EAZA Best Practice Guidelines

CAPUCHIN MONKEYS

(*Sapajus* and *Cebus sp.*)

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EAZA Preamble

Right from the very beginning it has been the concern of EAZA and the EEPs to encourage and promote the highest possible standards for husbandry of zoo and aquarium animals. For this reason, quite early on, EAZA developed the “Minimum Standards for the Accommodation and Care of Animals in Zoos and Aquaria”. These standards lay down general principles of animal keeping, to which the members of EAZA feel themselves committed. Above and beyond this, some countries have defined regulatory minimum standards for the keeping of individual species regarding the size and furnishings of enclosures etc., which, according to the opinion of authors, should definitely be fulfilled before allowing such animals to be kept within the area of the jurisdiction of those countries. These minimum standards are intended to determine the borderline of acceptable animal welfare. It is not permitted to fall short of these standards. How difficult it is to determine the standards, however, can be seen in the fact that minimum standards vary from country to country.

Above and beyond this, specialists of the EEPs and TAGs have undertaken the considerable task of laying down guidelines for keeping individual animal species. Whilst some aspects of husbandry reported in the guidelines will define minimum standards, in general, these guidelines are not to be understood as minimum requirements; they represent best practice. As such the EAZA Best Practice Guidelines for keeping animals intend rather to describe the desirable design of enclosures and prerequisites for animal keeping that are, according to the present state of knowledge, considered as being optimal for each species. They intend above all to indicate how enclosures should be designed and what conditions should be fulfilled for the optimal care of individual species.

Acknowledgements

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Furthermore, we thank all the 54 zoos that participated in our survey :

Summary

This document deals with general biology and keeping requirements to provide adequate levels of well-being for capuchins in captive environment.

Section 1., Biology and Field Data, reflects our current knowledge of species in the natural environment using the most recent taxonomic information. The philosophy behind this is that *ex situ* conservation can be used more effectively as a conservation tool if it is part of an integrated approach to species conservation (IUCN, 2014). The potential need for a conservation role of an EAZA *ex situ* population has therefore been decided in consultation with *in situ* specialists. Several TAG members and species coordinators are involved in range-state species conservation planning processes that evaluate and incorporate *ex situ* activities as part of the overall conservation strategy. This section provides wide and actual information about the species in its natural habitat.

Section 2., Management in Zoos, covers housing and exhibition, nutrition, food presentation, welfare and enrichment, social structure, behaviour and veterinary care. This part was written relying on 2 surveys realized at the end of winter-beginning of spring 2017 for the management part and summer 2017 for the vet part. Capuchins need to be kept in groups, however their social structure results in eventual evictions of group members. Therefore, keeping those animals implies having sufficient enclosures to accommodate evicted animals in appropriate conditions. The Guidelines include comprehensive sections on managing evictions and holding surplus animals. A comprehensive veterinary section provides information on current knowledge on all aspects of medical care. It is essential that capuchins are provided with complex environments and there is detailed practical information on environmental enrichment and medical training.

This document is for the capuchins holders to get the better knowledge about keeping this magnificent species in the appropriate and best possible way, and for future holders that should be prepared to offer the animals optimal housing and care. Regularly consulting the Guidelines and sharing them with all staff members (especially keepers!) is recommended. Holders are advised to contact TAG members with any concerns or queries about capuchin husbandry.

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Section 1: Biology and field data

1. Taxonomy

1) Order: primates

Primates can be divided into prosimians (25% of the taxa), monkeys (70% of the taxa) and apes (5% of the taxa). Their distribution is tropical: the majority (90%) are located between the Tropic of Capricorn and the Tropic of Cancer. Brazil and Madagascar are the richest countries in diversity of primate species (214 species in total for both) (Mittermeier et al., 2013).

The first of the series Handbook of The Mammals of the World listed 181 species of primates (Honacki et al., 1982). Our understanding of this order increased much in the last 15-20 years. This is the reason why the number of species recognized evolved from 181 to 479 between the 1990s and now. Thanks to the increasing application of molecular genetic techniques and the effort to study the members of this group, today the IUCN/SSC Primate Specialist Group recognizes 479 species and 681 taxa of primates (IUCN SSC Primate Specialist Group, 2013). Nevertheless, the number of recognized primates is constantly changing; there is no agreed-on "official" list (Rylands and Mittermeier, 2014), and new research give new insights and new species. It is quite interesting to see how important was our ignorance about this group and so this is crucial to carry on the work in research. Unfortunately, the evolution of our understanding of this group was accompanied by an important increase of threats, caused directly or indirectly by humans (Mittermeier et al., 2013). According to the IUCN Red list, nearly half of all living primates are threatened and almost 11% are in the critically endangered category. Four species and one subspecies of capuchins are critically endangered.

2) Suborder

In the group of primates, we distinguish 2 suborders: the *strepsirhini* and the *haplorhini*. While the formers are nocturnal or secondary diurnal, the latter are diurnal except for rare secondary forms (*Tarsius* and *Aotus*), which suggests that the separation of the two groups corresponds to an orientation towards two vital rhythms (Hoffstetter, 1977). The special characteristics of the *haplorhini* members are an invasive, hemochorial form of placenta, a postorbital plate and spatulate incisors (Feldhamer, 2015).

The capuchins are part of the *haplorhini* suborder, like all the simians.

3) Parvorder

The simian infraorder is composed of *catarrhini* and *platyrrhini* parvorders. While the catarrhines live in the Old World, the Platyrrhines are New World monkeys, like the capuchins.

In the table below, it is interesting to notice the morphological differences between Old World and New World monkeys.

Catarrhines	Platyrrhines
2 premolar teeth	3 premolar teeth
Bony ear tube	No bony ear tube
Zygomatic and parietal bones do not fuse	Zygomatic and parietal bones meet at a symphasis on the side of the brain case

Table 1: Morphological comparison between Catarrhines and Platyrrhines

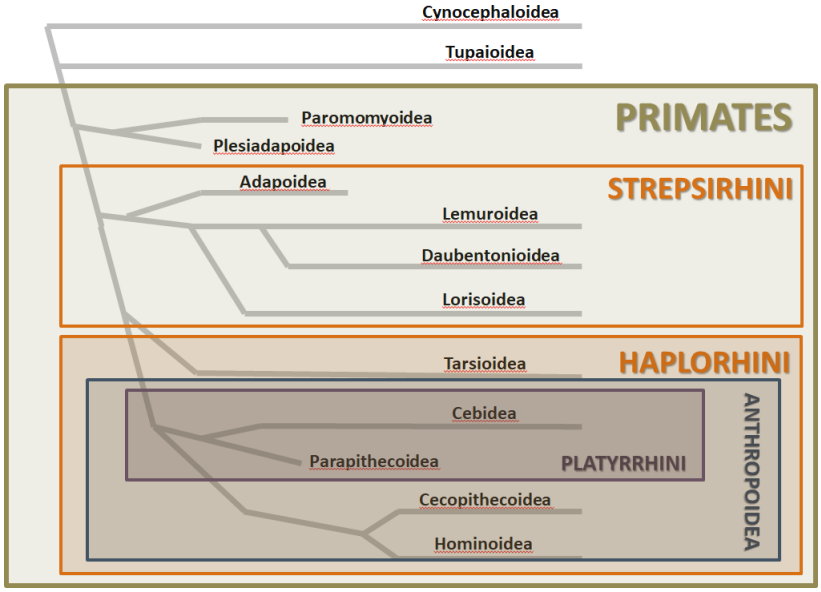


Figure 1: *Platyrrhini* parvorder in the phylogenetic tree of primates (adapted from Petkov & Jarvis, 2012)

4) Family

The *platyrrhini* parvorder is composed of 5 families: the *callitrichidae*, the *aotidae*, the *pitheciidae*, the *atelidae* and the *cebidae*. The family of *cebidae* is composed of *cebinae* and *saimirinae*. The close affinity between the 2 subfamilies was reinforced, among others, by genetic and postcranial studies (Mittermeier et al., 2013).

5) Subfamily

There are two different subfamilies in the *cebidae* family: the squirrel monkeys (*saimirinae*) and the capuchins (*cebinae*). We call « capuchins » all the members of the subfamily of *cebinae*. It forms a monophyletic clade, estimated to have diverged from squirrel monkeys about 15 million years ago (Mittermeier et al., 2013).

6) Genus

In this document, we will focus on the two genera of the *cebinae*: *Cebus* and *Sapajus*. The members of the *Cebus* genus are also called gracile or untufted capuchins. They are slenderer and longer-limbed than the *Sapajus*, which are more robust and compact. This is the reason why we also refer to them as “robust” or “tufted” capuchins.

7) Species

In the subfamily of *cebinae*, 22 species are identified: 14 for the *Cebus* genus and eight for the *Sapajus*. Below, there is a list with a short presentation of these 22 species classified by decreasing level of threats in the wild and then decreasing level of recommendation status in the Regional Collection Plan (IUCN, 2009, Mittermeier et al., 2013 and Vermeer, 2017). Only 7 species (4 species of *Sapajus* and 3 species of *Cebus*) are presented in member zoos of the European Association of Zoos and Aquaria (EAZA).

Sapajus xanthosternos

Common name:
Yellow-breasted Capuchin

IUCN Red List:	**Critically Endangered**
CITES:	Appendix II
EAZA Regional Collection Plan:	EEP

Taxonomy:
Cebus xanthosternos Wied-Neuwied, 1826, Rio Belmonte, Bahia, Brazil
Monotypic

Morphology:

	♀	♂
Body size	36-39 cm	39-42 cm
Tail	38-45 cm	38-45 cm
Weight	1,3-3,4 kg	2-4,8 kg

Darker in the south of its distribution, the Yellow-breasted Capuchin is brindled reddish above with a sharply marked, golden-red underside.

Habitat and distribution:
East coast of Brazil, in the south of Bahia state. Humid tropical lowland, submontane forest and dry, semi-deciduous or deciduous forest (caatinga).

Reproduction:
Gestation: 150 days.
Peak of births between May and August.

Diet:
Fruits, flowers, leaves of bromeliads, palm hearts and small animal prey (insects, birds and small mammals).
Important role of seed disperser (perhaps the only seed disperser of many plants in their habitat).

Behaviour:
Groups of 9 to 27 individuals.
Density: 3.7 individuals/km².

Sapajus flavius

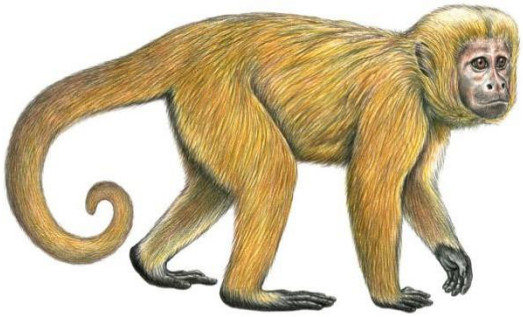
Common name:
Blond Capuchin

IUCN Red List:	**Critically Endangered**
CITES:	Appendix I
EAZA Regional Collection Plan:	Candidate for an EEP

Taxonomy:
Simia flavia Schreber, 1774, Côrrego do Inferno, Usina Maravilha, municipality of Goiana, Pernambucano, Brazil
Monotypic

Morphology:
Data about only 4 individuals

	♀	♂
Body size	*35,1-36,1 cm*	*36,8-40 cm*
Tail	*42 cm*	*37,8 cm*
Weight	*1,8-2,5 kg*	*2,9-3 kg*



Small, distinctive and untufted. Uniformly golden-yellow body and limbs (lower parts of the body little bit darker). Black hands and feets. Rectangular snow-white cap on the front of the head.

Habitat and distribution:
Lowland coastal rain forest and Montrichiardia linina swamp in north-east Brazil (Pontes et al., 2006), secondary forest, semi-deciduous seasonal forest, canopy at about 20 m and emergents about 25 m.

Reproduction:
Data deficient.

Diet:
Fruits, leaves, insects, spiders and small vertebrates.

Behaviour:
Very terrestrial in the caatinga scrub.
Large groups from 18 to 72 animals.
Complex fusion-fission society.
Only females carry infants.

Sapajus apella

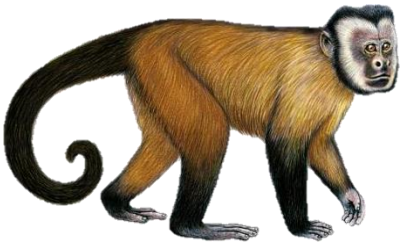
Common name:
Guianan Brown Capuchin

IUCN Red List:	**Least concern / Critically Endangered for *S. a. margaritae***
CITES:	Appendix II
EAZA Regional Collection Plan:	Replace

Taxonomy:
Simia apella Linnaeus, 1758, "America". Two subspecies recognized:
S. a. Apella Linnaeus, 1758, Eastern Coast of Amazon Basin in Colombia, South of Venezuela, Brazil
S. a. margaritae Hollister, 1914, East of Margarita Island, Venezuela

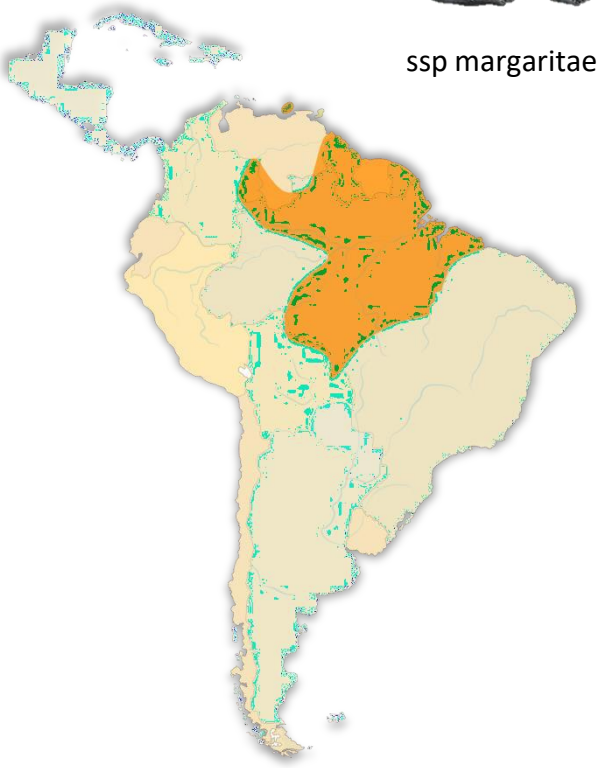
Morphology:

	♀	♂
Body size	38-46 cm	38-46 cm
Tail	38-49 cm	38-49 cm
Weight	1,3-3,4 kg	2,3-4,8 kg



ssp apella

ssp margaritae



Large, heavily built with a broad head, flat face and short limbs. Long and coarse coat with extremities darker than the rest of the body. Dark brown above with a yellowish or red underside. Thick mat of erect black hairs forming short tufts above the ears. Light grey brown face. *S. a. margaritae* is smaller.

Habitat and distribution:
Lowland, submontane and montane forests of the Guianan and Brazilian shields of the central and eastern Amazon Basin.

Reproduction:
Gestation: 155 days / Single offspring.
Peak of births in October-January.

Diet:
Fruits and seeds in large majority and small animal prey, palm heart and the rachis of palm leaves.

Behaviour:
Single-male or age-graded group of 10-20 individuals.
The Margarita Island Capuchin groups are smaller: 4-6 individuals.

