Phytotherapy in zoo animals

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Introduction

Phytotherapy is one of the oldest medical disciplines and was traditionally based on empiricism (Reichling et al., 2008). Nowadays, its use as an additional integral component of evidence based medicine is well accepted in human medicine (Finkelmann, 2009). Herbal remedies are generally characterised by a broad therapeutic index. They consist of multicomponent mixtures and act as multi-target drugs with pleiotropic effects. In Switzerland, veterinary phytotherapy has been relaunched in 2006 as a subunit of the Swiss Medical Society for Phytotherapy (SMGP-vet). Since 2012, the certificate of qualification in veterinary phytotherapy has been approved by the Swiss Veterinary Association (GST/SVS). Historically, one of the common approaches to gain insight into the medical effects of plants was self-medication. In non-human animals, self-medication remains a controversial subject, because evidence is mostly anecdotal. A few experimentally verified cases of self-medication support the theoretical expectation that animals can and do make specific foraging decisions that function specifically to remediate illness (Huffman and Caton, 2001; Villalba et al., 2006; Singer et al., 2009). In zoological medicine, this concept has first been implemented by primate keeping institutions. Permanent access to selected medicinal plants suggested self-medication and helped maintain the health of certain primate species (Cousins, 2006).

Zoological medicine is a veterinary discipline that deals with a very broad spectrum of taxa and diseases. Often, treatment protocols have to be extrapolated from farm and companion animals or humans. Clinical daily routine is limited and treatment decisions are based on limited scientific findings and the practitioner's experience. Zoo animals are generally highly susceptible to capture stress and handling for medical treatment may be counterproductive. Hence, the prevention of disease has to be emphasised (Hosey et al., 2009). The aim of this study was to give a summary on the practical experience with herbal remedies at Zoo Basel from 2010 to 2014 as a means to expand the disease prevention and therapy spectrum.

Results and Discussion

In the five-year investigation period, Zoo Basel kept an average number of 616 animal species, approximately two thirds of which belong to invertebrates and fishes. Overall, 31 applications in 20 animal species were evaluated. A total of 48 medicinal plants was used, either in a single (n = 21), or a mixed formulation (n = 10). For the classification of indication, the anatomical therapeutic chemical classification system for veterinary medicine products (ATCvet) was applied (WHO, 2015). Most frequently, herbal remedies were used for gastrointestinal and metabolic disorders (ATCvet code QA, n = 9), followed by dermatological (QD, n = 5), nervous (QN, n = 5) and cardiovascular (QB, n = 3) treatments. The highest number of treatments was received by the order of primates (n = 11), followed by perissodactyla (n = 7) and artiodactyla (n = 5).

Thirteen applications were further characterised as established standard therapeutics. The criteria for the inclusion in this group were on the one hand the proof of a repeatable positive effect to treat or prevent diseases, and on the other hand good patient compliance, simple administration and a lack of adverse effects. Details of indication, animal species, plant species and plant parts used as well as treatment regimens are listed in Table 1. We rated the effectiveness of these established standard applications subjectively as good (n = 9; treatment led to restitutio ad integrum or prevented disease), moderate (n = 1; treatment led to an improvement of a medical condition) or variable (n = 3; treatment led to an improvement of a medical condition in several but not all of the patients). For a comparison between different species including humans, daily dosages were converted to dosage per kilogram metabolic body weight (MBW = body weight$^{0.75}$). Live weight from animals was either taken from medical or pathological records established at Zoo Basel.

One example of an established application is the prophylaxis of gastrointestinal colic symptoms and diarrhea in African elephants (*Loxodonta africana*) with *Triticum aestivum* L. soaked in water for 30 minutes prior to feed-

Table 1: Established phytotherapeutics and treatment protocols used in different zoo animals at Zoo Basel from 2010 to 2014.

