.

The squirrel monkey *Saimiri boliviensis* enclosures were not quantified for the vegetation. They were rather new plots and the list of plants present was available in Apenheul. There were over 97 different species planted, and in the area's used for observation we noted the presence of 46 species.

For the woolly monkeys (*Lagothrix lagothricha)* in 1996 the consumption of 43 (and in 1997 of 44) different plant species from the wild was reported. There were large differences in plant choice between individuals and between specific days.

The average plant consumption in both years was about 7 g/animal/hour (22 bytes/hour); additional 4-6 insects/hour and 2 bites of sand, pebbles or clay were consumed on average every hour.

About 25% of the plant consumption in both years we found to be of the *Fagaceae* family. Equally available were *Quercus rubra* and *Fagus sylvatica*. Yet consumption of *Quercus* was 3 fold (1997) to 10 fold (1996) that of *Fagus*. There was also a substantial consumption of *Berberis* spp (10-15%). The preference in the consumption of trees and shrubs appeared to be rather consistent amongst the group members. There was more animal specificity in the choice of herbs. Summarizing we noticed specific herb preference for plants of the *Asteraceae, Caryophyllaceae, Rosaceae, Boraginaceae* and *Urticaceae* families and these plants are mostly well known medicinal herbs in the Dutch herbal tradition..

To illustrate this I will now make a short remark about an earlier project that gave us a good overview of traditional Dutch herbalism. We made an inventory of plant families with relatively many medicinal herbs in the Netherlands (Van Asseldonk 2001). To this aim we compaired on a plant family level the Dutch flora with all medicinal plants mentioned in the most popular 20th century Dutch herbals. So it was the same kind of study only with humans in stead of monkeys and we used the books in stead of a field study. Some plant families that came forward the Dutch share with all North European countries as is described by prof. Moerman (*Asteraceae, Lamiaceae, Apiaceae*) but some

seem to be typically Dutch (e.g. the medicinal use of *Rosaceae* plants).
It may not seem very much if an animal eats 2 or 3 bytes of a herb. But the dosage of these incidental bites is quite proportional to the human dosage when using these herbs as a food supplement or a home remedy. 2 bytes = 5 g/day (fresh) is about 0,5 g/dry = +/- half of human daily dosage for many herbs.
Herbs we noticed to be consumed included amongst others: *Taraxacum officinale*, *Matricaria chamomilla*, *Urtica* spp, *Plantago* spp, *Impatiens parviflora*, *Rumex* spp, *Aegopodium podagraria*, *Glechoma hederacea*, *Trifolium* spp, *Fragaria vesca*, *Myosotis arvensis, Stellaria media* and *Polygonum* spp.

With Bolivian squirrel monkeys (*Saimiri boliviensis*) consumption was seen of 17 (in 2000); 19 (2001) and 16 (2002) different plant species. Also for these monkeys a great deal of the foraging behavior concerned catching of insects: about 8 % (2000); 10 % (2001); 12 % (2002) of the total amount of bites. These monkeys have a preference for grass, flowers and flower- and leaf buds (*Rosa* spp*, Silene dioica)* and nuts and other parts of *Fagus sylvatica.* We noted about 10 bites an hour.

Conclusions of our primate research
* the monkeys seem to make a selection from the available plant species within the outdoor enclosure; although we could not establish health-consumption relations there was not an at random consumption; also there was very individual-specific consumption
* certain plant species like barberries, oak and grasses are frequently eaten by all the individuals. This suggests these are nonspecific, additional food items.
* Other plant species are consumed incidentally; the differences between separate days and individuals are enormous. And these are typical the human medicinal plants in our folk herbal culture. So in this respect selfmedication COULD play a role, but we have yet no actual PROOF it is health promoting.
* the dietary supplement that is achieved through spontaneous foraging included an unexpected large amount of animal prey; this has given rise to an increase of protein that is supplied through diet for the woolly monkeys in the Zoos; they get extra eggs and insects.
* the monkeys frequently eat inorganic material like sand, eart h and pebbles. The function of this has not yet been established, this could be a mineral supplement, or a detoxification, or even a combination of these and other factors. Once I folllowed a female with a young, she was known to consume lots of cement, so she did when she discovered a heap of it, and I saw her forbid the baby to eat it (while there was enough!).