Sapajus robustus

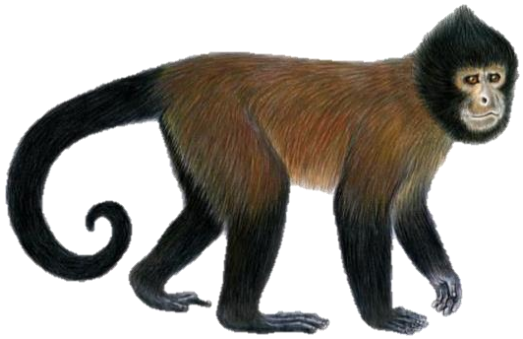
Common name:
Crested Capuchin

IUCN Red List:	**Endangered**
CITES:	Appendix II
EAZA Regional Collection Plan:	Do not obtain

Taxonomy:
Cebus robustus Kuhl, 1820, Morro da Arara, north of the Rio Mucuri, Minas Gerais, Brazil
Monotypic

Morphology:

	♀	♂
Body size	33-44 cm	42-56 cm
Tail	43-56 cm	43-56 cm
Weight	1,3-4,8 kg	1,3-4,8 kg



Very dark wood-brown or blackish above and on the limbs, with a trace of a dorsal stripe. Dark grayish face with some white hairs on the forehead and temples. Tall and conical crown tufts.

Habitat and distribution:
Tropical lowland and submontane forest in the Rio Jequitinhonha. Also dry, semi-deciduous forests in the western part of its range in Minas Gerais.

Reproduction:
Data deficient.

Diet:
Lack of data but the diet is certainly composed of fruits, leaves and animal prey (insects and small vertebrates).

Behaviour:
Group of 8-10 individuals (with 1-3 adult males).
Density: 0,2 group/km².

Sapajus nigritus

Common name:
Black-horned Capuchin

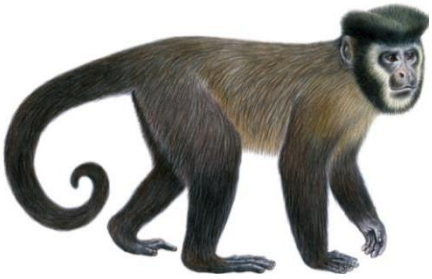
IUCN Red List:	**Near Threatened**
CITES:	Appendix II
EAZA Regional Collection Plan:	Replace

Taxonomy:
Cercopithecus nigritus Goldfuss, 1809, Serra dos Orgaos, Rio de Janeiro, Brazil
Monotypic

Morphology:

	♀	♂
Body size	42-48 cm	42-56 cm
Tail	No data	43-56 cm
Weight	2,6-4,8 kg	2,6-4,8 kg

Large with horn-like tufts of fur on either side of the head at the temples. Mostly black or dark brown with reddish or yellow-fawn underparts. Light colored face, dark crown and black tail. Crown tufts well developed in adults.



typical form

southern form

Habitat and distribution:
Lowland, submontane, montane tropical, subtropical forest, gallery and secondary forest.

Reproduction:
Gestation: 149-158 days.
Births only at the beginning and mid-wet season.
Interbirth interval is generally 25 months.

Diet:
Fruits, leaves, seeds, roots and animal prey (insects and small vertebrates).

Behaviour:
Generally, group of 12 to 17 individuals but it it's possible to observe up to 35 members.
Group is often divided into subgroups.

Sapajus libidinosus

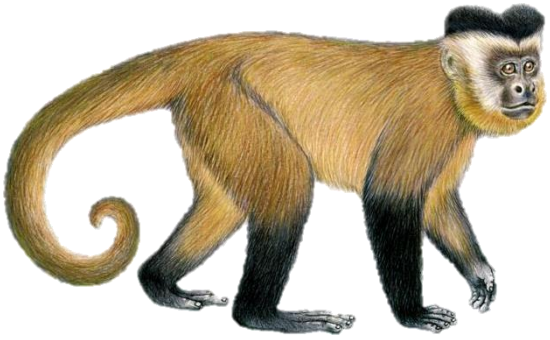
Common name:
Bearded Capuchin

IUCN Red List:	**Least concern**
CITES:	Appendix II
EAZA Regional Collection Plan:	Replace

Taxonomy:
Cebus libidinosus Spix, 1823, Rio Carinhanha, north of Minas Gerais, Brazil
Monotypic

Morphology:

	♀	♂
Body size	34-44 cm	*No*
Tail	38-49 cm	*Sexual*
Weight	1,3-4,8 kg	*Dimorphism*



Rusty red hair on the back of the neck, dark brown preauricular stripe running down the side of the face in front of the ears, orange-yellow throat and dorsal parts of the body, flanks, outer part of arms and two-thirds of the tail. Forearms are dark and the crown is black, with rounded, sometimes bushy, black tufts.

Habitat and distribution:
Dry xerophytic caatinga forest and scrub (North East).
Cerrado (central Brazil).

Reproduction:
Studies are lacking.
Nevertheless, aspects of reproduction are likely similar to other species of *Sapajus.*

Diet:
Mainly fruits and to a lesser extent small prey as insects. Uses stones to break open fruits to eat the endocarp.

Behaviour:
Cohesive groups of 9 to 16 individuals.
Clear dominance hierarchy.

Sapajus cay

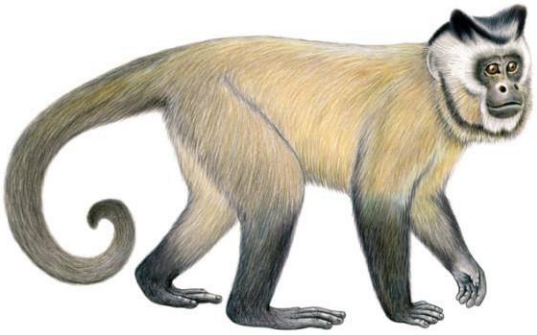
Common name:
Hooded Capuchin

IUCN Red List:	**Least Concern**
CITES:	Appendix II
EAZA Regional Collection Plan:	Replace

Taxonomy:
Cebus apella cay Illiger, 1815, left bank of the Rio Paraguai, Paraguay
Monotypic

Morphology:

	♀	♂
Body size	40-45 cm	*No*
Tail	41-47 cm	*Sexual*
Weight	3-3,5 kg	*Dimorphism*



Short-limbed species, typified mainly by its prominent dark dorsal stripe. Variable in color but generally quite pale. Slightly burnt brown hair on the back of the neck and dorsal proximal two-thirds of the tail. Grayish-brown dorsal parts of the body.

Habitat and distribution:
Different domains like Cerrado, Pantanal, part of Chaco, and the Atlantic and Amazonian Forests, as well as the Andean Yungas (Silva Jr., 2001).
The species is the only representative of the genus *Sapajus* in Paraguay (Lynch Alfaro et al., 2012).

Reproduction:
Data deficient.

Diet:
Fruits, leaves and animal prey (insects and small vertebrates).

Behaviour:
Data deficient.

Sapajus macrocephalus

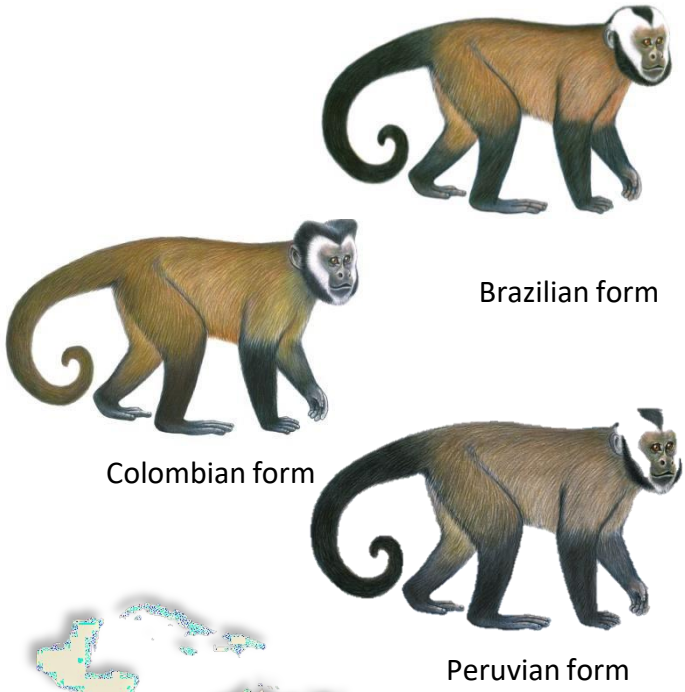
Common name:
Large-headed Capuchin

IUCN Red List:	**Least Concern**
CITES:	Appendix II
EAZA Regional Collection Plan:	Replace

Taxonomy:
Cebus macrocephalus Spix, 1823, forests of Lago Cactua, near Rio Solimoes, Amazonas, Brazil
Monotypic

Morphology:

	♀	♂
Body size	39,5-40,9 cm	37,5-45,5 cm
Tail	41,6-42 cm	42,5-49 cm
Weight	1,3-3,4 kg	2,9-4,6 kg



Mainly gray-brown or gray-orchery to dark brown above. Dark dorsal stripe and yellow-fawn or red-gold below. Well-developed, high, pointed crown tufts in adults. 3 forms identified: the Colombian form (bright brown above and red below), the Peruvian form (uniformly dark chestnut brown above and crown tufts absent or minimal), and the Brazilian form (reddish-brown above with very pronounced blackish dorsal stripe).

Habitat and distribution:
Nearly all types of Amazonian lowland and submontane forest, especially palm-dominated forest (Aquino and Encarnación, 1994).

Reproduction:
Ovarian cycle of 22 days.
Ovulatory period: 5-6 days.
Gestation: 153 days.

Diet:
Mainly fruits and insects but also seeds, pith, leaves, flowers, millipedes, lizards…

Behaviour:
Group of 8-14 individuals.

Cebus kaapori

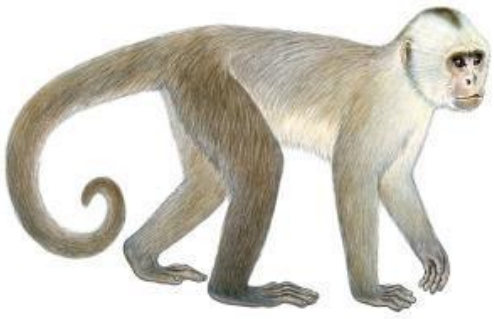
Common name:
Ka'apor Capuchin

IUCN Red List:	**Critically Endangered**
CITES:	Appendix II
EAZA Regional Collection Plan:	Candidate for an EEP

Taxonomy:
Cebus kaapori Queiroz, 1992, Quadrant 7,1 km south-west of the Chaga-Tudo Prospection, Carutapera, near right bank of Rio Gurupí, Maranhão, Brazil
Monotypic

Morphology:

	♀	♂
Body size	37-46 cm	37-46 cm
Tail	40-55 cm	40-55 cm
Weight	2,4 kg	3 kg



Gracile species with a long body compared with other species of *Cebus*. Grayish agouti brown, lighter on flanks. Silvery-gray face, shoulders, mantle and tip of the tail. Agouti limbs and dark brown or black hands and feet. Triangular black cap to the crown.

Habitat and distribution:
Undisturbed and slightly disturbed dense lowland Amazonian high forest, at altitudes of 200 m or less (Queiroz 1992). Can also be found in edge habitat in the transition with the Zona dos Cocais due to its propensity to feed on palm fruit.

Reproduction:
Data deficient.

Diet:
Lack of data but certainly fruits, seeds and insects.

Behaviour:
Groups of 1-7 individuals.

Cebus aequatorialis

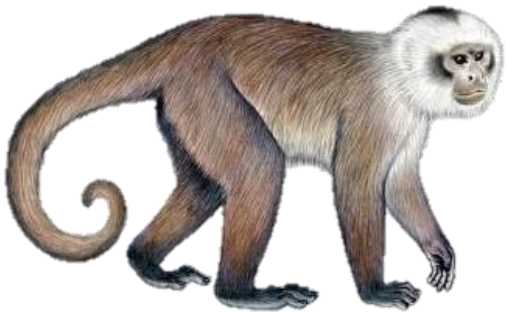
Common name:
Ecuadorian White-fronted Capuchin

IUCN Red List:	**Critically Endangered**
CITES:	Appendix I
EAZA Regional Collection Plan:	Do not obtain

Taxonomy:
Cebus aequatorialis J. A. Allen, 1914, Río del Oro, Manaví Province, near sea level, Ecuador
Monotypic

Morphology:

	♀	♂
Body size	35-51 cm	
Tail	40-50 cm	
Weight	1,2-2,2 kg	1,7-3,6 kg



Upperparts from the nape over the back, pale cinnamon rufous, darker along the midline of the back. Pale yellowish white front and sides of the head. Indistinct blackish line from the posterior border of the eye to the mouth.

Habitat and distribution:
Lowland, submontane and montane moist forests from seal level to 1500 m and mosaics of typical dry forest patches and gallery forest in different stages of generation, with severe dry seasons and annual rainfall less than 1700 mm.

Reproduction:
Females make “duck-face” when courting.
Females have a courtship dance.
Births most common in the dry season.

Diet:
Fruits, insects, snails, crabs, clams, slugs, frogs, lizards, nestling and adult birds.

Behaviour:
Groups average 16 individuals.
Sex-ratio: 0.7 male:1 female.

Cebus versicolor

Common name:
Varied White-fronted Capuchin

IUCN Red List:	**Endangered**
CITES:	Appendix II
EAZA Regional Collection Plan:	Do not obtain

Taxonomy:
Cebus versicolor Pucheran, 1845, Santa Fé de Bogota, Colombia
Monotypic

Morphology:

	♀	♂
Body size	45-50,5 cm	
Tail	42-45,5 cm	
Weight	Data deficient	

Darker than *C. cesarae* (see below). Rather pale form (extensions of the pale areas being fairly variable), with red tones on the mid-dorsal region and foreparts of limbs, generally contrasting with the rest of the body.

Habitat and distribution:
Lowland moist forest and palm swamps in the middle Río Magdalena Valley.

Reproduction:
Data deficient.

Diet:
Data deficient.

Behaviour:
Data deficient.

Cebus malitiosus

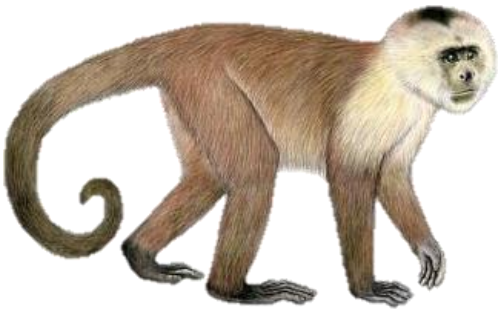
Common name:
Santa Marta White-fronted Capuchin

IUCN Red List:	**Endangered**
CITES:	Appendix II
EAZA Regional Collection Plan:	Do not obtain

Taxonomy:
Cebus malitiosus Elliot, 1909, vicinity of Bonda, north-west corner of base of Sierra Nevada de Santa Marta, Magdalena, Colombia
Monotypic

Morphology:

	♀	♂
Body size	45,7 cm	
Tail	43,3 cm	
Weight	Data deficient	



Pale brown cap with cinnamon brown back. Hairs on the belly and chest: ochreous tawny to cinnamon brown and silvery. Contrasting pale area of the front extending well over upper surfaces of the shoulders and inner sides of upper arms.

Habitat and distribution:
Lowland, submontane and montane forest.

Reproduction:
Data deficient.

Diet:
Data deficient.

Behaviour:
Data deficient.