ATCvet	Species	Plant (latin name)	Plant part	Dosage/ MBW[a] ($kg^{0.75}$)	Application	Duration	Effecti-veness	Use in other species
QA06	African elephant	*Triticum aestivum* L.	furfur	13.7 g	b.i.w.[b] p.o.[c]	continuous	good	no
QA06	Grant's zebra	*Plantago ovata* Forssk	semen	693 mg	s.i.d.[d] p.o.	few days	good	domestic equids
QA06	Ostrich	*Linum usitatissimum* L.	semen	342 mg	s.i.d. p.o.	breeding season	good	great apes
QA07	Chimpanzee	*Ceratonia siliqua* L.	fructus	2.1 g	b.i.d.[e] p.o.	few days	variable	various primates
QA07	Crab-eating macaque	*Theobroma cacao* L.	semen	522 mg	s.i.d. p.o.	few days	good	great apes
QA07	Red forest duiker	*Picea abies* L.	summitates	48 mg	s.i.d. p.o.	few days to weeks	variable	various mammals
QB06	Chestnut-mandibled toucan	*Quercus robur* L.	cortex	23.5 g	s.i.d. p.o.	continuous	moderate	various sturnidae, Fischer's turako
QC02	Woolly monkey	*Allium sativum* L. *Viscum album* L. *Crateagus laevigata* Dc.	bulbus herba fructus	27 mg 11 mg 11 mg	s.i.d. p.o.	continuous	good	no
QD11	Indian rhinoceros	*Calendula officinalis* L. *Echinacea purpurea* L.	flos herba	1.7 mg 1.7 mg	b.i.d. top.[f]	1 to 2 weeks	good	no
QG52	Sumatran orangutan	*Urtica dioica* L. *Foeniculum vulgare* L. *Carum carvi* L. *Pimpinella anisum* L. *Galegae officinalis* L.	herba fructus fructus fructus herba	126 mg 126 mg 126 mg 126 mg 126 mg	b.i.d. p.o.	6 months	good	various primates
QM01	Ostrich	*Harpagophytum procumbens* DC. Ex Meisn.	radix	26 mg	b.i.d. p.o.	2 to 4 weeks	variable	various mammals
QN06	Western lowland gorilla	*Panax ginseng* C.A. Meyer	radix	1.9 mg	s.i.d. p.o.	continuous	good	great apes
QR05	Western lowland gorilla	*Citrus x limon* *Allium cepa* L. *Tilia cordata* Mill. *Pimpinella anisum* L. *Cuminum cyminum* L.	fructus bulbus flos fructus fructus	 112 mg 112 mg 112 mg	t.i.d.[g] p.o.	few days	good	great apes

ATCvet, Anatomical Therapeutic Chemical Classification System for veterinary medicinal products; QA, alimentary tract and metabolism; QA06, drugs for constipation; QA07, antidiarrheals, intestinal anti-inflammatory/antiinfective agents; QB, blood and blood forming organs; QB06, other haematological agents; QC, cardiovascular system; QC02, antihypertensives; QD, dermatologicals, QD11, other dermatological preparations; QG, genito urinary system; QG52, products for teats and udder; QM, musculo-sceletal system; QM01, antiinflammatory and antirheumatic products; QN, nervous system; QN06, psychoanaleptics; QR, respiratory system; QR05, cough and cold preparations.
[a]MBW, metabolic body weight; [b]b.i.w., twice weekly; [c]p.o., orally; [d]s.i.d., once daily; [e]b.i.d., twice daily; [f]top., topical; [g]t.i.d., three times daily.

ing (Fig. 1). It is based on own experience and has also been described for this indication in livestock and horses as a Swiss ethnoveterinary use report (Klarer et al., 2013). Since this regular treatment was administered, gastrointestinal disorders have been minimized. Whenever crab-eating macaques suffer from unspecific diarrhea, they are offered dried beans of *Theobroma cacao* L. (Fig. 2). This treatment has been used repeatedly with success. The mode of action, i. e. the inhibition of salt and water secretion by flavonoids, was described in vitro (Schuier et al., 2005). A further established application is the use of Citrus x limon, *Tilia cordata* Mill., *Pimpinella anisum* L., *Allium cepa* L.and *Cuminum cyminum* L. in the form of an infusion as a cold preparation in western lowland gorillas (*Gorilla g. gorilla*) and other great apes. Although the latter two plants are mainly known for their effect on the alimentary tract, both *Tilia cordata* Mill. and *Pimpinella anisum* L. also have an impact on respiratory diseases (ESCOP, 2003). The synergy of antimicrobial, secretolytic and expectorant properties of this combination may be responsible for the good therapeutic outcome.