* the spontaneous foraging in the Zoo is an interesting complementing diet factor, that could be health promoting by offering
  * *additional micro-nutrients for example minerals or the anti-oxidants that are present in "wild vegetables"
  * *adaptive individual-specific corrections to the supplied food and the possibility for active coping behavior
Specific cases of sick primates that use bitter herbs as were reported by Huffman (2005) we did not find in the Zoos because for obvious reasons sick animals were not allowed to mix with visitors.

In the search for specific health related consumption several primatologists have looked into the differences between pregnant and non pregnant (lactating) individuals. It is well known that lactating females have to consume more calories, but the specific different type of food is not so easy to explain. For example Michaelle Sauther did a study on lemurs in Madagaskar. She noticed differences in leaf and fruit consumption between males and pregnant females. Another (more recent) example is the study of Carrai et al. that is closer to the subject of today. These researchers have addressed the problem by taking samples and analyses of specific compounds of the plants. In this case the percentage of condensed tannins was analyzed, both in the vegetation present and in the food used. Here also there are remarkable differences that cannot be easily explained. My suggestion would be that maybe the tannin content itself is related to the flavonoid content and that may be related to the estrogen content. Maybe we can shed some lights on things like that in our study with cattle that we have just started.

Research by the Institute for Ethnobotany and Zoopharmacognosy (IEZ) II. Cattle

From 2001 onwards we have students studying consumption of medicinal plants by grazing herds in nature reserve area's in the Netherlands. Here we hope to register more specific cases of sick animals behavior in relation to medicinal herbs, because the owners let very much nature have its course. But also we want to look into specific health challenging situations to see how the animals adapt. First I will show you the situation in a glance.

The grazing herds that we study at this moment (Konik horses and Galloways cattle) have a large area of free ranging, in between 45 and 700 ha each. The method used is again focal animal (continuous) sampling. Herd sizes vary from 10 to 50 animals.

At this moment we are still in the process of sampling single case studies for these animals. Already some specific behavior was registered by us (IEZ) and others. This concerns for example the consumption of herbs known to be toxic, like *Colchicum autumnale, Conium maculatum* and *Convallaria majalis*. It has been demonstrated by Provenza et al (2003) that cattle can combine two toxic species of herbs into useful food. Palatability is the interrelationship between a foods flavor and its postingestive effects (both nutritional and toxic) and dosage makes a poison. Animals have a very effective feed back mechanism. For example they can learn to combine two toxic foods into a less toxic meal. An example can be tannins and alkaloids that detoxificate one another. And liver and kidney have many mechanisms for detoxification. But detoxification for animals has a price in energy and they must be given some food choice opportunities.

There are mostly three or more parties involved with the grazing herds:
- the owners of the land, mostly nature conserve organisation or gouvernment organisation. Their concern is mainly the way the animals manage to keep the grass short. For example in the NL it is important that these areas can take enough water volume in winter when necessary. Too much vegetation would prevent that so the grazing herds will have to serve as lawn moiers.
- the owners of the animals and their veterinarians; they mostly are concerend about whether the animals have enough to eat especially in winter, most of the times there is no interest in the medicinal herbs, only a fear for toxic herbs.
- the third party are the scientists involved. As you might know herbalism and all other kind of naturopathy is in Holland very much "not done" on universities, so universities stick to the first item, maybe the second (but rarely) whereas the third item is specifically our field of study.

Now from other scientists we got some overviews for example this one by Theo
Vulink.

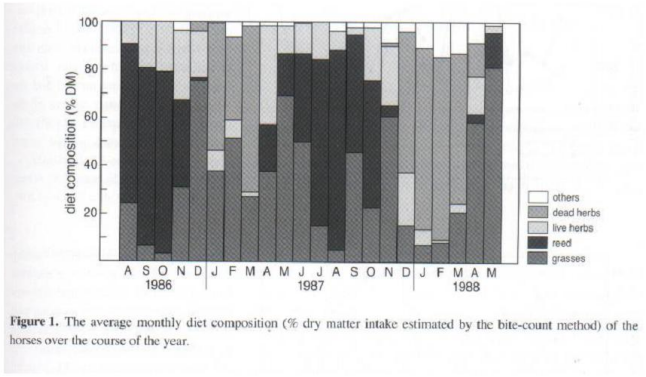


Figure 1. The average monthly diet composition (% dry matter intake estimated by the bite-count method) of the horses over the course of the year.