Cebus cuscinus

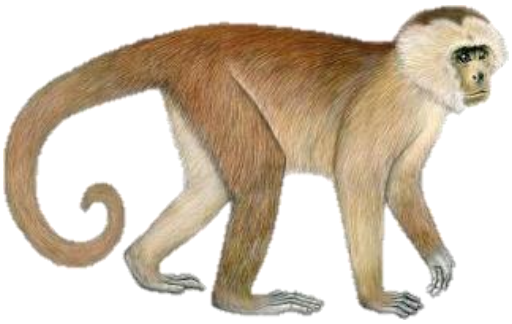
Common name:
Shock-headed Capuchin

IUCN Red List:	**Near Threatened**
CITES:	Appendix II
EAZA Regional Collection Plan:	Do not obtain

Taxonomy:
Cebus flavescens cuscinus Thomas, 1901, Callanga, Rio Pinipini, upper Rio Madre de Dios, Cuzco, Peru
Monotypic

Morphology:

	♀	♂
Body size	39-46 cm	40 cm
Tail	39-47,5 cm	44 cm
Weight	2,8-3 kg	2,8-3 kg



Similar to *C. unicolor* (see below) but with longer, silkier and less brightly colored fur. Large, distinct and dark brown cap. Tail: cinnamon brown above and brown below. The male has a broad pale frontal region sharply defining the dark brown cap. The female has a dark brown frontal diadem continuous with the cap.

Habitat and distribution:
Lowland terra firma and seasonally inundated forests in the upper Amazon basin, to the western slopes of the Andes in montane forest at elevations up to 1800 m.

Reproduction:
Mating is not restricted to the most dominant male.
Data deficient.

Diet:
Similar to *Sapajus macrocephalus* but with different strategies during fruit shortages (*C. cuscinus* travels larger distance to forage).

Behaviour:
Groups average c.15 individuals.
Sex-ratio is about even (1:1).
Large home range: more than 150 ha.

Cebus capucinus

Common name:
Colombian White-faced Capuchin

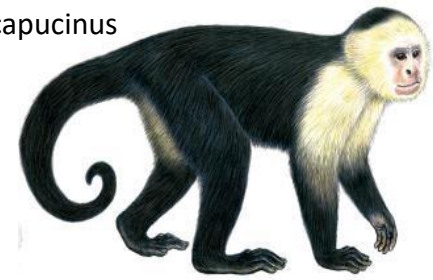
IUCN Red List:	**Least concern**
CITES:	Appendix II
EAZA Regional Collection Plan:	Do not obtain

Taxonomy:
Simia capucina Linnaeus, 1758, Colombia.
Two subspecies recognized:
C. c. capucinus Linnaeus, 1758, East of Panama, West of Colombia and North West of Ecuador
C. c. curtus Bangs, 1905, Gorgona Island, Colombia

Morphology:

	♀	♂
Body size	33-45 cm	33-45 cm
Tail	33-55 cm	33-55 cm
Weight	3-4 kg	1,5-3 kg

ssp capucinus



ssp curtus

Relatively slender, the Colombian White-faced Capuchin has a black body and a white chest extending to the face, the front of the crown, upward to the shoulders and upper arms. *C. c. curtus* is smaller than *C. c. capucinus* and relatively shorter-tailed.

Habitat and distribution:
Colombia and Panama.
Preference for terra firma primary forest or older secondary forest.
Occur up to elevations of 1800-2100 m.

Reproduction:
Gestation: 157-167 days.
Single cub every two years.
Peak of births in December-April.

Diet:
In majority ripe fruits and insects but also flowers, leaves and bird eggs and even oysters for *C. c. curtus.*

Behaviour:
Groups of 6 to 24 individuals.

Cebus imitator

Common name:
Panamanian White-faced Capuchin

IUCN Red List:	**Least Concern**
CITES:	Appendix II
EAZA Regional Collection Plan:	EEP

Taxonomy:
Cebus imitator Thomas, 1903, Chiriquí, Boquete, Panamá, altitude 1350 m
Monotypic

Morphology:

	♀	♂
Body size	38,5-40,5 cm	34,3-42 cm
Tail	43-45 cm	44-46 cm
Weight	2,6-2,7 kg	3,7-3,9 kg

Males 27% larger than females.
Females: elongated frontal tufts with hairs c.40 mm long, with a brownish tinge contrasting with the white of the cheeks and throat, entirely altering the facial appearance.

Habitat and distribution:
Data deficient.

Reproduction:
Data deficient.

Diet:
Data deficient.

Behaviour:
Groups of 1-7 individuals.

Cebus albifrons

Common name:
Humboldt's White-fronted Capuchin

IUCN Red List:	**Least concern**
CITES:	Appendix II
EAZA Regional Collection Plan:	Do not obtain

Taxonomy:
Simia albifrons Humboldt, 1812, forests near Santa-Barbara and the cataracts of the Rio Orinoco, Amazonas, Venezuela
Monotypic

Morphology:

	♀	♂
Body size	36,5-37,5 cm	37,5 cm
Tail	41-46 cm	42,5 cm
Weight	2,3 kg	No specific data / Only: 2,6 kg for a young male

The body is pale grayish-brown, darker on limbs. Hands and feet are yellowish brown. The face is naked and pink. The tail is ashy above, whitish below.

Habitat and distribution:
Prefer moister and less disturbed forest than other capuchins. Primary and some secondary deciduous, gallery, mangrove and flooded forest.

Reproduction:
Gestation: 162-180 days / Single young.
Births: Throughout the year but a peak at the end of the dry season in highly seasonal Llanos.

Diet:
Fruits, nuts, seeds, leaves, stems, flowers and small animal preys (mostly insects).

Behaviour:
Groups of 7 to 35 individuals (Berton et al., 2008). Sex ratio of 0.82 adult males for each adult female (Jack, 2012). Smaller groups in high altitude (Berton et al., 2008).

Cebus olivaceus

Common name:
Guianan Weeper Capuchin

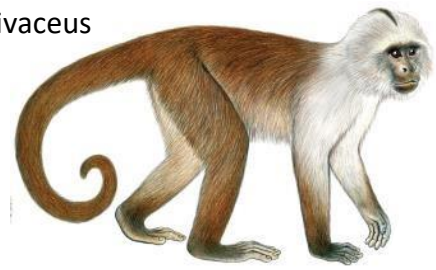
IUCN Red List:	**Least concern**
CITES:	Appendix II
EAZA Regional Collection Plan:	Replace

Taxonomy:
Cebus olivaceus Schomburgk, 1848, Venezuela. Two subspecies recognized:
C. o. olivaceus Schomburgk, 1848, Venezuelan Amazon Basin
C. o. castaneus I.Geoffroy Saint-Hilaire, 1851, Guianas and North Brazil

Morphology:

	♀	♂
Body size	37-46 cm	37-46 cm
Tail	45-55 cm	45-55 cm
Weight	2,3-3 kg	3-4,2 kg

ssp olivaceus



ssp castaneus

Large, heavy-set, shaggy fur. The coat is brown with black-agouti on flanks, limbs and tail. Naked and normally pink face. *C. o. olivaceus* is mainly dark brown or reddish with black on the extremities and buffy-white cheeks. The black triangle in the crown of the *C. o. castaneus* is narrow and the rest of the head is yellowish-white.

Habitat and distribution:
Primary rainforest, evergreen, and gallery forest from sea level to 2000m.

Reproduction:
Gestation: 149-158 days.
Peak of births at the end of the dry season and at the beginning of wet season.

Diet:
Fruits, largely fleshy and mostly ripe, small seeds, small prey.

Behaviour:
Group sizes average 20 individuals (approximately 35% of males and 65% of females). Spend almost 70% of their day foraging (most of the time on the ground).

Cebus unicolor

Common name:
Spix's White-fronted Capuchin

IUCN Red List:	**Least Concern**
CITES:	Appendix II
EAZA Regional Collection Plan:	Do not obtain

Taxonomy:
Cebus unicolor Spix, 1823, Forests of the Rio Tefé, near its confluence with the Rio Solimões, Amazonas, Brazil
Monotypic

Morphology:

	♀	♂
Body size	36,5-37,5 cm	36,5-37,5 cm
Tail	42-46 cm	42-46 cm
Weight	Lack of data	

Uniformly bright ocher or greyish-brown (flanks greyer and mid-back darker brown), with a yellowish or creamy-fawn front and reddish-yellow or reddish limbs and tail. Nearly black crown.

Habitat and distribution:
Lowland terra firma and seasonally inundated forest (Váreza) and forest patches in Amazonian savannas.

Reproduction:
Data deficient.

Diet:
Fruits and invertebrate prey.

Behaviour:
Groups of 12-16 individuals.

Cebus brunneus

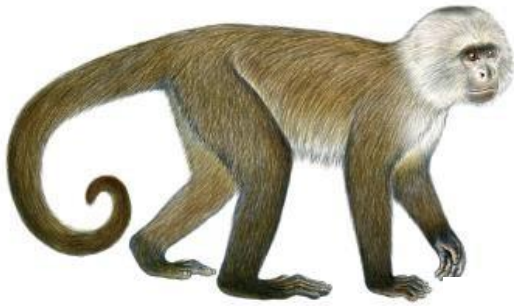
Common name:
Venezuelan Brown Capuchin

IUCN Red List:	**Least Concern**
CITES:	Appendix II
EAZA Regional Collection Plan:	Do not obtain

Taxonomy:
Cebus apella brunneus Allen, 1914, Aroa (Pueblo Nuevo), station on the Bolívar Railway, Yaracuy, north-western Venezuela, altitude 730 feet
Monotypic

Morphology:

	♀	♂
Body size	42 cm	42 cm
Tail	44 cm	44 cm
Weight	Data deficient	



Very thick and long pelage. Pale yellowish gray face and sides of the head. General color of upperparts darker along the middle of the back than on the sides. The crown: broad V-shaped patch of longish hairs. Whitish chin and lower part of the cheeks.

Habitat and distribution:
Lowland moist, montane, and submontane forests along the central and eastern Cordillera de la Costa of northern Venezuela and dry semi-deciduous forest and gallery forests in the western Venezuelan Llanos.

Reproduction:
Data deficient.

Diet:
Lack of data but certainly fruits, seeds and small animal prey.

Behaviour:
Data deficient.

Cebus cesarae

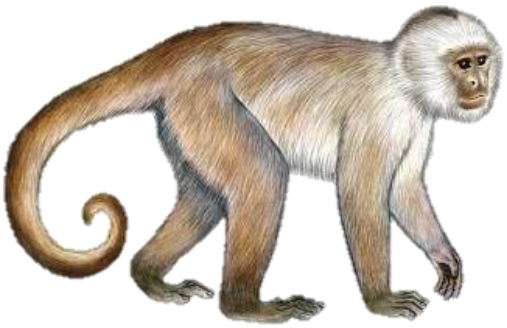
Common name:
Río Cesar White-fronted Capuchin

IUCN Red List:	**Data Deficient**
CITES:	Appendix II
EAZA Regional Collection Plan:	Do not obtain

Taxonomy:
Cebus cesarae Hershkovitz, 1949, Río Guaimaral, a channel of the Río César, Department of Magdalena, Colombia, altitude 140 m
Monotypic

Morphology:

	♀	♂
Body size	35,3-38,5 cm	34,8-40,7 cm
Tail	46,1-50 cm	41,9-49,5 cm
Weight	Data deficient	



The palest of the northern Colombian and Venezuelan white-fronted capuchins. Cinnamon or snuff brown-orangey cap. Middle of the back, forearms, forelegs are orangey and contrasted with sides of back and trunk. Frosted cinnamon-brown upper surface of the tail.

Habitat and distribution:
Dry semi-deciduous forest patches and gallery forest and mangroves in a region that is largely deforested.

Reproduction:
Data deficient.

Diet:
Data deficient.

Behaviour:
Data deficient.

Cebus yuracus

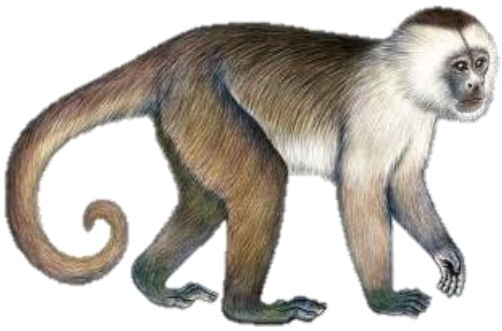
Common name:
Marañon White-fronted Capuchin

IUCN Red List:	**Not evaluated**
CITES:	Appendix II
EAZA Regional Collection Plan:	Do not obtain

Taxonomy:
Cebus albifrons yuracus Hershkovitz, 1949, Montalvo, a site on the left bank of the Rio Bobanaza, c.45 above its junction with the Rio Pastaza, an affluent of the Marañon, Eastern Ecuador, altitude c.500 m (C.P.Grooves in 2001 considered this form to be a junior synonym of *C. cuscinus*)
Monotypic

Morphology:

	♀	♂
Body size	37 cm	43 cm
Tail	45 cm	47 cm
Weight	2-4,7 kg	2-4,7 kg



Grey-fronted on the forehead, sides of the face, chest, and outer sides of the arms. Similar to *C. unicolor* but is general color is ochreous brown, sharply contrasting with grayish or buffy on the outer side of forelimbs; flanks are paler. Brown tail and dark to very dark brown cap.

Habitat and distribution:
Wet lowland terra firma and seasonally inundated forests in the upper Amazon basin, extending to montane forests on western slopes of the Andes at elevations up to 2000m.

Reproduction:
Births in September-March in Peru and
In November-January at Tiputini.

Diet:
Fruits, flowers, seeds, insects, bird eggs and small vertebrates.

Behaviour:
Groups of 5-35 individuals.

Cebus leucocephalus

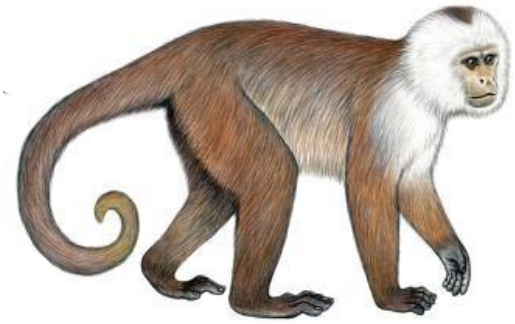
Common name:
Sierra de Perijá White-fronted Capuchin

IUCN Red List:	**Not evaluated**
CITES:	Appendix II
EAZA Regional Collection Plan:	Do not obtain

Taxonomy:
Cebus leucocephalus Gray, 1866, Colombia, restricted by P. Hershkovitz in 1949 to El Tambor, Río Labrija, 25 km north-west of Bucaramanga, Santander, Colombia
Monotypic

Morphology:

	♀	♂
Body size	Data deficient	37-47,7 cm
Tail		39,2-49,9 cm
Weight	Data deficient	



The darkest of the white-fronted capuchins. Cinamon brown, pale flanks. Auburn wrists, ankles and upper surfaces of hands and feet. Tail: cinnamon brown above, paler toward the tip and paler buffy underneath.

Habitat and distribution:
Lowland moist forest, semi-deciduous dry forest and mangroves.

Reproduction:
Data deficient.

Diet:
Data deficient.

Behaviour:
Data deficient.

