

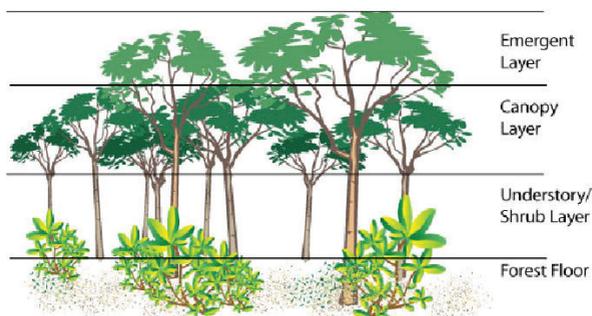
The mega-folivorous mammals of the Rainforest: feeding ecology in nature and in a controlled environment: A contribution to their conservation.

By Francesco Nardelli

Introduction

Most of our knowledge of breeding wild animals in controlled environments comes from hands-on experience, fieldwork observation and intuition. Thus, it is of fundamental importance to publish as many data as possible. This article is concerning diets for mega-folivores mammals of the rainforest, as an instrument for their *ex-situ* husbandry, breeding and future re-introduction into nature. Folivores, hindgut fermenters, face two functional problems with food digestion in which they differ from ruminants. Not only do they consume more food per day than a ruminant of similar size and diet, but they must also ensure that the cell walls are ruptured on initial food ingestion (while a ruminant can rely on fermentation to break down the cell walls). In contrast with animals having an enlarged hindgut, where microbial fermentation occurs *after* gastro-intestinal digestion (Stevens, C.E. and Hume, I.D. 1995), their foodstuff is composed of high fibre. Concerted efforts have to be made to maintain and breed these endangered species in controlled environments and proper diet and nutrition underlie success.

Rainforest Structure



The Sumatran and the Javan Rhinos, the Okapi and probably the Saola are almost entirely (>97%) folivorous mammals, feeding on leaves, buds and twigs from the Forest Floor, as observed clearly in their natural habitat, the rainforest. (Van Strien N.,1985, Amman H.,1985, Nardelli F., 1988, Hart J. & Hart T.,1989, Robichaud W.1998,1999)

The species

SUMATRAN RHINO *Dicerorhinus sumatrensis*

Rhinos habitat is on open grasslands and floodplains for black rhinos and white rhinos; swamps and open forests for Indian rhinos and Rainforest for Javan and Sumatran rhinos. 97% of the latter ones diet consists of leaves, buds and twigs. Fruit (only 1-2% of diet) is seldom found in the Rainforest thus it is to avoid and remove from a controlled environment feeding protocol, but in very small quantity. Although their ability to ferment food in their hindgut allows them to feed off on more fibrous plant matter, e.g. bark, if necessary.



Photo: Borneo Rhino Alliance

The Sumatran rhinoceros *Dicerorhinus sumatrensis* is an emblematic folivore, eating leaves and stems of broad-leaved shrubs and trees. The stems of giant gingers of the family Zingiberaceae are chewed to extract the soft, juicy pith and the hearts of some species also seem attractive, as *Eugenia* species in the family Sapotaceae. A preference for certain plants of the families Gesneriaceae, Acanthaceae, Piperaceae, Begoniaceae, Balsaminaceae, Rubiaceae, Compositae, Commelinaceae, and Araceae is clear and a rather extraordinary food-plant appears to be a species of *Melanorrhoea* (Strickland, 1967), the latex of which causes a serious rash or ulceration on human skin, but evidently does not affect the rhinos. In cleared, regenerating areas, following landslides or tree-falls, the rhino may, in addition to the above plants, feed intensively on the resulting dense vegetation, sampling Melastomaceae, Labiatae, Schisandraceae, Moraceae, Euphorbiaceae, Sabiaceae, Caprifoliaceae, Staphyleaceae, and Verbenaceae. Deliberate clearance of selected forest patches might, therefore, be a sound management technique in some areas where rhinos are known to be present. The animal's diet reflects the richness of its favourite forest habitat, with over a hundred species from more than 40 plant families identified among its food: a varied mixture of trees and shrubs,

many aromatic (not surprising, considering the rhino's well-developed sense of smell) but excluding grasses, except for bamboo. Trees of the families Guttiferae, Oleaceae, and Styracaceae are favourites with the rhinos in Gunung Leuser. Fruit is only occasionally sampled there, where the fruit most often found on the ground is 'kandis' (a species of *Garcinia*), a favourite of deer and pigs, though van Strien, 1985, reported that the rhinos never took it, no matter how plentiful it was. Grasses and sedges are not eaten.