Theo Vulink, 2001: Hungry herds (diss)

That shows there is interesting season specific consumption. You see there is a remarkable difference between uses of browse , herbs, reed and grass in the specific months of the year. At this moment my students are filling up some missing months here.
We focus on plant use in early and late pregnancy of cattle. We had several anecdotical reports about cows
- that ate Rumex spp (burdock) after loss of a calve
- that ate more Urtica spp (nettle) around birth
- that ate Arctium lappa stems (and leaves, but specific the stems) around birth

That is why we expect to find changes in foraging behavior related to the pregnancy condition, changes that provide for individual adaptions in the selection of food. This may have a relation to the hormonal effects of plants. This is a complicated matter, and I will try to explain some of it.

Avoidance and chemical ecology

I will tell you something about the chemical ecological background of this type of research. The pharmacological effects of plants are explained by their secondary compounds. The name secondary compounds distinguishes them from the primary plant compounds that are most important for the metabolism: proteins, carbohydrates, fatty acids, nucleic acids, etc. Biologists explain the presence of these compounds as one of possible ways that plants defend themselves against grazing and other attacks. Several mechanisms can be applied in this plant defense:

1. Avoidance: they can have a low growing point (monocots); so we see very few toxic and hence medicinal aspects in these plants; the important food plants wheat rice mais etc are in this group.
2. Hairs, spikes, thorns, etc (dicotyledones); roses etc invest not so much in toxins either
3. Reduced digestibility: by compounds like (hemi) cellulose (large CH), silica (Si), lignins and tannins (polyphenols), in general large condensed structures, or on the other hand by proteinase inhibitors (*Solanaceae*) or more general inhiibiters of the parasympathicus

4. Then they can make toxins: alkaloids, terpenoids, glucosinolates, cyanogens, (steroid) saponins, lectins (protein), coumarins, etc.
5. Or (and that is recently gaining more and more interest) they make (also) chemicals that help to repair damage by free radical damage, heat etc: (iso)flavones, anthocyans, etc. (anti-oxidants).

Now they found out that the synthesis of these secondary plant compounds is often induced by insect attacks (phyto-alexins), drought-stress, etc. And that the pharmacological effects of these compounds vary but mostly:

- in a low dose they are beneficial (they can correct small health problems)
- and in a high dose they are poisonous (they can give drastic changes)

Nearly all known medicinal effects of herbs (in human medicine) are related to specific effects of these (many, different) compounds. Animals will need to have access to a diversity of plants to optimise their health.

I will now just take ONE example of the very complex plant-animal interactions due to the pharmacological effects of some of these secondary plant compounds. We know that some of them look like oestrogen and act like this. Phyto-estrogens are more or less hormone-identical structures; inhibiting or triggering hormone receptors:

- They can have anti-hormonal activity or hormonal effect; antihormonal when they only block the receptor; hormonal when they trigger it. What will be the effect is also a result of the concentration of these and other compounds, condition of intestinal flora and unknown factors. Examples of chemical structures; the distance between these two OH groups (phenol on C3 and alcohol on C17) is important, if it is 1,1-1,2 nm and the structure in between is hydrofobic, not too flexible, it will probably fit the oestrogen receptor.

Also we know that isoflavones compete more with estradiol on beta-receptors (BBP) than on alpha-receptors (PRK)

- They belong to several phytochemical groups: lignans, polyphenoles,(iso)flavonoids, steroids, alcohols.
- They are present at a high level in *Leguminosae (Fabaceae*) family (e.g. *Trifolium subterraneum / T. pratense* caused infertility in sheep); but also in many other families (e.g. *Apiacea, Lamiaceae, Asteraceae, Moraceae, Brassicaceae, Rosaceae)*
- They are sometimes present as a fungotoxin as a result from specific environmental conditions, for example in hay, mais or grass because of *Fusarium roseum* root fungus (Groot, 2003). This fungus makes Zearalenon, a mycotoxin with very strong oestrogen effect that can cause serious problems in animals.

I show you just for a moment the long lists of plants with these kind of possible activities; these are all plants that the animals actually can use in their environment in the NL.

We now only talked about estrogens. But another interesting story can be told about plants that have oxytocin activity or other uterostimulating properties (for example *Viburnum*, *Arctium lappa*, and strong aromatic plants like *Tanacetum, Artemisia* or *Chamomilla* species) plants with ergotamin like activity (*Capsella bursa pastoris, Urtica* leaves) and plants that have uterospasmic acitivity (for example *Oenothera biennes, Quercus* and *Salix*, and several *Solanacea* species).

We hope to document uses of these plants by cattle in our ongoing field study that focuses on pregnant cows.