2. Morphology

1) Body size

	♀	♂
Cebus albifrons		
Body size	36,5-37,5 cm	37,5 cm
Tail	41-46 cm	42,5 cm
Weight	2,3 kg	No specific data / Only: 2,6 kg for a young male
Cebus capucinus		
Body size	33-45 cm	33-45 cm
Tail	33-55 cm	33-55 cm
Weight	3-4 kg	1,5-3 kg
Cebus olivaceus		
Body size	37-46 cm	37-46 cm
Tail	45-55 cm	45-55 cm
Weight	2,3-3 kg	3-4,2 kg
Sapajus nigritus		
Body size	42-48 cm	42-56 cm
Tail	No data	43-56 cm
Weight	2,6-4,8 kg	2,6-4,8 kg
Sapajus libidinosus		
Body size	34-44 cm	*No specific data*
Tail	38-49 cm	
Weight	1,3-4,8 kg	
Sapajus apella		
Body size	38-46 cm	38-46 cm
Tail	38-49 cm	38-49 cm
Weight	1,3-3,4 kg	2,3-4,8
Sapajus xanthosternos		
Body size	36-39 cm	39-42 cm
Tail	38-45 cm	38-45 cm
Weight	1,3-3,4 kg	2-4,8 kg

Table 2: Morphological characteristics of several capuchin species (Mittermeier et al., 2013)

Generally, the average weight of the capuchins is 3 kg. It represents 4 to 6 times the weight of a squirrel monkey. There is a sexual dimorphism in bodyweight of 24% advantage to the males (except *Sapajus libidinosus*) (Mittermeier et al., 2013).

Drawings in annex 1 show the equivalent size of each species compared to the other.

2) General description

The capuchins are small primates with a body size that does not exceed 60 cm. The color of the coat can vary a lot from black to yellow and even to white. The tuft is absent in the *Cebus* species (at least for the males; exception for some females of *C. olivaceus* and *C. albifrons*) but variably present in the members of *Sapajus* (Jungers and Fleagle, 1980).

The capuchins are quadrupedal leapers and walkers. The gracile ones are less quadrupedal than the robust ones. They both have a prehensile and functional tail but they just use it to grasp (not to hang). The length of the tail ranges from 33 cm (for *Cebus capucinus*) to 56 cm (for *Sapajus nigritus*). With their pseudo-opposable thumbs, the capuchins have the best dexterity known in all the New World monkeys, as effective as the Chimpanzees (Mittermeier et al., 2013).

3) Basic anatomy

The basic anatomy of the capuchins is different between the *Cebus* species (the gracile capuchins) and the *Sapajus* species (the robust capuchins). It is one of the arguments that justify the use of the two genera: *Sapajus* and *Cebus*.

To begin, the *Sapajus* species are more robust and compact in their tails, limbs, jaws and skulls than the species of *Cebus* (Mittermeier et al., 2013). The robustness could be associated with increased durophagy. Silva suggested that this difference was a result of character displacement and niche partitioning between *Cebus* and *Sapajus* (Silva, 2001). Moreover, the robust capuchins have shorter forelimbs and relatively shorter hands and feet (Mittermeier et al., 2013). They spend less time on the ground compared to the *Cebus* species. There are differences in the proportion of the body from the beginning of their development: for example, *C. albifrons* and *C. apella* show divergent growth trajectories in the length of the limb as a function of body mass (Jungers & Fleagle, 1980). Silva's morphometric analysis of *Sapajus* species showed a hierarchy of *Sapajus* species relationships and he subdivided this genus into three geographical groups (Silva,2001):

1: Amazonian species (*S. macrocephalus and S. apella*)—At present, there is no genetic evidence that supports the distinction between these two species (Lynch Alfaro et al., 2011).
2: Species from the center of South America, from the Cerrado (bush savanna of Central Brazil) and the Atlantic Forest north of the Rio Doce (*S. libidinosus, S. cay, S. robustus, S. xanthosternos*).
3: Species from the Atlantic Forest south of the Rio Doce (*S. nigritus*).

The male robust capuchins have a sagittal crest that doesn't exist in the gracile capuchins. Thanks to this, the cranial area is bigger for the attachment of temporal muscles (Silva, 2001). The adult male *Sapajus* has larger and thicker mandibles compared to the *Cebus* adult male (Jungers & Fleagle,1980). The canines of the gracile capuchins are long and slender while they are short and large for the robust capuchins. The orbits are both taller and wider in *Cebus* compared to *Sapajus* (Lynch Alfaro et al., 2011). Their brain is large in comparison to their body size: its postnatal development is important. Capuchin monkeys have the largest encephalization quotients of any nonhuman primate (Stephan & al. 1988).

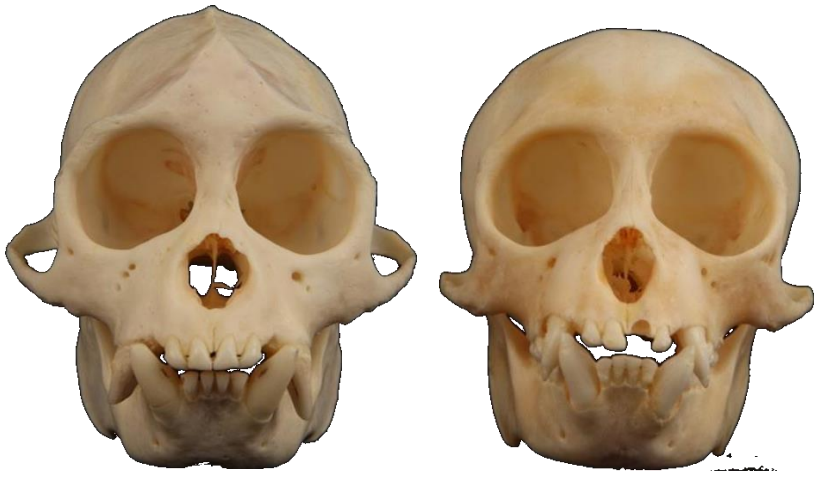


Figure 2: Photographs of male (left) and female (right) *Sapajus* skulls (©Besançon Museum)

3. Physiology

Body temperature: 36,7 – 38,4 °C
Respiratory rate: 30 – 50 cycles/min
Heart rate: 165 – 230 beats/min

4. Longevity

Hakeem (1996) estimated that the life expectancy of captive male white-faced capuchins is 55 years (Hakeem, 1996). Nevertheless, the exact life expectancy of wild male capuchins is unknown and the oldest male in the study groups of Jack and Fedigan was estimated to be 20 years (Jack and Fedigan, 2004). *Cebus capucinus* and *Cebus albifrons* are known to live over 40 years. Currently, the oldest capuchin alive in an EAZA zoo is a *Cebus capucinus* female which is 38 years old.

5. Zoogeography and ecology

1) Distribution

All the members of *cebinae* live in Central and South America on about 12 million km², from Honduras to Bolivia, occupying all the tropical and subtropical regions, from the level of the sea to over 2,500 meters. The gracile capuchins occupy the Amazon Basin for longer than the robust capuchins (Mittermeier et al., 2013).

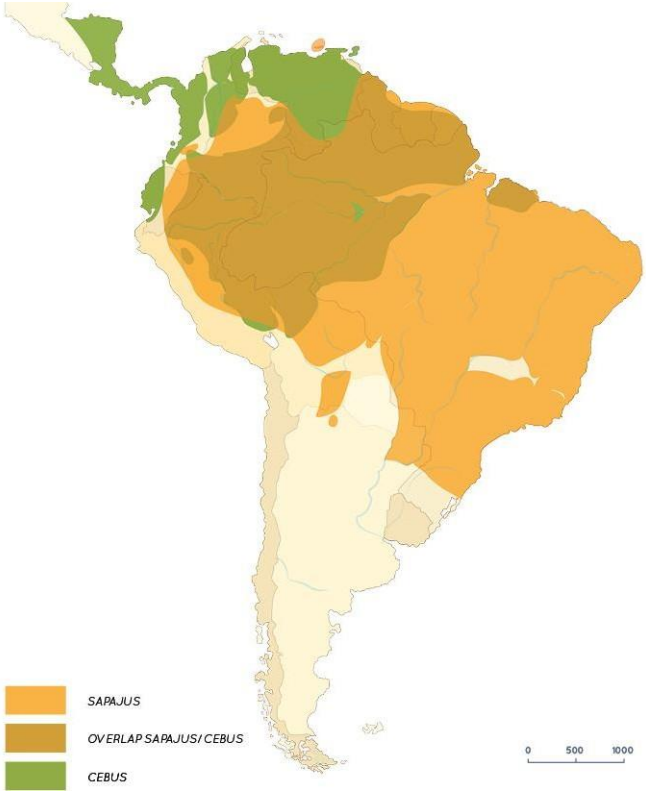


Figure 3: Map of distribution and overlap of *Cebus*/*Sapajus* (©Camille Fiore)

The figure 3 shows clearly the distribution of *Cebus* and *Sapajus* genera. We can notice that *Cebus* capuchins can be found on the north west of South America and *Sapajus* species distribution spreads almost all the north part of South America. The overlap of *Cebus* and *Sapajus* species distributions consists in a wide area where the two genera can be found in the same place.

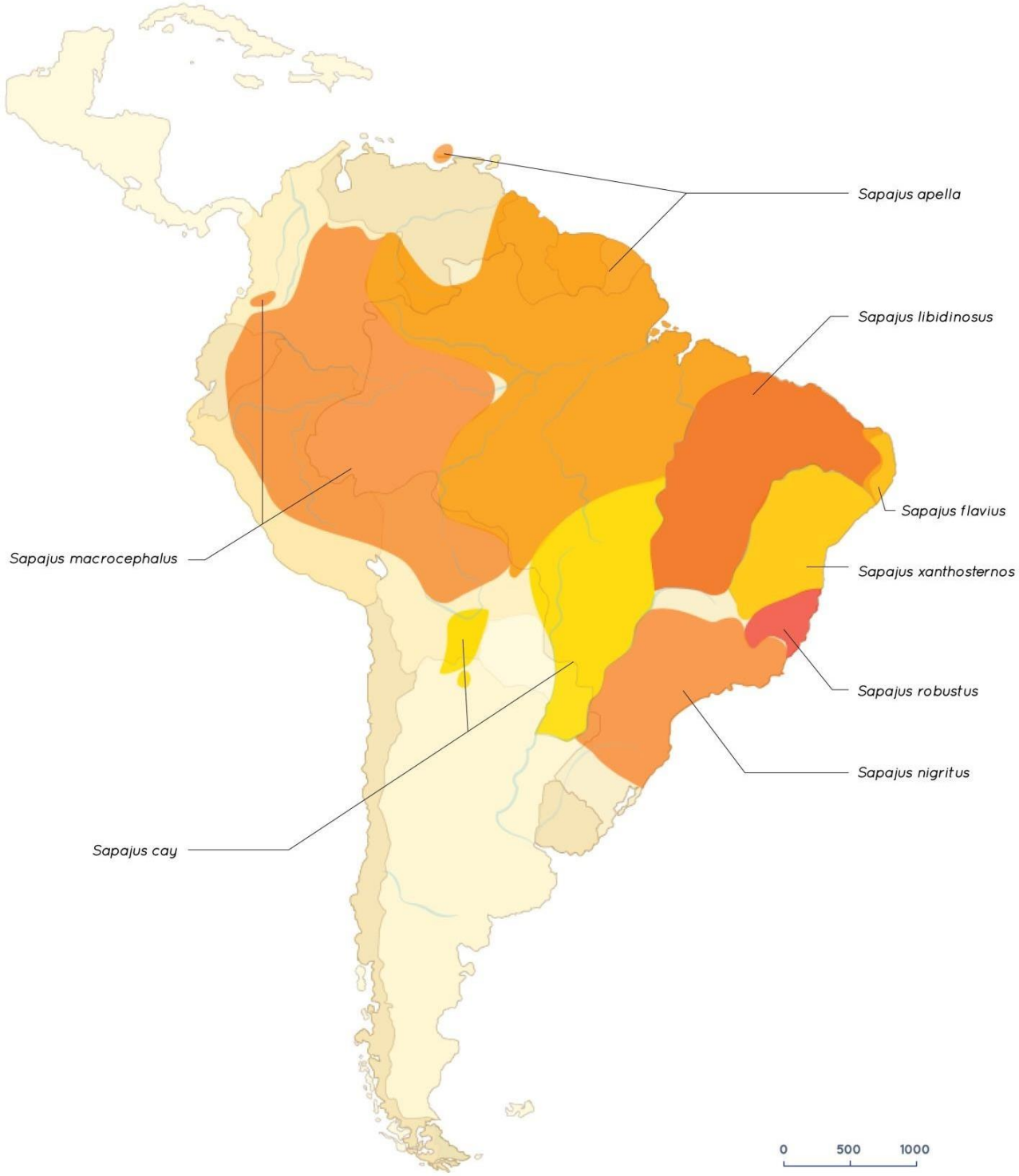


Figure 4: Distribution map of *Sapajus* species (©Camille Fiore)

Whereas the overlap between *Cebus* and *Sapajus* genus is important (figure 3), we can see that the distribution of all the species within the same genus, either *Sapajus* (figure 4) or *Cebus* (figure 5), are generally distinct and there is not wide places of overlap. Most of the time a natural barrier like a river delimits the distribution range of each species.

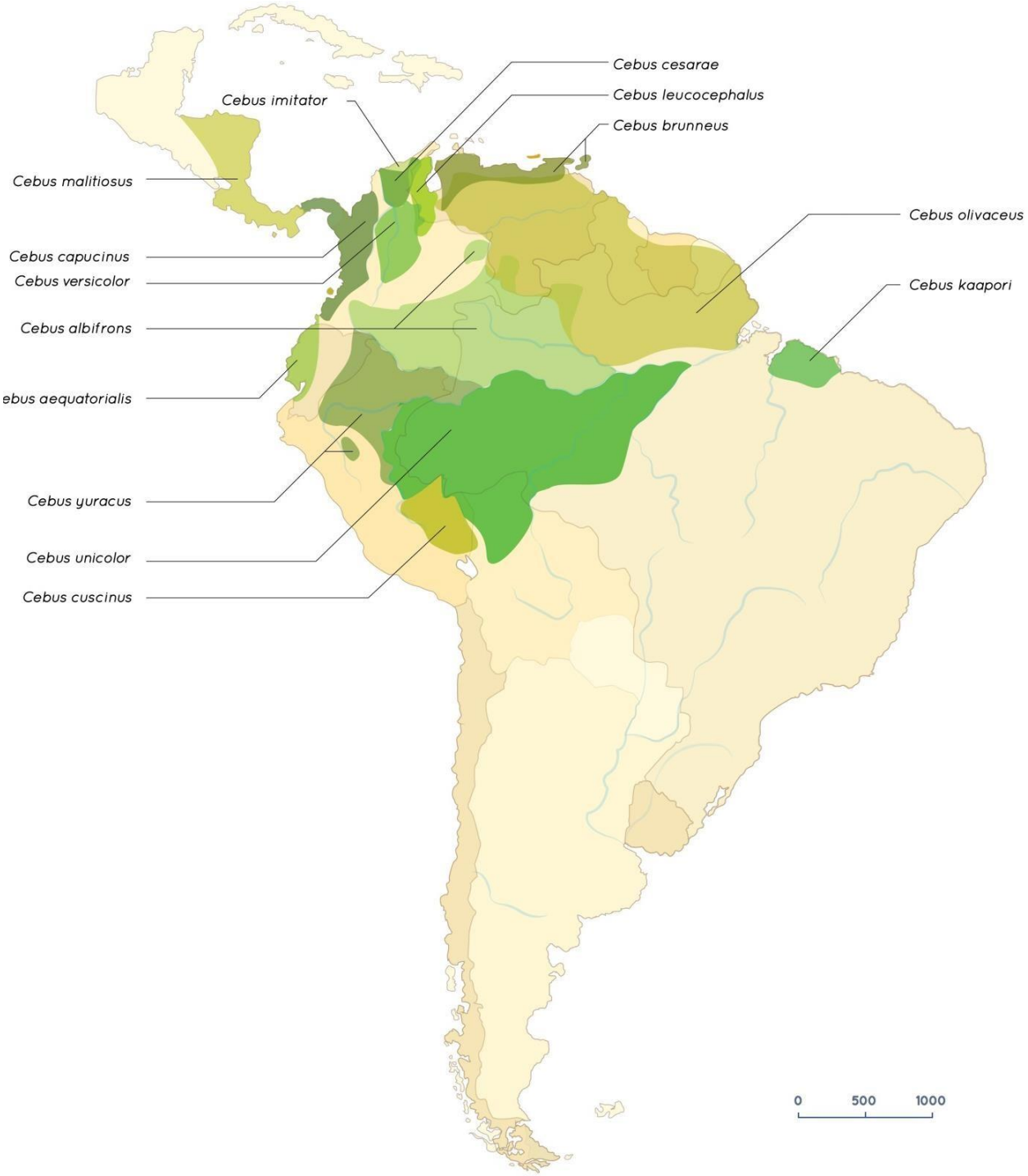


Figure 5: Distribution map of *Cebus* species (©Camille Fiore)

2) Habitat

The capuchins occupy all the tropical and subtropical regions, in humid or dry forests, swamps and mangroves. Some species like the Panamian White-faced Capuchin and the Colombian White-faced Capuchin, live in very wet forests with rainfall of over 5000 mm per year, but can also occur in dry deciduous forests (Mittermeier et al., 2013). It shows the extraordinary capacity of the members of the *cebinae* to adapt and spread in several and very different types of environment.