The remaining 18 applications, listed in Table 2, are descriptions of single or few treatments with variable effectiveness. The same details of information are provided as in table 1. We rated the effectiveness of these applications as good (n = 12), moderate (n = 2) or unsatisfactory (n = 4). An example is the use of dried *Ginkgo biloba* L. as a vasoprotective in a 29-yr-old sun bear (*Helarctos malayanus*) (Fig. 3). This treatment is based on a survey of pathological reports that revealed arteriosclerosis as a major concern in this species in captivity (Hoby et al., 2010). At present, the physical condition and the quality of life of the geriatric bear are still rated as good (Föllmi et al., 2007). Three applications concern the promising treatment of the nervous system in an Indian rhinoceros (*Rhinoceros unicornis*), a western lowland gorilla and a Sumatran orangutan (*Pongo abelii*). After a change in their social environment, these ani-

Table 2: Single use of phytotherapeutics and treatment protocols in different zoo animals at Zoo Basel from 2010 to 2014.

ATCvet	Species	Plant (latin name)	Plant part	Dosage/ MBW[a] ($kg^{0.75}$)	Application	Duration	Effectiveness	Use in other species
QA01	African elephant	*Calendula officinalis* L. *Matricaria recutita* L. *Malva sylvestris* L. *Commiphora myrrha* Propolis	flos flos folium resina	18 mg 18 mg 18 mg 18 mg 18 mg	s.i.d.[b] p.o.[c]	2 weeks	good	Indian rhinoceros
QA03	Okapi	*Ceratonia siliqua* L. *Gentiana lutea* L. *Foeniculum vulgare*	fructus radix fructus	222 mg 222 mg 222 mg	s.i.d. p.o.	few days	good	no
QA05	Western lowland gorilla	*Silybum marianum* L.	fructus	41 mg	b.i.d.[d] p.o.	continuous	good	no
QC05	Black-handed spider monkey	*Pinus pinea* L.	cortex	6.2 mg	b.i.d. p.o.	few days	good	no
QC05	Sun bear	*Ginkgo biloba* L.	folium	17 mg	s.i.d. p.o.	continuous	good	no
QD03	Scarlet pleco	Propolis *Aloe barbadensis* et *ferox* Mill. *Silybum marianum* L. *Matricaria recutita* L.	 folium semen flos	365 mg 37 mg 74 mg 74 mg	s.i.w.[e] top.[f]	3 weeks	good	no
QD11	Red-bellied tamarin	*Filipendula ulmaria* L.	herba	42 mg	s.i.d. p.o.	2 months	unsatisfactory	various new-world primates
QD51	Indian rhinoceros	*Calendula officinalis* L.	flos, in bees wax	3.4 mg	s.i.d. top.	few months	unsatisfactory	no
QD51	Indian rhinoceros	*Viscum album* L.	herba, lipophilic extract 5 and 2%	0.7 to 1.7 mg	s.i.d. top.	few months	unsatisfactory	no
QG02	Sable antelope	*Tilia* sp.	cambium corticis	325 mg	s.i.d. p.o.	few days	good	no
QL03	Okapi	*Calendula officinalis* L.	flos	304 mg	s.i.d. p.o.	3 months	good	no
QL03	Reindeer	*Eleutherococcus senticosus* Maxim.	radix	252 mg	s.i.d. p.o.	20 days	unsatisfactory	no
QN05	African wild ass	*Humulus lupulus* L. *Lavandula angustifolia* Mill. *Melissa officinalis* L. *Passiflora incarnata* L. *Vitex agnus castus* L.	flos flos folium herba fructus	4 mg 4 mg 4 mg 4 mg 4 mg	b.i.d. p.o.	10 days	unsatisfactory	Grant's zebra
QN05	Indian rhinoceros	*Humulus lupulus* L. *Passiflora incarnata* L. *Valeriana officinalis* L.	flos herba radix	4 mg 1.3 mg 1.3 mg	b.i.d. p.o.	3 months	good	no
QN05	Western lowland gorilla	*Humulus lupulus* L.	flos	32 mg	b.i.d. p.o.	2 weeks	good	no
QN06	Sumatran orangutan	*Hypericum perforatum* L.	herba	10 mg	b.i.d. p.o.	9 months	good	no
QP53	California sheephead	*Allium sativum* L.	bulbus	1.5 g	s.i.d. p.o. q[g] 48h	6 months	moderate	no
QR03	Grant's zebra	*Thymus vulgaris* L. *Primula veris* L. *Eucalyptus globulus* *Nigella sativa* L.	herba radix folium semen	11 mg 9 mg 15 mg 6 mg	s.i.d. p.o.	10 days, repeated	good	Okapi