Fruit is not an important part of the rhino's diet and fallen ones are very seldom found. The Sumatran rhino may have an average consumption of somewhat more than 50 kg of browse per day. When the rhinos were originally captured in Sumatra, they were fed solely native browses and slowly conditioned to accept alfalfa hay as a browse substitute - a method practiced successfully with Black rhinos, a browser. To facilitate this process, the alfalfa was soaked in water and small amounts were combined with fresh browse to improve acceptability. Over time, the percentage of alfalfa was increased; the rhinos adapted to alfalfa hay soaked in water with no browse added, then gradually to dry alfalfa. The inclusion of a high proportion of sub-tropical browse in the diets greatly contributes to the successful maintenance of this species at Cincinnati. Over the years, the male (Ipuh) has been fed a variety of temperate browses when available (along with herbivore pellets and alfalfa hay), but appetite was limited and preferences were distinct for mulberry (*Morus*), hackberry (*Celtis*), and willow (*Salix*) species. In 1993, a change to a higher-fibre browser pellet and mixed grass: legume hay was implemented successfully for 1 year, then the male showed depressed appetite for 6 months, went recumbent, and stopped eating for 4 days. The emergency acquisition of fresh *Ficus* browse (four species) from California stimulated his appetite immediately. The rhino consumed 20 kg of browse within the first 2 hours, continued to eat 32 to 40 kg/d, and regained 100 kg in 1 week. Fresh browse has also stimulated appetite in both females. ((Dierenfeld et al., 1994; Dierenfeld, 1995, Dierenfeld, 2000, Steve Romo, personal comm.).



Photo: Cincinnati Zoo

The browses offered, and particularly the preferred species *Ficus benjamina*, appear low in available protein compared with both native Indonesian browses and equine nutrient requirements. More critically, however, the mineral constituents of the imported browses appear to differ considerably from those in Indonesian browses examined (Dierenfeld, 1995). Other macro-minerals (potassium, magnesium) appear present in more than adequate concentrations. Of trace elements evaluated, copper, manganese, selenium, and zinc may be low in the temperate browses; similar low copper, selenium, and zinc ranges were also found in native browses. Iron concentration is lowest in the preferred species: *F. benjamina*. Given this, Sumatran rhinos are breeding in very large enclosures similarly to wild conditions, but where they can be carefully monitored and protected.

JAVAN RHINO

Rhinoceros sondaicus



Photo: Ujung Kulon National Park and WWF

Over 190 plant species from 61 families have been identified among this animal's food, 179 of them dicotyledons and only 11 monocotyledons, from rattan and pandanus palms to young bamboos, mangoes, and figs. Contrary to early supposition, there is no evidence that the rhino eats grasses, apart from bamboos. The four principal species eaten, 44 per cent of the total, are *Spondia pinnata*, an herbaceous *Amomum* species, *Leea sambucina*, and *Dillenia excelsa*. Other important plants are the climbers *Uncaria* species (possibly *U. ferrea*), *Poikilospermum suaveolens*,

Merremia vitifolia, *Mikania cordata*, and *Lantana camara* with *Syzygium polyanthum* (Amman, 1985). The rhino shows a strong preference for several other plants when they are available: *Kleinhovia variegata*, the fig *Ficus variegata*, *Sumbaviopsis albicans*, *Planchonia valida*, a kind of mango *Dracontomelum mangiferum*, *Hibiscus tiliaceus*, *Chisocheton microcarpus*, and *Gossampinus valetoni*.

The animal seems well able to cope with prickly plants too, although it will avoid dense thickets of mature bamboo and rattan, and, like its Sumatran relative, can even digest some species of *Melanorrhoea* of types that often raise blisters on human skin. It rarely eats bark, however, preferring the softer shoots and foliage on the upper parts of trees or shrubs. In considering the relative ecological niches of the Javan and Sumatran species it should be noted that the bulkier Javan rhino is able to withstand toxins in larger doses than the Sumatran and this, combined with the observation that its feet seem less well adapted to slopes, suggests that the Javan is generally more comfortable in thick lowland forest (where shade-tolerant plants are well protected by toxins) than the Sumatran, which favours hilly areas. Both species, however, choose clearings, often man-made, and areas beneath gaps in the canopy created by fallen trees, where they are available.