3) Threats

Unfortunately, the global capuchin population is decreasing because of the threats like fragmentation and loss of habitat. Their habitat is destroyed to convert forests in agricultural lands, for cattle ranching or new plantations (sugar cane, eucalyptus, corn…). It means that capuchins lose their resources and the habitat but also that small populations become more isolated from each other. *Cebus kaapori* suffers from selective logging, leading to the loss of trees providing fruits that are a significant component of its diet (Lopes, 1993). Besides, capuchins are hunted either for food or to use them as pets. This threat is really common in South America and all the species of capuchins are concerned. Guajá Indians are used to catch and keep *Cebus kaapori* as pets (Queiroz, 1992). Stallings (1985) wrote that hunting (by indigenous peoples) and forest loss are the main threats for *Sapajus cay* in eastern Paraguay. Finally, according to Sanz and Marquez (1994), hunting pressure for pest control could be the main factor driving the subspecies *Sapajus apella margaritae* to extinction in a few years. Release of monkey pets in the habitat of the Margarita Island Capuchin is another threat for this subspecies (Martinez et al., 2000), as they represent an important risk of disease transmission and hybridization.

4) Conservation status and actions

Species	IUCN status	Ex-situ conservation
SAPAJUS		
Sapajus xanthosternos	Critically Endangered	EEP
Sapajus flavius	Critically Endangered	Candidate for an EEP
Sapajus apella margaritae	Critically Endangered	Replace
Sapajus robustus	Endangered	Do not obtain
Sapajus nigritus	Near threatened	Replace
Sapajus cay	Least Concern	Replace
Sapajus libidinosus	Least concern	Replace
Sapajus apella apella	Least Concern	Replace
Sapajus macrocephelus	Least Concern	Replace
CEBUS		
Cebus kaapori	Critically Endangered	Candidate for an EEP
Cebus aequatorialis	Critically Endangered	Do not obtain
Cebus versicolor	Endangered	Do not obtain
Cebus malitiosus	Endangered	Do not obtain
Cebus capucinus curtus	Vulnerable	Do not obtain
Cebus cuscinus	Near threatened	Do not obtain
Cebus unicolor	Least Concern	Do not obtain
Cebus albifrons	Least Concern	Do not obtain
Cebus olivaceus olivaceus	Least Concern	Replace
Cebus olivaceus castaneus	Least Concern	Replace
Cebus brunneus	Least Concern	Do not obtain
Cebus capucinus capucinus	Least Concern	Do not obtain
Cebus imitator	Least Concern	EEP

Cebus yuracus	Not assessed (NT in Ecuador and V in Peru)	Do not obtain
Cebus leucocephalus	Not assessed	Do not obtain
Cebus cesarae	Data deficient	Do not obtain

Table 3: IUCN and *Ex-situ* conservation status of the capuchin species (RCP for the Larger New World Monkeys Edition 2 – 2017, Jan Vermeer)

As you can see above (table 3), the majority of the capuchin's species are classified as Least Concern according to the IUCN Red List. Nevertheless, 4 species and 1 subspecies of capuchins are Critically Endangered; hence the efforts made for conservation are different for each species. Concerning the most endangered *Sapajus*, the Yellow-Breasted Capuchin, numerous protected areas have been created in the South of Bahia State since 2000. Moreover, the Rio de Janeiro Primate Center started a captive breeding program in 1980. This program was extended via Mulhouse zoo to European zoos. In 2019, the EEP of the Yellow-Breasted Capuchin, managed by Dr. Benoit Quintard (Mulhouse zoo), was composed of 235 animals in 31 institutions.

For several other species we are lacking studies (and therefore data), even if the species lives in a protected area. For some of them, we don't even know exactly where they live and the size of the population. Therefore, it would be really interesting to improve our knowledge about these species in order to make the conservation work more efficiently in the future.

Field work on the conservation of the yellow-breasted capuchin monkeys :
by Gustavo Rodrigues Canale

"In 2002-2005, we conducted a survey of remaining populations of yellow-breasted capuchin monkeys. We found that the remnant populations of yellow-breasted capuchins were isolated in patchy forests. Small population size and hunting are the main causes of the extirpation of these populations. Yellow-breasted capuchins are one of the most hunted primates for subsistence in the region and it is very much the preferred pet (Canale et al., 2013 & Lernoult et al., 2012).

Based on our studies and of other research groups investigating other species, in June 2010 the Brazilian government created the Serra das Lontras National Park, with 11,400 ha of protected forest. In addition, in 2007 the Una Biological Reserve was increased in size by about 7000 ha, to attain a total of 18.500 ha of protected forest.

Despite the relevance of the information already obtained, further research in the western part of capuchins' distribution is necessary. In this region the populations of *S. xanthosternos* are scarcer and they inhabit harsher environments, such as the dry forests and open scrub. Capuchins living there were observed using stones to crack palm nuts (Canale et al., 2009). There is only one protected area (State Park Lapa Grande) harbouring a population of the yellow-breasted capuchins. But it is likely that populations of *S. xanthosternos* are also present in other protected areas that must be investigated."

6. Diet and feeding behaviour

Capuchins are frugivores-insectivores (Mittermeier et al., 2013). The energy is brought by the fruits and the proteins are provided by small animal prey (like insects). Contrary to the squirrel monkeys, the *cebinae* look for insects under bark and in tough substrates. They are not able to catch them stealthily. It means that they spend more time foraging: generally, we consider that the capuchins spend 50% of the day for this activity (Mittermeier et al., 2013).

Capuchins are quite strong compared to the squirrel monkeys. They use their strength and their strong jaws to collect resources which are difficult to obtain. Furthermore, the capuchins can use tools like heavy stones: *Sapajus xanthosternos* has been recorded using tools (stones) to break nuts (Canale et al., 2009). Capuchins have long been known for their ability to crack open hard-shelled fruit by pounding it against a hard substrate (Izawa and Mizuno, 1977; Struhsaker, 1977) as well as for their capabilities for complex object manipulation in laboratory settings (Visalberghi, 1990; Westergaard and Fragaszy, 1987). According to Brown and Zunino (1990), the ability of capuchins to explore resources not accessible to other primate species is one of the reasons for their wide geographical distribution and occurrence in marginal ecosystems.

The diet of capuchins is really eclectic, certainly one of the most omnivorous diet of the New World Monkeys. It is mainly composed of fruits and in a lesser extent of flowers, seeds, buds and small animal prey, except for *Cebus olivaceus* who sometimes forage more insects and seeds (less ripe fruits) than the other gracile capuchins (Mittermeier et al., 2013). Among vegetal families consumed by capuchins, we can find mostly the *Arecaceae, Moraceae, Annonaceae, Fabaceae, Anacardiaceae, Lecythidaceae, Meliaceae*. Concerning the insects, the capuchins prefer *larvae* and *pupae* of social *Hymenoptera*. The vertebrates that we can find in the diet are lizards, birds (and eggs), frogs, bats, mice and squirrels.

7. Reproduction

1) Sexual maturity

Sexual maturity is generally reached at 8 years for the females and 10 years for the males in the wild. However, we observe that sometimes it can be earlier, especially in captivity where the resources are available easily: males can be fertile by four and a half years of age (Fragaszy & Adams-Curtis, 1998; Carosi & al. 2006). Concerning *Sapajus xanthosternos* in captivity, it was observed that females reach sexual maturity at 4-6 years old, and males at 8-10 years old (Quintard, 2016). Reproductive life is long and there is no evidence of true reproductive senescence in the capuchin species (Fragaszy et al., 2004). Quintard observed for *Sapajus xanthosternos* a strong slowdown of fecundity from 20 years old for the females and 23 years old for the males (Quintard, 2016).

2) Reproductive cycle of females

The ovarian cycle of New World monkeys is characterized by the secretion of high concentrations of steroids, in particular progestogens (Preslock & al, 1973; Wolf & al, 1977; Bonney & al, 1979). In the capuchin monkey, the circulating concentrations of progesterone are 2-12 times higher than those observed in Old World primates and human beings (Nagle & al, 1979). Morphologically, male and female external genitalia are quite similar, females exhibiting a highly developed clitoris, like many primates from South America (Avril, 2015).

The ovarian cycle of female capuchins may varie a little bit between and into the same species. As you can see below, we can regret that there is a lack of data for the majority of different species:

- *Cebus olivaceus:* 16-20 days
- *Cebus albifrons:* 16-20 days
- *Sapajus apella*: 20.8 days (Linn et al. 1995)
- *Sapajus nigritus*: 14-21 days
  (data extracted from Mittermeier et al., 2013)*
- *Sapajus xanthosternos*: 12-26 days (Avril, 2015)

The existence or absence of menstruation constitutes a point of contrast between primates of the Old World, in whom their presence is the norm, and primates of the New World, where they appear (or at least are easily detectable) only in very few species (Avril, 2015). For *Sapajus apella*, the bleeding lasts on average between 1 and 5 days and is mainly detectable by vaginal swabs (Wright et al., 1977, Fragaszy et al., 2004).

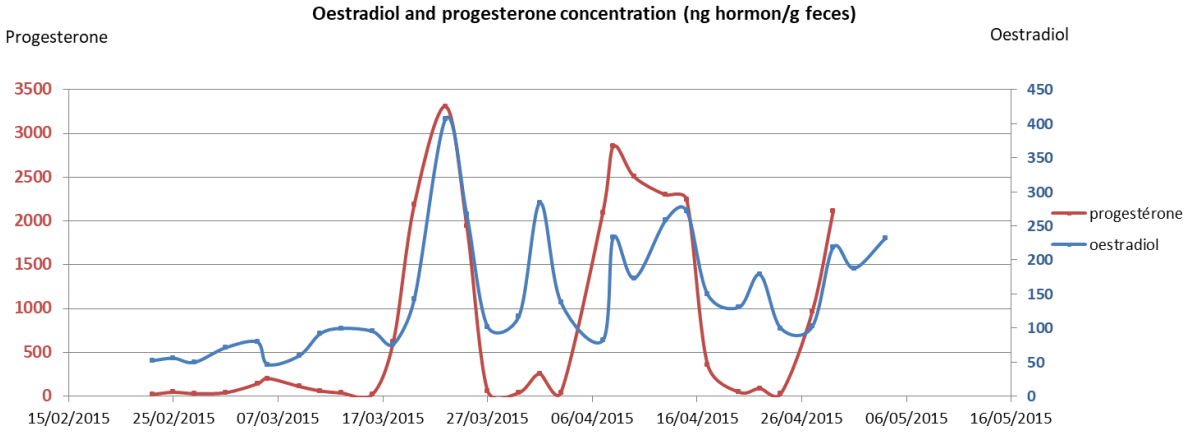


Figure 6: Oestradiol and progesterone concentration (ng hormon/g feces) (© Sandra Avril)

3) Seasonality

Most primates show some sort of birth seasonality because food abundance usually cycles in predictable ways (Brockman and van Schaik, 2005) and infant survival is greater for infants born during the optimal period of fruit abundance (Di Bitetti and Janson, 2000).

In captivity, the births occur all year long (Hayes et al., 1971; Abee et al., 2012) but a seasonality seems to exist in wild population (Fragaszy et al., 2004). According to the Yellow-Breasted Capuchin EEP 2016 Annual report (Quintard, 2016), the birth period of the yellow-breasted capuchin is statistically seasonal (during the spring season), with a reproductive active period estimated between December and March.

In the wild, the births can occur all over the year, but there are birth peaks at different times, depending on the habitat where the different species live and therefore the food abundance. For example, *Cebus olivaceus* and *Cebus albifrons* have a peak of births late in the dry season/early in the rain season, while *Sapajus nigritus* shows a strong seasonality with the majority of births occurring in December and January. In each case, these peaks correspond with the increase of food availability.

4) Gestation period and birth rate

The gestation length ranges from 149 (*Sapajus macrocephalus*) to 167 days (*Cebus imitator*) (Mittermeier et al., 2013).

5) Birth rate

Generally, a female gives birth for the first time between seven and eight years old. The most common is a single offspring but some twins were reported in some species, like *Sapajus xanthosternos* for instance. The interbirth interval ranges from 19 to 26 months. Compared to other platyrhines of the same size, capuchins have a later age at first birth (really long after nutritional independence from the mother) and a long interbirth interval (Avril, 2015).

6) Development

The growth of the infant is fast between birth and six to eight months and slows down after that age. This growth is correlated with the important evolution of the brain, which has a relatively large size in adults (Rilling and Insel, 1999). There is a high rate of infant mortality with, for example, 32% of dead individuals during their first year for the Panamanian White-faced Capuchin (Mittermeier et al., 2013). The capuchins reach their adult size around seven years old.

8. Behaviour

1) Activity

- Tool use:

The capuchins are diurnal extractive foragers: they have strong jaws to bite, they search a lot, they break… They are known to forage resources not easily available. Galleti and Pedroni (1994) presented data showing that *S. nigritus* increases its time on the ground and the consumption of nuts during dry periods in the semi-deciduous forest in south-eastern Brazil. This dietary variability is linked to a manipulative-destructive foraging strategy (Parker and Gibson, 1977). To this goal, they often use tools when they are on the ground (Ottoni and Izar, 2008). These tools can be stones (up to 1kg) or tree trunks. This ability to use tools is one of the evidences that show how intelligent these primates are. They are able to pick off ripe fruits, drop it to the floor and wait until these fruits are dry enough to be pounded and opened. Generally, the dryer the environment, the more efficient the foraging behaviour of the capuchins.