Other animal species
It was reported to us that shepherds had been noticing that sheep tended to eat dandelion flowers, plantain, or burdock leaves when they were weak. They brought them to a place where these plants were available to them when they felt the animals needed it.

One of my students works in a goat farm and she said there was after delivery a noteworth consumption of *Anthriscus sylvestris* (cow parsley or wild chervil). Now this is a herb *not* known for its medicinal properties nowadays, but I found in the old Fuchs (Renaissance herbal) that it is used to expell better the placenta (afterbirth).

In the old days it was common that people used aromatic plants in their houses, especially when there were ill people around, to diminuish the risk of infections. Lately several ethologists showed that birds do the same thing: they use aromatic herbs in their nests to protect their young. This was shown for starlings by Gwinner (in 2000): the birds use specific herbs, they do not take Brassica's (that smell like mustard) but they take extra time to look for aromatic plants like *Achillea millefolium* (yarrow), *Daucus carota* (wild carrot), *Agrimonia spp.*, *Erigeron spp* , *Solidago spp* (goldenrod). These plants did *not* cause a reduction in endoparasites, but the green nests had stronger young, that had a higher amount of haemoglobin in their blood.

For blue tits it was shown by Petit et al (2002) that olfaction is used to discriminate and select the plant substances.

Recent also ant researchers have joined the discussion; Christe et al (2003) showed that ants that use conifer rasins in their buildings have an advantage above those who are prevented from doing so, because they suffer less growth of micro-organisms.

Anting is a well known phenomenon amongst birds. They rub themselves for example with millipedes (recently it was confirmed that the milliped toxins do not actually *kill* the ticks, but they are slowed down by it and cannot climb for a long period, even at a low dose of benzoquinones, which is the millipedes poison (Carroll et al 2005.). The behavior of birds in captivity using sigarets, orange peels and all kinds of stuff for the same purpose is very well known.

In 2002 Cindy Engel, an English biology teacher, published a book called Wild Health where a lot of examples of selfmedication for several species of animals were brought together. In the Netherlands some researchers were inspired by her book and in 2004 a study with pigs was set up. A choice of three herbs was made available for pigs; the setting was meant to compare groups of dewormed pigs with groups of non-dewormed pigs, but as it was unknown if these herbs actually were effective against worms; and there was no difference visible between the two main groups, and also there was not much worm infection, this line of research was not continued in the NL but it is in Germany by the Kassel University (professor Ton Baars).

Anecdotical reports about pets
We receive many anecdotical reports of specific behavior of pets and horses regarding the spontaneous consumption of herbs. Mostly this concerns craving, even digging out of the earth, of certain herbs by one animal, wheras its relatives do not show any interest in the same herb. Also some herbal folk remedies have a zoopharmacognostic origin (Van Asseldonk and Beijer, 2006). One student reported a case of a woman who made a digestive tea from some herbs for herself. Her cat came and drank from it, whereas she normally didn't do this. The event was repeated a few times and the woman noticed an improvement in the cat's appetite. Also the cat's chronic vomiting and diarrhea ceased. The remedy was also effective on the rare occasions the digestive problems returned in later years. There was a dog who used to dig up and eat from roots of a Thuja occidentalis tree. The animal had several health problems and was treated by one of my students with a homeopathic Thuja preparation, then the behavior disappeared and the health restored.

Especially horse owners often call or send me e-mails about strange cravings. For example they have two horses, one is a nervous kind, it eats chamomilla, whereas the other hates this herb. The same thing goes for nettles and thistles; there often is a connection with kidney or liver weakness, if you ask for it. Once there was a horse that had ruined its back with too harsh a training, that was eating *Heracleum sphondylium*, only in the period of recovery. No other horses seemed to like it; however I had also an ethnoveterinary case report on this plant being a roborans for horses. Two horses out of a group

that suffered from fly-eczema consumed *Epilobium* spp, whereas the other horses had no interest in these herbs.

A phenomenon that is very well known, but poorly understood, is the consumption of grass by dogs and cats. A lot of hypotheses are to be found in popular media, it could be the need for the contents of the stomach of the herbivorous pray, it could be purging, maybe also a physical worm expelling, this was seen by goose, brown bears and wolves. None of these hypotheses have been tested. That is why at this moment there is an ongoing study from the university of California where pet owners are asked tot join it by filling in a questionnaire on their website. Of course we had many reports about this phenomenon, and I have observed my own dog showing this behavior, therefore I know for my dog, and for some others, it is a specific kind of grass they need; he checks the roughness (and not the taste!) with his mouth. He decides for *Elymus* species (it's not like he knows that *Elymus caninus*, cough grass, was named after him; he also takes *Elymus repens*, which by the way is a traditional medicinal plant. Else he also takes some Carex species, whose leaves have an equally rough structure.