Despite some Javan rhinos have been kept in ‘Zoological Collections’ – aptly named at that time - there are no records of diets for those rhinos. Unfortunately it is easy to consider they were fed the same unbecoming food.

Any future *ex situ* breeding programme to regard the Javan rhino exclusively a folivore, like the Sumatran.



Photo: Alain Compost

OKAPI

Okapia johnstonii



Photo: Eli Greenbaum

To date only one long-term *in situ* ecological study of okapi has been conducted, at Epulu in the Ituri Forest (Hart and Hart 1989). This study revealed that Okapi are almost exclusively folivorous mammals, highly selective browsers, feeding primarily on the leaves of young, emerging trees, shrubs and lianas. In most zoos Okapis are fed alfalfa (*Medicago sativa*) hay, browse (cuttings from trees and shrubs) and a variety of greens (for example: lettuce, kale, spinach), vegetables (for example: carrots, yams/sweet potatoes), fruits (for example: apples) and a nutritionally complete or formulated pellet. The importance of high fibre is clearly underestimated. Given this species' special adaptations for procuring and digesting food, manipulation of browse and rumination are important considerations in selecting the types of food items offered. This highlights the importance of offering forage items that can be manipulated by the tongue, and with high fibre content in very large amounts. This unequivocal classification as a folivore, can be based on solid literature evidence: (Hart and Hart, 1988, 1989) and (Hart 1992) report that Okapis do not include monocots in their diet. Already Bume (1917) reported on remnants of natural food in the oesophagus of an Okapi from the wild: a bolus of small fragments of leaves of trees which were identified as fragments of

dicotyledonous plants, with grasses being evidently absent. This author cites different other authors who all observed the absence of grass and the complete focus on leaves in the natural diet of the Okapi (Wilmet 1913, Christy 1915). Okapis in the wild spend a majority of their time foraging from over two hundred species of plants although the bulk of their food comes from thirty species.

SAOLA

Pseudoryx nghetinhensis



Photo: Bill Robichaud

Quote from ultimateungulate.com: “Villagers’ reports suggest *P. nghetinhensis* feeds on the leaves of fig trees and other riverside bushes; the relatively short incisors suggest a browsing diet, supporting this theory (Dung *et al.*, 1994). Local reports suggest that the saola is quite fond of the medicinal herb *Homalomena aromatica* (Araceae) (Dung *et al.*, 1994). The saola is a rather delicate feeder – the captive female observed by Robichaud (1998) rarely jerked or pulled on vegetation while feeding, but rather chewed the petioles to separate the leaves from the stem before chewing the leaves themselves. This saola only occasionally pulled leaves into mouth using her tongue (surprising, given its length and mobility). This captive

individual was fed *Homalomena* sp. (Araceae – later identified as the related species *Schismatoglottis cochinchinensis* (Araceae)), *Asplenium* sp. (Aspleniaceae), and an unidentified broad-leaved plant of the family Sterculiaceae, all of which are reported to be part of the diet in the wild (Robichaud, 1998, 1999). Faecal deposits are composed of boluses (around eight deposited per episode), each measuring about 7.5 cm long by 4.5-6.0 cm in diameter. Each bolus is formed of smaller oval-shaped pellets (each about 1 cm by 2 cm by 0.75 cm – one bolus examined contained 46 pellets) (Robichaud, 1998). Boluses of fresh dung were eaten on one observed occasion (Robichaud, 1998). Observations of the drinking habits of the saola suggest that they can consumed large quantities of water at one time – in one 4 minute span, the captive female observed by Robichaud (1998) took nearly 60 draughts of water, pausing only five times to lick her nose and muzzle.“



Photo: AP

Feeding protocol for mega-folivorous mammals in a controlled environment.

Folivores are generally difficult to breed in a controlled environment, because plant material is extremely variable in its nutritional composition and regular quantities of appropriate forage may be difficult to obtain. Studies of nutrition in both wild and captive mega-folivorous mammals indicate that these species have a typically folivorous diet containing high fibre and relatively low energy. It is not very clear how these large mammals can sustain themselves on a completely folivorous diet. Constraints of low energy and low fibre digestibility could theoretically be met by specializations of the digestive tract, and behavioural adaptation. The existence of these strategies suggest some relevant implications for captive management: the diet rich in high fibre to maintain gut function it is indispensable. Large amounts and variety of forage should be provided to allow the folivores to be selective.