- Anointing:

The capuchins show a special behaviour: the anointing. It can be practiced by individuals on their own (self-anointing) or in social sessions with two or more individuals (social anointing). It consists in crushing and spreading a foreign substance on the fur with hands or feet (Baker, 1996). This substance can be vegetal (leaves, fruits, flowers…) or animal (ants, wasps, crickets, millipedes, worms…). While robust capuchins anoint only with animals and prefer to do it solitary, the gracile ones use a wide diversity of anointing materials (with a preference for citrus fruits and onion) and tend to be more social (Leca et al., 2007).

- Mixed species group:

In Amazonia, robust capuchins (and to a lesser extent the gracile capuchins) form mixed-species groups with squirrel monkeys. In these groups, the capuchins are the leaders and the squirrel monkeys the followers. It seems to be of mutual benefit to enhance the security of both species and the vigilance against predators.

- Communication:

Communication is really important in a group of capuchins. They are quite noisy: squeals, whistles, peeps… A rich repertoire of communication is commonly used by the capuchins. According to the Handbook of the Mammals of the World (Mittermeier et al., 2013), there are 20 types of vocalization, consisting of five separate classes: “Purring calls”, “Twittering”, “Calls produced during

social interactions", "Yapping and alarm peeps" and "Groaning, cawing and shrieking calls". The communication consists also in the manifold postures and facial expressions. Overall, these expressions are the same for all the capuchins with little differences concerning the sexual behaviour.

2) Locomotion

The capuchins are quadrupeds but can walk on two limbs for short periods of time (Mittermeier et al., 2013). According to, Mittermeier et al. (2013) the *Cebus* species travel further than *Sapajus* species, exploiting fruiting trees that are widely dispersed. Most of the time, the time spent on the floor increases with the dry season foraging.

3) Social behaviour

Capuchins are social and live in groups. Groups are composed from 10 to 27 (or even more) individuals. The group size is influenced by the availability of food resources. Generally, the sex-ratio is biased toward females, but it depends on the species studied. Fedigan (1993) showed that *C. capucinus* females spent more time in proximity and engaged in higher rates of affiliation with females than males did with either males or females. Females form a stable dominance hierarchy (Fedigan, 2013). The size of the home range and the relationships between neighbouring groups vary a lot depending on the food abundance.

When food is seasonally scarce, the home range tends to be bigger and the relationships between neighbouring groups are worse. The males (and mostly the dominant male) spend less time foraging in order to be more vigilant. It's a way to detect predators, neighbours or all other threats. Dispersal is an event biased to the males between 5 and 10 years of age (often when they reach the full body size), and for all the species of capuchins (Fragaszy et al., 2004). Therefore, the hierarchy is organized around the females. However, the males are often dominant. Grooming in platyrrhine primates serves a hygienic function (Dunbar, 1991, 1993), but also has a social function (O'Brien's, 1993). It is really important in the hierarchy; the alpha male is a favoured receiver of grooming. Generally, the males groom less than the females (but the examples of the reverse exist).

4) Sexual behaviour

The reproductive success of a female depends on food availability, due to the cost of high parental investment (Trivers, 1972). Consequently, the competition for food impacts the number of females in a group (Isbell, 1991; Sterck et al., 1997; Van Schaik, 1989; Wrangham, 1980). The reproductive success of a male is conditioned by access to sexually receptive females. Therefore, the number of males in a group tends to be higher when the spatial and temporal distribution of reproductive females is important (Clutton-Brock, 2004; Lindenfors et al., 2004).

The female capuchins don't have the tendency to deposit scent and urine or change their appearance to stimulate the males (however, urine marking seems to be more important for gracile capuchins than for the robust ones). They use rather a proceptive behaviour (courtship) to indicate their receptivity. Many behaviours are involved: Facial expressions, vocalizations, "approach and retreat dance", body postures… For example, a typical female *Sapajus apella* spends the first 3 or 4 days of her 4–6-day proceptive phase following a male and attempting to mate with him (Janson, 1984). This species is considered to have a lot of active female proceptivity (Dixson, 1998; Manson, 1994; Smuts, 1987). The female capuchins seem to prefer mating with the dominant male. Generally, the latter has a higher copulatory rate than the other males of the group.

The courtship is composed of four stages (Fragaszy, 2005):

- Stage 1: the female tries to attract the male's attention. She moves around the male, watches him with persistence, vocalizes continually and sometimes touches him.
- Stage 2: the male shows interest for the female. The female stops touching the male and runs off. It's the time of vocalizations, mutual gazing and eyebrow-raising (replace by the "duck-face" for the Panamanian and Colombian White-faced Capuchins), dance of approach and retreat, grinning, head tilting.
- Stage 3: they mate while continuing with the behaviour of the previous stage.
- Stage 4: after ejaculation, they continue their behaviour of the second stage but more intensely for the male. This stage spends 20 to 40 minutes until the fading of their interest.

Section 2 : Management in zoos

This part was written relying on a survey conducted in 2016/2017. Two exhaustive questionnaires (one for the general management, and another for the vet part) were sent to all European zoos that exhibit capuchins, in order to have a better understanding about how these institutions manage their capuchins. 54 European zoos took part to this survey and gave us precious information concerning the enclosure, the diet, the enrichment, etc. All this work was made under supervision of Dr. Benoit Quintard, Yellow-breasted Capuchin (*Sapajus xanthosternos*) EEP coordinator, in collaboration with Jean-Pascal Guéry, ESB studbook keeper for White-throated Capuchin (*Cebus capucinus*) and under consent of the Larger New World Monkey TAG. In the following text, it will be written "BPGQ" (Best Practice Guidelines Questionnaire) when it refers to the survey.

1. Housing

Capuchins require an environment that is really important for animal welfare and the expression of their behavioural repertoire. Space is measured in three dimensions (width, length and height), and the vertical dimension is very important for all the primates, the majority of species being arboreal. Most of the time, it is believed that a big enclosure is necessarily a synonym of animal welfare. However, we should keep in mind that the qualitative aspect of the enclosure, and therefore the development of this space, is as, if not important than the size. To clarify and illustrate this point, a large space without any vegetation or structures is a lot less favourable in promoting optimal animal welfare, compared to a smaller, but well planned and adjusted environment.

In all temperate countries, a combination of indoor and outside enclosures is a basic requirement. However, it should be remembered that the climatic conditions within a region differ considerably. In the northern countries, the capuchins are expected to spend more time indoor while it might be the reverse in the southern countries. Differences of time spent indoors versus outdoors should be reflected in the planning, design of maintenance of all housing.

1) Indoor enclosure

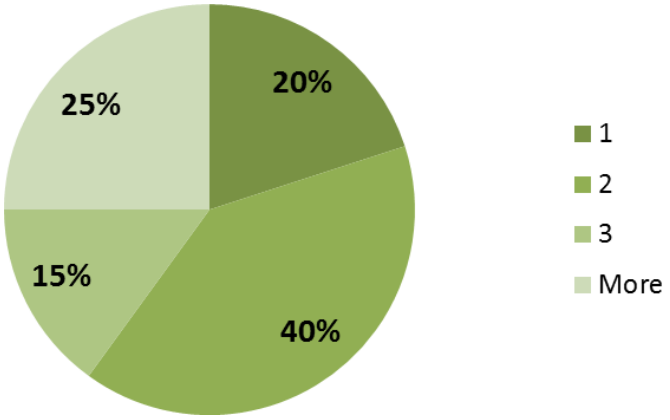
Indoor enclosures are indispensable to protect capuchins against the vagaries of a cold climate, including the rain and wind, especially in temperate countries. The animals are also protected from predators, and to some extent from some pathogens. However, indoor enclosures are most of the time considerably smaller than outside enclosures while, generally, the capuchins spend more time indoor. New World monkeys don't cope with the cold temperatures and are obliged to stay indoor when the temperature falls. The indoor accommodation can be composed of a network of several rooms connected to each other by raceways, tunnels or corridors; creating a more complex environment and permits to manage the groups(s) easily. This is also desired in case of an injured capuchin or new individual can be temporarily isolated.

The indoor housing may or may not be visible to the public : it primarily depends on the climate and therefore the probable time spent by the capuchins indoor. However, the keepers should have the possibility to observe the animals in any part of the indoor enclosure: no matter how (by the mesh, windows or even cameras) but they must be able to see all the animals in order to monitor their overall welfare, including perceiving problems such as safety concerns, or seeing possible positive outcomes such as interaction with enrichment. Always keep in mind that if animals are locked in for the night, they will spend more time inside than outside, even during summertime.

- Spatial requirements:

Number, size and use of boxes:

Boxes	Responses	Percentage
1	8	20 %
2	16	40 %
3	6	15 %
More	10	25 %



	Average	Standard deviation
Square meters (m²)	10,5	6,82
Height (m)	2,98	0,74
Individuals/Box	3,7	2,07

Space available per individual (all the indoor environment):

	Average	Standard deviation
m²/Individual	4,80	3,66
m³/Individual	11,8	7,98

Figure 7: Overview of the results about indoor enclosures in EAZA zoos

The BPGQ provided data about the size of the capuchins indoor environment in EAZA zoos. Figure 7 shows that on average there are almost four animals per box and a capuchin living in an EAZA zoo has access to 4,8 m² (11,8 m³). The average height is 2,9 m. As expected the data received on housing stans varies considerably between zoos, but it gives information about how the holders currently manage their capuchins. To the question "In your own opinion, what is the minimum (and the optimum) size of the indoor enclosure for a group of 10 to 15 capuchins?" in the BPGQ, the capuchin holders answered an average of 102,75 m³ (6,7x5x3m) in minimum and 310,15 m³ (10,2x7,7x3,9) in optimum.

For a group of 10 to 15 capuchins, the LNWM TAG recommends having a minimum of 3 indoor boxes, preferably more. A breeding group of about 10 capuchin monkeys needs an indoor enclosure with a surface of at least 40 m². The minimal height of the cage should be 3 meters, with structures at various heights, between 0,5 to 2,5 m. For a bachelor group at least 8 m² per animal is required.

- Substrate:

In order to clean and disinfect easily, the floor (generally concrete or epoxy) must preferably be sloped approximately 5%. Drains should be placed outside the enclosure wherever possible.

Litter is useful to absorb urine and faeces, provides comfort to the animals, gives the possibility of foraging and can constitute an element of play. This litter can be sawdust, wood chips or bark; any natural nontoxic substrate would be suitable. It has to be to be easy to clean 2 or 3 times per week. 38,5% of the capuchins holders just have concrete in the indoor enclosure. Knowing that this type of substrate is the most commonly used in zoos, LNWM definitely recommends adding another substrate like mulch (used by almost 36% of capuchins EAZA holders). Deep litters is different from the substrates described above, maybe this should be added, not only for cleaning and time saving, but also behavioural opportunities and acoustics.

- Lighting and UV supplementation:

The quantity and quality of light are important for primates. Daylight (with its important UV rays) is essential and available by access of the animals to the outside enclosure and by the presence of windows in the indoor housings of windows. Lack of natural light can cause problems of vitamin D synthesis resulting in breeding and fur problems. The day/night cycles are important for breeding. The capuchins, as the majority of primates, need 12h of light per day minimum and no light during the night (or very little: some zoos give some “moonlight” to allow the animals to find their way through the enclosure at night). Artificial lights can be used to complete the “light time” but it’s important to be careful to avoid burns (International Primatological Society, 2007).

Do you use UV supplementation in the enclosure ?

	Responses	Percentage
YES	10	25 %
NO	30	75 %

Some examples : X-reptile, UVA/UVB fluorescent tubes (2x120cm), Osram Ultravitalux 150 …

Do you use artificial lighting ?

	Responses	Percentage
YES	32	80 %
NO	8	20 %

Some examples : LEDs, UV, IR lamps, neon lights, UVA/UVB fluorescent tubes, fluo tubes, LED-roomlights, STRIP LIGHTS, halogen spotlight …

Figure 8: Overview of the results about lighting in EAZA zoos

- Temperature:

Average	Standard deviation
20°C	3,03

Table 4: Temperature in the indoor enclosure in EAZA zoos

As we can see above, the average temperature of the indoor enclosure in EAZA zoos is 20°C. Nevertheless, we observe that for several institutions, the temperature is about 15°C which is too low. The recommended temperature for New World monkeys is higher than for the other primates: between 18 and 27°C. The LNWM TAG recommends a temperature between 18 and 20°C for capuchin monkeys. The indoor heating can be done by lamps, radiators or central heating, with the same warnings mentioned for lighting. Care should be taking that different climate gradients are offered throughout the enclosures and boxes, and to remember that heat goes up, which may affect space and provision use if too warm, e.g. on higher shelves, or use of nest boxes. To provide a better isolation between inside and outside, plastic shelves can be added on every trap.

- Humidity:

Average	Standard deviation
57 %	12,96

Table 5: Humidity in the indoor enclosure in EAZA zoos

Results of the BPGQ, indicates that 90% of capuchin holders do not monitor the humidity of the capuchin's indoor environment. However, good humidity is important for the health of primates and opinions differ about the rate of humidity; several authors advocate for a humidity of 50-60%, some others for more, between 70 and 80%. The table 5 shows that the average humidity rate in the indoor enclosure of the EAZA zoos is about 57 %. The LNWM TAG recommends a humidity of between 60 and 70 %. The humidity of the space can be increased simply by sprinkling the substrate or by installing humidifiers and/or containers with water near the heating points.

- Ventilation:

The ventilation allows the supply of oxygen, the evacuation of carbon dioxide, ammonia and bad smell (for both animals and humans). It must therefore be sufficient, with a minimum of approximately 10 to 15 renewals per hour ; It can be natural, thanks to doors and hatches, or mechanical thanks to systems of extractors (International Primatological Society, 2007).

- Doors:

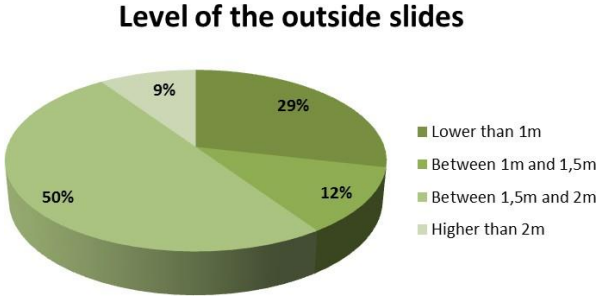


Figure 9: Level of the outside slides in EAZA zoos

The figure 9 shows the different levels of the outside slides in EAZA institutions. The outside slides should be high because the capuchins are arboreal animals and prefer to move in height. While there is still one third of institutions with slides lower than 1 m, LNWM TAG recommends future capuchin holders to install outside slides higher than 1,5 m. Multiple slides, tunnels and doors are recommended, to allow for social flow, decrease monopoly of access, etc.

2) Outside enclosure

Access to the outside and inside should preferably be left as a choice of animals, even when it's freezing, if it's sunny and not much wind. A hot spot can be installed in the outdoor enclosure, with a lamp or a radiant panel for example.

Outdoor enclosures should be natural to elicit natural opportunities for animals. However, primates are exposed to many germs and a control of unwanted animals and predators is needed. Most outdoor substrates are cleaned naturally by sun, rain and time, and therefore do not require special maintenance except removing faeces on daily basis. It is important to provide clean drinking water *ad libitum*. In the same way as for the indoor enclosure, additional outside enclosures are recommended to separate individuals if necessary.