Other animals, as mentioned by a.o. Engel, use grass or carex spp to purge and diminuish their worm loads: this is is seen in brown bears before hibernating (lots of fibers and worms are to be seen in the dung); by wolves (roundworms expelled together with the grass) and by tigers: they do it to lose tapeworms.

Discussion on the implications: what can we learn from all this?

We already mentioned the spontaneous foraging in the zoo as an interesting supplementing diet factor, that could be health promoting by offering additional micro nutrients, for example minerals or anti-oxidants, that are present in "wild vegetables" (Pieroni *et al*. 2002), and also by allowing the animals to make adaptive individual-specific corrections to the supplied zoo diet.

It is a well known fact that primates in an ecodisplay, and horses and cattle in nature reserves, manage to keep themselves in a more healthy state when compared to cages or farm animals.
It has also been established that that cows that can graze freely outside produce milk that is richer in unsaturated fatty acids, rumenic acid and vaccenic acid, than cows that are kept indoors; even when they are fed freshly mown grass. But what role the availability of certain medicinal plants plays for each animal is difficult to establish. As the individual-specific adaptations, that the animals make by their specific food choice, give the researcher many confusing data, it is very difficult to prove statistically that their food choice is health promoting. Yet most zoopharmacognosy researchers share the opinion that what is to be learned from the animals is "health promotion" rather than "combating illness".

SO,

What did we learn?

1. Animals relate to medicinal herbs, more in a way that keeps them healthy, than in a way that combats disease (so: prevention is better than cure) How they do this, how we can make holistic health portraits of the animals and combine this with the integral pattern of their herb use, is still a challenge to us. We hope our new analyses of the traditional herbalism can help us out here.
2. There is more than one way to skin a cat: the chemical combating or supplementing strategies are only two of the possible medicinal strategies that a plant can be used for; other strategies are of a physical nature (for example rough leaves to induce vomit, or to expell worms), and there maybe other uses we don't know of yet, such as informational use (for example homeopathic use, or some messages about climate and soil that animals get from plants)
3. It may be important to give animals the possibility to make individual adjustments to their diet; and also give them the chance to perform more natural behaviour by "hunting" for food themselves.

It seems obvious, but this of course will have to be proven, that the fact that the animals are able to care some care for their food supply by themselves give them less stress and a better health. We know from human health care that active *coping* is very health promoting and that

for people having less *grip* on your situation means more stress and this is bad for general health.

What should we observe?
There is a lot to see and a lot to learn for those who are open minded.
Huffman gave us this list of clues, that may suggest self medicative behavior:

1 unusual eating behavior (swallowing without chewing; eating parts with no food value, very bitter tasting parts)
2 use of plants that is very specific related to a certain season or a certain place (look for a relation with a parasite load; with birth cycle etc)
3. specific use of a plant when an animal is ill (plants that are normaly avoided) ; may be (or may not be) followed by restoring health
4. the use of plants that are specifically well known because of their medicinal effects (I must however add that, when you study more and more books about herbalism, you will hardly ever find a plant that has NO claims of medicinal value)

A lot is known about pharmacological effects of secondary plant metabolites. The science of pharmacognosy in our country has nearly disappeared, but natural product chemistry, metabolomics and chemical ecology take its place. The last mentioned science we consider to be an important bridge between concepts of traditional herbalism and modern science.

I cannot go any deeper into this now, but just in a blink I will show you this. In another study we performed on traditional European herbals we found a relation between the philosophical concepts in traditional herbalism (the hot/dry/cold/wet classification) and the secundary plant compounds involved. The interesting thing here is that traditional herbalism has concepts for restoring health (rather then combating disease) and is individual specific, so this may give us clues for understanding the health promoting plant choices of animals.

Zoopharmacognosy may serve as an eye-opener; it does not provide fix and ready recipes yet, it is still in the phase of anecdotic observations.
But, we will have to realise, that all behaviour takes part in health promotion, or constitutes health risks, this goes for both humans and animals.

Thank you very much for giving me the opportunity to talk with you about my work!

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