There are two types of fibre: Low (*short*) – soluble, which dissolves in water, and high (*long*) – insoluble, which does not. Both types are in all plant foods, but often in unequal proportions. High fibre foods are those that are good sources of insoluble fibre.

Some vegetables contain high amounts of insoluble fibre. Leaves of trees, shrubs, saplings are mostly containing high-fibre, which is what is vital to captive folivore animals. Several zoos think that some diseases may have been caused by inadequate diets. A logical deduction from this point is that many zoos will also agree that additional research is needed in the field of zoo animal nutrition. (Nijboer J., et al., 2000, 2003).

The diet of the Sumatran rhinoceros in Sumatran Rhino Conservation Center (SRCC), Department of Wildlife and National Park, Malaysia is a good example of a mega-folivorous mammal diet (Romo S., et al.):

Type of Food – Weight (kg.)

Concentrates – 2.0 :

Horse pellets (Cargill (M) Sdn. Bhd.)

Browses – 50:

Nangka (Jackfruit) leaves (*Artocarpus “gidis”*)

Pulai (*Alstonia specilata*)

Mahang (*Macaranga triloba* & *M. Gigantea*)

Kelompong (*Ficus variegata* & *F.glossolariodius*)

Produce/Fruit:

Banana – 2.0

Papaya – 2.0

Sweet potatoes – 2.0

Some plant sources of leaves in temperate climate regions:

Hackberry (*Celtis*), **Willow** (*Salix*), **Privet** (*Ligustrum*) **Poplar** (*Populus*), **Acacia** (*Robinia*), **Hawthorn** (*Crataegus*), **Ash** (*Fraxinus*), **Elm** (*Ulmus*), **Mulberry** (*Morus*), **Oak** (*Quercus*), **Hazel** (*Corylus*), **Apple** (*Malus*), **Pear** (*Pyrus*), **Rose** (*Rosa*), **Raspberries, Blackberries, and Dewberries** (*Rubus*) **Squashberry, Mooseberry, Cranberry** (*Viburnum*) have been successfully utilized.

To fulfil the necessity to provide fresh leaves, not always available, there are items which contain high fibre and are optimal substitutes.

To feed in large quantities besides, or in place of, fresh leaves:

String and green beans: contain a number of vitamins such as A, B-6, and C. **Broad green beans** are also excellent, but fed in smaller quantities.

They are low in calories and important in high-fibre and could supply up to 50% of the daily-recommended intake.

Some leafy greens are a good source of high-fibre. **“Romaine” lettuce** (long-narrow leaves), **celery** are healthful high fibre additions to the diet. They are low in calories, high in nutrients and minerals and do not cause the digestive problems that cellulose and starch in other vegetables might cause.

To feed in small quantities, not daily and not more than 5-10% of the total diet quantity:

Root Vegetables

Root vegetables are plant roots, meaning the underground portions of the plant that are edible. Carrots, potatoes and turnips skins hold nutrients and are a good source of high fibre.

Whole Grains

Rye and brown rice are good sources of insoluble high-fibre. Wheat is a plant that is harvested to make flour. The bran is the outer hull that covers the kernel. Foods high in high-fibre contain the kernel and the bran, including wheat bran, whole wheat bread and wheat cereal. Plain wheat without the bran, like processed flour, does not contain insoluble high-fibre. Other types of whole grains, the kind that include the bran as well as the kernel, also contain the insoluble kind.

Fruit

Certain fruit contain high-fibre. Think of foods with rough or stringy peels or hulls, or seeds. They contain high-fibre that cannot be broken down in the digestive

tract and pass through unchanged. Apple skin contains a large amount of insoluble high-fibre.

Vegetables

Most raw vegetables contain some amount of high-fibre. Vegetables with the highest amounts are turnips, beets, cauliflower, cabbage, Brussels sprouts and carrots. Leafy greens, broccoli, green beans, cucumbers, onions, sprouts, celery, tomatoes, eggplant, bell peppers and corn also contain some insoluble high-fibre.

Beans, Seeds and Nuts

Beans come to many people's mind when high-fibre is mentioned. The tough, yet flexible outer shell of most beans and other legumes contain valuable high-fibre. This type of fibre is also found in seeds, such as pumpkin and flax, nuts, sunflowers, peanuts, walnuts, cashews, almonds and lentils.