Although the size of the enclosure is not the only important parameter for an outside enclosure, it is one of the criteria that determines animal welfare. This is the reason why all capuchins holders were asked to indicate the size of their outside enclosure. Table 6 shows the huge difference between institutions. On average, a capuchin living in an EAZA zoo has a space of 34,6 m², some animals having access to more than 90 m², and some more than 220 m² (in order to have a clear graph, we chose to remove 3 "extreme" data from 3 different zoos: 225, 265 and 1128,4 m²). The average maximum height of the outside enclosure is 4,98 m in EAZA zoos (from 2,5 to 12 m). The answer to the question "In your own opinion, what is the minimum (and the optimum) size of the outside enclosure for a group of 10 to 15 capuchins?" the answer was a minimum of 153,34 m² (with a height of 4,45 m) and an optimum of 436,15 m³ (with a height of 7.14).

	MINIMUM	AVERAGE	MAXIMUM
m²	18	537,3	9027
m²/individual	2,8	75,5	1128,4

Table 6: m²/individual for the outside enclosure in EAZA zoos

For a group of 10 to 15 capuchins, the LNWM Tag recommends having a minimum of 2 different outside enclosures – see comment above for names of different environments. The total area of the outside environment should be minimum 10 m²/individual (150 m² for the group) with a minimum height of 4,5 m for this same group.

3) Habitat design

The environment of the capuchins, and more generally for all the primates, needs to be complex enough to allow them to express a large part of their behavioural repertoire. It is really important that they can play, climb, jump, run, have views, but also hide to avoid the different sources of stress coming from the visitors and/or the other animals of the group, or other or similar species housed nearby. More and more zoos now try to recreate the natural environment using exotic plants. It is quite important to think about vegetation before developing an enclosure for

capuchins (for instance, it's important to know if the vegetation is edible or toxic). The vegetation can constitute of roosts, shelters, visual barriers and will likely include spaces where insects live (that can be eaten by primates – and to acknowledge that insects and other animals might live there who are not edible or good for the primates). Thanks to the vegetation, the environment of capuchins is alive and in constant evolution (depending on types, resistance to descruction, effect of weather…). The BPGQ showed that more than 50% of the zoos have enclosures with a vegetation cover less than 25%, and in 25% of the EAZA zoos the vegetation is non-existent. We urge all the zoos (current and future capuchins holders) to think about that and try to obtain a vegetation cover of at least 40%. The environment should also be enriched with artificial items like ropes, branches or lianas. This is expected to contribute to the promotion of optimal animal welfare by allowing for more complexity, choices and control.

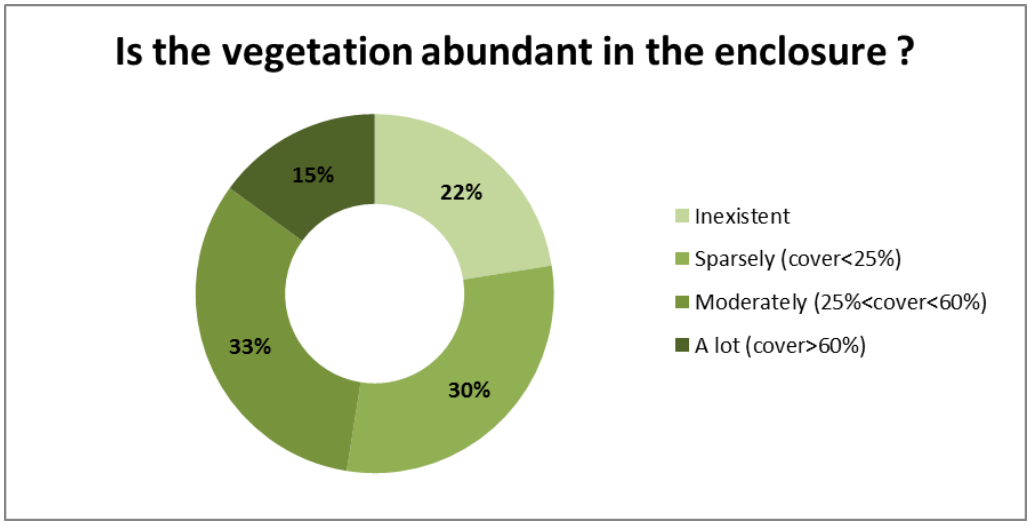


Figure 10: Vegetation in the enclosure of the EAZA zoos

Figure 11: Example of a complex environment in Schwerin zoo (©Schwerin zoo)

4) Barriers and containment

The barriers must represent an impassable obstacle for the animals, and must keep the visitors and other unauthorized people outside of the enclosures. They must be robust and enduring in order to be capuchin and people proof. Table 7 summarizes several advantages and disadvantages of each type of barrier. The barrier should allow a visual access for the visitors for no more than ½ or ⅔ maximum of the enclosure perimeter in order to to give the animals opportunities to hide and move away from unwanted people or other stimuli.

Type of barrier	Advantages	Disadvantages
Walls (concrete, cement, wood)	- Easy to build - Natural shelter (wind, sun) - Safe	- Not esthetical, if nothing is added unusable surfaces for the animals
Water	- Natural barrier - Good landscape integration	- Risks of drowning - In winter, risks of ice formation (escape)
Wire mesh	- Increase the useful surface for capuchins (to climb) - Safe	- Not esthetical - Possible transmission of disease
Electric fences	- Discreet - Good complement for other types of barrier - Cheap	- Risks of escape (if short-circuit with vegetation) - Risks of electrocution
Glass walls and glass windows	- Esthetic - Safe	- Shorter distance between animals and visitors, if nothing is added unusable surfaces for the animals

Table 7: Advantages and disadvantages of different types of barrier

Most of the time, the outside enclosures are made with a mix of several types of barrier. Moreover, a net is sometimes installed on the top of the enclosure to avoid escape from the trees.

- Walls:

The walls must be high (4m minimum) and smooth in order to represent a non-climbable barrier (overhangs can also be installed). They are not too expensive and easy to build but it is often necessary to add furniture to make it more functional for the animals, and esthetical for the public (which represent an additional cost). It is common to install a net or wire-mesh roof to avoid an important loss of space for climbing structures : indeed, without this, the climbing structures should be far enough from the wall (more than 3.5 meters) to avoid animal escape. The walls can be a good shelter against wind and sun, but it is important to keep in mind that it means also that the wind will not be able to refresh the environment of the animals when the temperatures will be high. Usually, the walls have several windows and it is recommended to give them the opportunity to see outside the enclosure.

- Glass walls and glass windows:

Nowadays, the glass walls are really common in zoos because they give the visitors the feeling to be inside the enclosure, living a special experience with the animal. They are also quite expensive: generally, the zoos prefer to use smaller glass windows built into vertical walls. The glass has the advantage to protect the animals (and visitors) from different infectious diseases and to represent a safe barrier (impossible to escape, if high enough (2,2 m min)). Nevertheless, it's recommended to avoid an enclosure with only glass walls because the animal needs to have sides out of the view of the public. Moreover, glass walls can be combined with electric wires running across the top of the walls. Finally, it's important to be careful with the capuchins that use tools: they could break the glass wall so the stones and other hard materials must be removed of the enclosure (limitation of their natural behaviour). Glass barriers and windows can partly be covered with safe cargo netting or other materials that not only create more functional surface areas, but also provide hiding from and possible positive interacting areas between the animals and the visitors.

Figure 12: Example of glass walls in Gyor zoo (©Gyor zoo)

- Water:

The water boundaries or islands give the visitors the feeling that there is no barrier between them and the animals. They are esthetical pleasing and looks very natural. However, it represents a risk of drowning and to avoid this the moat must have sloping edges to allow the animal the possibility to climb back on the island in case of falling in the water occurs, and safe 'lifelines' in the form of vegetation or other can be explored. If a bridge leads the animals from their indoor enclosure to the island, a net must be installed below it to avoid a possible fall.

Much space is required to create an island or install a water moat. This is the reason why it is recommended to avoid this type of barrier when little space is available for the exhibit as it would take functional space for the animals. It is recommended to have a moat of 4 meters wide and 40 cm deep to keep the animals in the enclosure.

Figure 13: Example of an island in Zurich zoo (©Sandro Carlotti)

- Wire mesh:

The wire mesh needs to be solid and be of the appropriate mesh size of 4x4 cm to avoid animal escape. As it increases the areas available for the animals, i.e. being able to climb the mesh, it is recommended to install a net or wire mesh roof to make the enclosure safe. In order to avoid disease transmission with the public, the distance between visitors and the wire mesh must be at least 120 cm or the wire-mesh should be mixed with glass windows. Usually, the wire mesh is not enjoyed by the visitors because of its appearance, however education programs and caregiver presentations, as well as panels can describe how we care for animals and the benefits mesh has over solid walls.

- Electric fences:

For the capuchins, electric fences cannot be the only barrier because they could go through them, but represent a good secondary barrier. Generally, they are installed on the top of walls or fences or on the border of a water barrier to discourage the animals. It is better is to have a double fence, with on the indoor electric wires and on the outside wire-mesh. An example is from Münster Zoo: the electric fence is 150 cm high, 15 cm of overhang at 45°, 4000 V, with wire at 5 cm from the ground, with 10 to 50 cm between wires, with 2,5 x 2,5 cm wire mesh (1,2 m high). The distance between mesh and electric fence must be as small as possible (it is less than 5cm in Munster). A single litz-wire (bigger, green) should be installed 1 m in front of the fence for the animals which are new in the enclosure. Like this new animals such as offspring, or other animals which come from a different facility where this is not present, will experience their first time the electricity before they reach the fence. This is in order to avoid that they will have the first electric contact on the main-fence and will run upward and onto the fence in panic. It is important to be really careful with the use of this barrier, especially with the intensity of the electric current, if the voltage is too high, this containment represents risks of electrocution, and if the voltage is too low or if there is a power outage, the animals could escape. Therefore, the electric fences should be monitored daily. According to the BPGQ, 5000 V seems to be the good voltage to exhibit capuchin monkeys with electric fences.

Figure 14: Examples of electric device in Allwetterzoo Münster (©Dirk Wewers) and in Schwerin zoo (©Schwerin zoo)

2. Feeding

1) Basic diet

As mentioned earlier, capuchins are frugivores-insectivores in the wild. Therefore, it's really important to provide them a wide variety of produce. These fruits (and vegetables) must be fresh. All animals should have access to water at all times. Besides, the preparation of food and the feeding should be planned and monitored ensure that all the individuals of the group, including subordinates, young animals, lactating females, and geriatric animals receive the necessary nutrients. At least two points of alimentation should be provided to avoid conflicts and monopolization of food. More locations can be added if conflicts at feeding time are noticed.

Most of the time, the animals make their choice based on the sugar and fat content, or novelty and not on their nutritional requirements (Price, 1992), and they will choose depending on taste. Consequently, the zookeeper has to be careful to avoid that the animal eats just what he likes. The fruits commonly given are e.g. banana, apple, papaya, pears, kiwi fruit, avocado, melon, watermelon, orange, mango, berries, grape, pineapple. A wide variety of vegetables is provided, including carrot, sweet potato, broccoli, lettuces, green beans, turnip, peas, corn, celery, greens, egg plant, zucchini, cauliflower. Nuts, seeds, insects, eggs and meat are also important to fulfil the rest of nutritional requirements.

"The biggest difference between wild and captive diets of capuchins is because of the fruits. The fruits eaten in the wild are completely different nutritionally than the fruits used in zoos (Oftedal and Allen, 1997; Schwitzer and Kaumanns, 2003). The soluble carbohydrates such as sugars found in market fruits are much higher than that of wild fruits. The wild food items are also higher in protein, minerals and fibre. Sugar, protein and fibre amounts of wild fruit were generally more similar to our cultivated vegetables (however still different). Many health issues and gut dysbiosis can be at least in part blamed by the high sugar content of fruits fed to zoo capuchins (Oftedal and Allen, 1997; Schwitzer and Kaumanns, 2003; Less et al. 2014). Fruits are completely unnecessary for capuchins which will adapt nicely to a diet of pellets, nuts/seeds and vegetables."

Francis Cabana,
Wildlife Nutritionist & Senior Manager Wildlife Nutrition Centre
Wildlife Reserves Singapore

Below, you can see 4 examples of diet sheets obtained thanks to the BPGQ and selected from the 38 collected diets, because of their compliance to the animal nutritional and health needs.

- Example of daily diet: Zoo A

ANIMALS	1.7.0 Sapajus apella
Description of the diet	Fruit free diet, they get half a bucket of greens and vegetables plus pellets and whole nuts am and pm. Scatter feeds and puzzle feeders throughout the day, including live insects.
Supplements	YES Vionate
Number of meals	2 main meals + several scatter of enrichment feeds
Hours	9 am 11 am

	13 pm 15 pm 16 pm
Method of feeding	Scattered around the bedroom
Method of feeding 2	In group

➢ Example of daily diet: Zoo B

ANIMALS	**3.2.2**	**Sapajus xanthosternos**
Supplements	**NO**	
Number of meals	3	
Hours	8 am 13 pm 16 or 18 pm (depending on the season)	
Method of feeding	- In bowls - As enrichment randomly - During training	
Method of feeding 2	In group	

	MONDAY	**TUESDAY**	**WEDNESDAY**	**THURSDAY**	**FRIDAY**	**SATURDAY**	**SUNDAY**
MORNING	Saint Laurent pellets "Nouveau Monde" 80 g / per animal						
13 h	Sunflower germinated seeds 22 g for the group						
	Lettuce and/or endive 40 g / per animal						
			Hard egg 20 g / per animal	Boiled chicken 20 g / per animal		Boiled chicken 20 g / per animal	Hard egg 20 g / per animal
EVENING	- Apple 140 g - Onion, squash, chicory, turnip 100 g - Carrot 60 g - Cucumber and/or pepper 60 g - Varied seasonal fruits 80 g (Be careful: low quantities of citrus fruits, blackcurrants, strawberries, mangoes and kiwis) - Varied seasonal vegetables 120 g (Be careful : low quantities of broccoli and Brussels sprouts)						

Per animal

➢ Example of daily diet: Zoo C

ANIMALS	9.4.0	Sapajus xanthosternos

Number of meals	**4**
Hours	8 am 11 am 14 pm 16 pm
Method of feeding	- As enrichment randomly - As enrichment in toys
Method of feeding 2	In group

Product	Unit	Per animal
Monday, Thursday		
DK Leafeater Large	Gram	120
Walnuts in shell	Gram	33
Celeriac / Celery	Gram	132
Broccoli / Cauliflower	Gram	132
Endive	Gram	132
Boiled egg	Piece	1
Mealworm	Gram	10
Vitamin D	Drops	1
Tuesday, Saturday		
NZ New Wold Primate	Gram	120
Walnuts in shell	Gram	33
Boiled chicken	Gram	27,5
Cucumber	Gram	110
Cabbage	Gram	110
Kohlrabi	Gram	110
Chicory	Gram	110
Mealworm	Gram	10
Vitamin D	Drops	1
Wednesday, Sunday		
DK Leafeater Large	Gram	120
Tomato	Gram	110
Sweet pepper (green)	Gram	110
Endive	Gram	110
Fennel	Gram	110
Mealworm	Gram	10
Vitamin D	Drops	1

Friday		
NZ New World Primate	Gram	120
Papaya / Avocado	Gram	110
Boiled potato	Gram	55
Carrot	Gram	88
Boiled green beans	Gram	88
Cabbage	Gram	110
Locust	Piece	1
Vitamin D	Drops	1

- Example of daily diet: Zoo D

ANIMALS	4.0.0	Sapajus xanthosternos
Product	**Unit**	**Per animal**
	8.00 h:	
Crispbread	g	30
Garlic	cloves	3
Salad	g	180
Banana	g	110
Orange	g	250
Pear	g	400
Paprika	g	230
Fennel	g	180
Cucumber	g	200
Celery	g	250
Carrots	g	400
	15.00 h:	
Crispbread	g	30
Lettuce (cabbage lettuce)	g	340
Melon	g	310
Apple	g	350
Carrots	g	90
Tomato	g	300
Cucumber	g	200
Celery	g	170
Parsley	g	70

Nutrient category		%
Crude fat		3 to 6
Crude protein		> 14

ADF		5 to 10
NDF		14 to 20
Vitamins	Vit A	8 to 14
	Vit B1	1,1 to 3
	Vit B12	0,01 to 0,03
	Vit B2 (Riboflavin)	1,7 to 4
	Vit B3 (Niacin)	16 to 56
	Vit B6 (Pyridoxine)	2,5 to 4,4
	Vit C Ascorbic Acid	55 to 110
	Vit D3	> 2
	Vit E	50 to 100
	Vit K	0,5 to 12
Calcium		0,55 to 0,8
Phosphorous		0,33 to 0,6

2) Special dietary requirements

Capuchins need, like other New World Primates, Vitamin D3, which they can metabolise when they are exposed to sunlight (or other UV sources). The amount of sunlight exposure in European countries is generally to limited for insufficient Vitamin D3 production, and therefore it is necessary to supplement this vitamin in the diet to minimize the risk of deficiencies.