ATCvet, Anatomical Therapeutic Chemical Classification System for veterinary medicinal products; QA, alimentary tract and metabolism; QA01, stomatological preparations; QA03, drugs for functional gastrointestinal disorders; QA05, bile and liver therapy; QC, cardiovascular system; QC05, vasoprotectives; QD, dermatologicals, QD03, preparations for treatment of wounds and ulcers; QD11, other dermatological preparations; QD51, products for the treatment of claws and hoofs; QG, genito urinary system; QG02, other gynecologicals; QL, antineoplastic and immunomodulating agents; QL03, immunostimulants; QM, musculo-sceletal system; QN, nervous system; QN05, psycholeptics; QN06, psychoanaleptics; QP, antiparasitic products, insecticides and repellents; QP53, ectoparasiticides, insecticides and repellents; QR, respiratory system; QR03, drugs for obstructive airway diseases.
[a]MBW, metabolic body weight; [b]s.i.d., once daily; [c]p.o., orally; [d]b.i.d., twice daily; [e]s.i.w., once weekly; [f]top., topical; [g]q., every.

Figure 1: An adult female African elephant feeding on *Triticum aestivum* L. as a prophylactic treatment of gastrointestinal colic and diarrhea at Zoo Basel.

Figure 2: A subadult male crab-eating macaque is offered dried beans of *Theobroma cacao* L. to treat against diarrhea at Zoo Basel.

Figure 3: A geriatric sun bear ingests dried *Ginkgo biloba* L. as a vasoprotective agent at Zoo Basel.

mals were treated for a limited period of time with herbal remedies that are well known for their calming, anxiolytic or mild antidepressive effects from in vivo as well as human clinical research (ESCOP, 2003). The adult rhinoceros that reared a calf reacted very nervously about the presence of another female with its calf. The sedative and anxiolytic effects of *Humulus lupulus* L., *Passiflora incarnata* L. and *Valeriana officinalis* L. tincture helped to relieve the social stress drastically. The use of *Humulus lupulus* L. alone was successful in the integration process of a young female gorilla. When the dominant female was treated with the herbal tincture, a significant reduction in aggressive behaviour towards the new female was recorded. Another application during an integration process concerned a subadult orangutan. The animal was successfully treated with a registered human standard preparation based on dried *Hypericum perforatum* L. after a depressive mood was suspected (Hoby and Wenker, 2014).

Conclusion

Many of the herbal remedies used in this study were based on applications that were established in human or domestic veterinary medicine and applied to zoological medicine. Others were implemented according to practical experience, literature research or exchange with colleagues from various zoological institutions, hence the results are based on subjective perceptions. The presented phytotherapeutics included both the three medicinal products (Koi Med Wound Spray, Reinigungstrank Natuerlich, Stullmisan®S) that are currently commercially available and registered in the Swiss veterinary formulary (Tierarzneimittelkompendium, 2015), and pharmacy specialties, mixtures according to authors' prescriptions, feed additives, feed items and human therapeutic agents. Further surveys in other zoological institutions should be carried out to obtain a better overview of the knowledge and use of herbal remedies in zoological medicine.

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