Culturing leafy bushes and trees.

Ideally, zoological institutions that keep folivores and that do not have reliable access to browse guaranteed by third parties, should maintain or contract their own browse plantation. Although this concept has been pursued by individual facilities for a long time, general interest in such resource management has increased only recently.

In his contribution, Marcus Clauss (Clauss et al. 2006) has explained the different necessary steps of planning, starting and maintaining a browse plantation for the purpose of regular harvesting. The author gives quantitative information on the size, plant density, expected browse yield, etc., that allow the calculation of the necessary resources (in terms of land and logistics) for a targeted amount of browse. Combined with estimates of recommended browse provision to different zoo animal species, this information allows the planning of a browse plantation tailored to any given needs.



Other high-fibre vegetables to be considered likely suitable in a folivorous diet, but need further research.

Artichoke

This vegetable has the highest percentage of high fibre but it is fed to folivores seldom - if at all - but may be the ideal substitute of leaves for mega-folivorous mammals during the autumn/winter. They are perennials that normally produce the edible flower only during the second and subsequent years, certain varieties of artichoke can be grown from seed as annuals, this means that zoo gardeners in northern regions can attempt to produce a crop without the need to overwinter plants with special treatment or protection. The artichoke leaves are edible too.

Asparagus, Leeks.

Leeks and asparagus are possibly suitable, but they ought to be tested first.

Supplements:

Vitamins, mineral and salt blocks.

To stimulate a beneficial gut microflora: **Vetrumex** – Fort Dodge, USA, a natural product entirely free of antibiotics or other chemotherapeutic substances. It contains SRE (synthetic rumen extract fermented in vitro), and nutrients (carbohydrates, proteins, minerals and vitamins).



Ratu with Andatu, born in Way Kambas on 23/06/2012; 1st in Indonesia, 7th ever.

Conclusions

A little less than thirty years has passed since the Singapore Sumatran Rhino Meeting (1984) that launched the First Sumatran Rhino Conservation Project.

The opinions on the project have been controversial, mainly due to the disappointment over the deaths of a quota of the animals moved to Zoos in the U.S.A., Great Britain, Malaysia and Indonesia; animals in any case with no hope of survival in their soon to be logged forest areas and as a consequence of their particular feeding requirements, poorly known at the time.

While Sumatran rhinos are imperilled worldwide by habitat loss and poaching, the gravest concern is that the populations are too small and scattered to maintain healthy breeding populations. Given this, we are now attempting to breed Sumatran rhinos in large, semi-free enclosures where they can be carefully monitored and protected. Just recently such a rhino sanctuary at Way Kambas National Park on the island of Sumatra has made headlines, producing its first offspring on June 23rd, 2012.

Among the other things to ponder, the project produced the birth of four Rhinos, improved the skill of Indonesians on methods to professionally maintain, breed and transfer these animals, permitted to ascertain that, unlike the other Rhino species, the Sumatran females do not have a set cycle, ovulating only as a consequence of pairing (induced ovulation) and that, besides habitat destruction and poaching, the declining trend included lack of genetic diversity and low breeding rate.

Ex situ conservation is today fundamental to support the few surviving Rhinos and Saolas, for the benefit of the species or merely for the sake of living creatures. So many are the species brought back from extinction and reintroduced into the wild that breeding in controlled environment is a priority, not a last resource. Today some of the conservation priorities for these species are:

- 1) To realize breeding facilities in Ujung Kulon and Bu Huong like the existing ones in Way Kambas and Ituri.
- 2) To transfer a number of Javan rhinos, Sumatran rhinos and Saolas from areas at risk to the controlled facilities.

This operation, besides reproduction opportunities, could contribute to better understand the *in situ* requirements of the species and to increase their numbers, the primary objective at this time.

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Links for further data:

<http://131.230.176.4/index.html>

<http://131.230.176.4/index.html>

http://www.ultimateungulate.com/artiodactyla/Pseudoryx_nghetinhensis

<http://phys.org/news/2012-03-diet-affecting-rhino-reproduction.html#nR1v>

http://www.zora.uzh.ch/3522/1/ZAN_III_browse_plant_2006.pdf

<http://www.pfaf.org/user/cmspage.aspx?pageid=226>

http://www.aspc.org/Pet-care/poison-control/Plants?plant_toxicity=non-toxic-to-horses

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