Particular attention must be paid to pregnant and lactating females, young and very old animals, as these have higher needs for Vitamin D3.

- Sugar:

Capuchins quickly get fat from the sugars in fruit because fructose has a specific metabolic pathway, it essentially has no feedback mechanism so they can gorge themselves on it. A wild capuchin is building up fat reserves in times of high food availability to cope with periods of food shortage. They are using daily much energy for e.g. foraging, mating, mate guarding, patrolling territory, escaping from predators. So, with this in mind, a bit of sugar itself is not bad, as some sugar is necessary healthy functioning. But the sheer amount of sugar found in fruit is leads to e.g. obesity, diabetes, dental disease, cancers, behavioural issues, all stem from unbalanced sugar in the diet. High constant sugar severely impacts the gut microbe communities which leads to many health issues. Sugar itself isn't necessarily bad, sugar in captivity however usually is because of e.g. the types of fruits fed and overall reduced energy expenditure. Fruits should not be necessary as part of the regular diet, because they don't provide anything unique or necessary for the animals that cannot be given in a better and healthier way through the provision of vegetables. primates love fruits is not a good reason to include it in the diet. Nevertheless, the fruits can be used occasionally for medical training or to give medical treatment.

- Insects:

Insects are rich in proteins despite their small size (McGrew,2001; Verkerk et al., 2007). The protein concentration is similar to the vertebrate meat (McGrew, 2001; O'Malley and Power, 2012). Insect proteins have completely different amino acid profiles than mammal or avian. Protein quality of insects is excellent; insect protein contains a high concentration of essential amino acids: between 46 and 96% (Verkerk et al., 2007; Finke, 2013). Research done on insectivorous mammals show that their requirements are much closer to the profiles found in insects. This makes a big difference in the

long term, especially in breeding. Insects have chitin which is a really good prebiotic for insect eating species. Chitinases, identified in the digestive tracts of capuchins (National Research Council, 2003), may partially digest chitin to usable energy and protein, though chitin digestibility is likely less than 20%. If insects are gut-loaded then they can provide a host of other nutrients as well.

- Meat:

Meat should never be given to capuchins. The energy is so dense in the meat and it is consumed so quickly that it is highly a large amount of other food items which take a much longer time to feed on. So, giving meat that the animals do not need (protein in pellets, insects and nuts are more than enough) is a threat to their health because of the saturated fats and a threat to their well-being because it reduces their feeding time to unnaturally low levels.

- Nuts:

Nuts contain good amounts of protein, some starch and good polyunsaturated fats. Nuts are also rich sources of other bioactive macronutrients that have the potential to beneficially affect metabolic and cardiovascular outcomes (Ros, 2010). Nutrients such as zinc lead to a healthy coat and optimal breeding. Breaking and eating nuts is a natural behaviour of wild capuchins, and it takes time and skills, it is therefore recommended to give the nuts in their shell. However, it is important to keep in mind that nuts are caloric dense food so the quantity given should be low.

3) Methods of feeding

Wild capuchins spend approximately half of the day foraging, a behaviour that should be promoted. Therefore, a large part of their welfare in captivity depends on the time allotted to this and feeding methods should reflect this goal, and try to increase foraging time. It is recommended to give at least 3 meals per day, in a variety of different ways, such as e.g. scatter feeding and puzzles. Capuchins have many cognitive capacities and capabilities, and they need to be stimulated to avoid boredom, and to have positive experiences. It is recommended to have goal-oriented feeding strategies, such as increasing processing time by e.g. giving food as enrichment, increase the number of meals per day, change periodically the availability of food in time and in space, and other subcategories mentioned in e.g. the Five Categories of Enrichment by the SHAPE of Enrichment. The full feeding repertoire should be considered, including e.g. social aspects and access to food when care staff is not available.

3. Social environment

1) Group structure and size

Wild capuchins are social animals and live in groups. It is rather difficult to create the same conditions in captivity, but efforts should be done to obtain and maintain a group composition as similar as possible to what is observed in the wild. The group should ideally be composed of 7 to 15 animals, but this depends on the space available in the enclosures, and the quality of the relationships and social bonds animals have. The keeper must keep in mind that hierarchy is extremely important in the social life of all species of capuchins, it is common to observe conflicts in a captive group of capuchins, and…. Recommendations on how this should be handled? Figure 11 shows that 42% of capuchin holders have difficulties with keeping a group stable. According to the

BPGQ, 58% of the capuchin's holders consider that conflicts occur independently of the sex and the main reason of these conflicts is the competition for a higher rank in the hierarchy (36,73%).

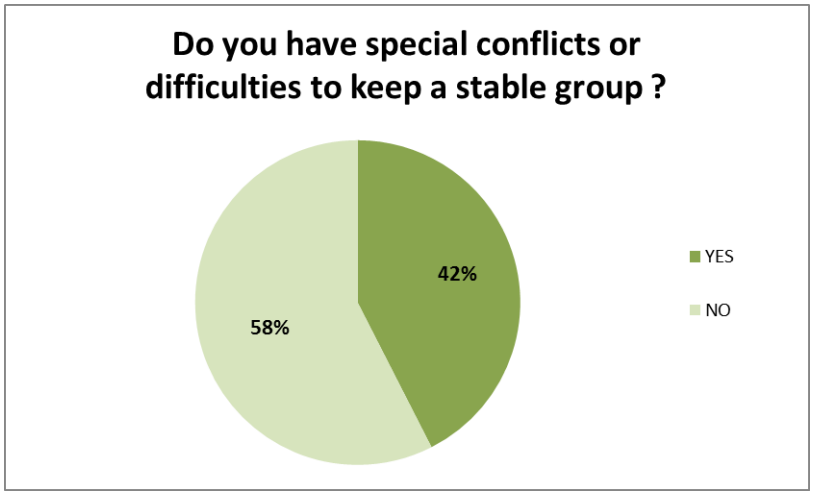


Figure 15: Capuchin holders and conflicts in EAZA zoos

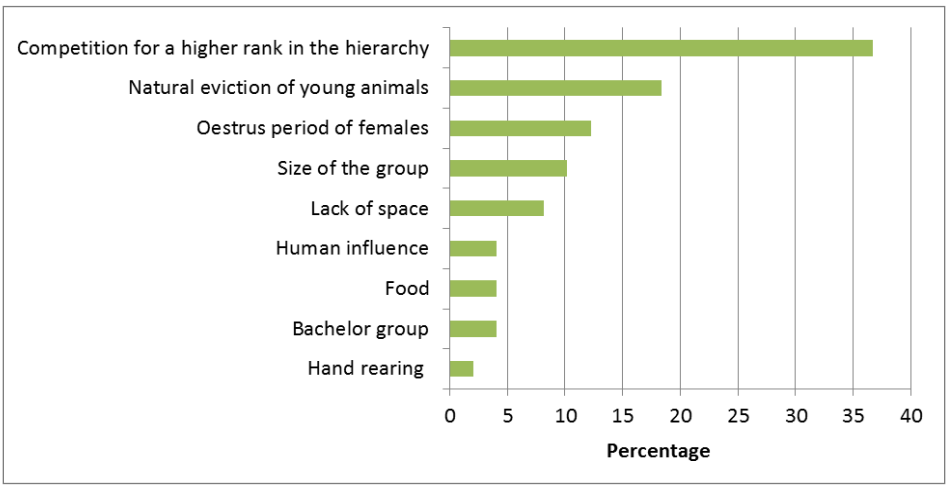


Figure 16: Reasons for the conflicts in EAZA zoos

Staff has to be careful in order to prevent an individual from being rejected or even mistreated. To decrease the risk of conflicts, it is recommended to have for each group a complex of several indoor rooms (minimum 3) and outdoor enclosures.

- Moving the youngsters:

Generally, the capuchins are transferred from a zoo to another between 4 and 6 years old. It corresponds approximatively to the age of dispersal in the wild.

- Management of surplus males:

Because sex-ratio is biased towards male in captive populations, there are a lot of surplus males. One of the solutions to manage these males is to create bachelor groups. Another solution is to castrate surplus males. The castration will decrease the aggressiveness of the male and it can be a

possibility to keep the less interesting animals (in a genetic point of view) in the group. The feedback from zoos which have the experience with this type is situation is that it is a good solution to keep a stable group without proceeding to a transfer, but it doesn't work well all the time, some conflicts still occur and several individuals can be injured.

2) General behaviour repertoire and communication

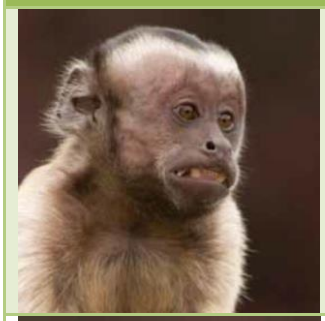
Capuchins use a wide variety of signals to communicate. These signals can take many forms: vocal, visual, tactile or olfactory. The interactions that can observed in a group of capuchins are particularly complex and it is commonly agreed that there is still a much work to be done in order to fully understand the behaviour of these monkeys.

Thanks to a strong facial musculature, capuchins have a rich repertoire of facial expressions and the visual ability to accurately interpret the meaning of these signals (Weigel 1978). The variations of opening the mouth, grimacing and pulling back their scalp to effectively raise their eyebrows are the expressions generally used to communicate with the other members of the group (Mittermeier et al., 2013). Despite some little differences, the expressions tend to be similar in the two genera.

Below, you can find a table made by Bowler and Whiten showing how the capuchins communicate between themselves. This table can be found following this link: http://www.living-links.org/wp-content/uploads/2012/05/CebusSIGNteachers.pdf. The authors warmly thank Living links, the University of St Andrews and RZSS for sharing this document.

How to 'Speak' Capuchin

Capuchin monkeys have a wide range of vocalisations, but they also communicate with a variety of visual signals and behaviours.

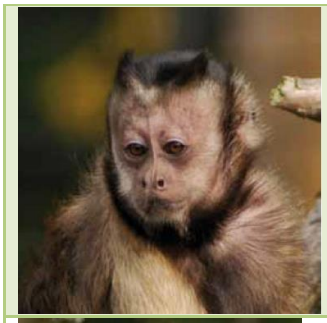


Submissive Grin

Scientists also call this the 'silent baredteeth display'. The lips are apart, and the corners of the mouth are down-turned. Capuchins use this face to say they are not a threat, or as part of courtship.

Open Mouth Grin

Scientists also call this the 'open mouth silent bared teeth display'. This is a submissive face like the submissive grin in meaning, but is clearer and may signal fear.



Scalp Lift

Raising the eyebrows can be a friendly or submissive signal between capuchins, often used by females to court a male. Don't confuse with a 'threat face', which also uses raised eyebrows.

Head Tilt

The head is tilted to one side while gazing at the monkey they are communicating with. This gesture is often combined with a 'submissive grin' and can be used in courtship.

Play Face

Scientists also call this the 'relaxed open mouth display'. This means 'I want to play' and capuchins will often use it while they are play fighting or chasing each other.

Threat Face

Capuchins often use this threat face with flattened ears when they are scared. It differs from the 'scalp-lift' in the angle of the head and the staring eyes. The monkey may also raise its fur and tail.

Open Mouth Threat Face

For more serious threats the capuchin monkey will open its mouth and call. The eyebrows, fur and tail will be raised, and the monkey will stare at the monkey or predator it is threatening.

Lip Smack

Older capuchins will often say hello to young or baby monkeys by smacking their lips, opening and closing them rapidly. It is a very friendly signal, and the baby may respond by reaching out.

Reunion Display

This is a special display performed between adult males after they have been apart for some time. They may be using this display to reinforce the social hierachy and their alliances.

Urine Wash

Capuchin monkeys, especially older males, wash their hands and feet with their own urine. This gives them an individual odour, that they leave everywhere they walk!

Beg

Scientists call this 'food solicitation'. One monkey holds its hands under another's while it is eating. Their friend might then drop pieces of food into their waiting hands.

Social Groom

Grooming is a very social activity, and monkeys typically groom their close friends and relatives most. The alpha male usually gets groomed a lot by the females.

Mount

A monkey might hug another monkey from behind. This is often done in play, but can also be signal of dominance or sometimes be used as part of a male 'reunion display'.

Branch Shake

Adult male capuchins shake branches to show other monkeys how strong they are, and sometimes do this when they are annoyed. They also shake branches to scare away predators.

Touch and Run

Female capuchins are very proactive about courting the alpha male. One
way they attract the male's attention is to touch him and run away, as if they are playing tag.

The vocal communication is also quite important: squeals, whistles or peeps for instance. In the wild, they need vocalizations when they forage, because they are often out of sight of each other. It is a way to stay in touch with the group and warn other individuals when a threat appears. In captivity, the vocalizations are also commonly used by capuchins, especially when stimulations, like feeding, occurs.

The olfactory sense is not well described in capuchins. To date, studies do not show an important use of olfactory signals. Nevertheless, scent marking occurs sometimes and urine rubbing and washing may be seen. Urine is composed of chemical cues like pheromones that provide social information (sex, age, place in the hierarchy, identity). This type of communication is generally seen during breeding period.

Finally, the tactile mode represents one part of the global communication between capuchins. Physical contacts like grooming illustrate the relations in the hierarchy. A lack of physical contact in a group of capuchin may be a sign of illness. Besides, playing is a normal and common behaviour in capuchin monkeys, especially in the juveniles. It is important to preserve and promote this type of behaviour through good social groups and enrichment.

Keepers must be aware of, and be informed about all these type of communications in order to understand what happens in the group of capuchins, and how to prevent problems and promote positive experiences.

3) Introduction methods

As mentioned before/earlier, capuchins are highly social and need to live in groups. In captivity, space is limited and the dispersion from a group is impossible. Therefore, humans are obliged to transfer individuals in order to avoid conflicts and/or loss of genetic diversity. While dispersal is most of the time reserved to the males in the wild, a female is as likely as a male to be transferred in captivity. When a zoo receives one (or more) individuals, the staff has to do its best to make the introduction a success. It is not an easy work, and much patience and good understanding of animal behaviour are needed. The introduction of new individual(s) is a stressful period for both newcomers and residents. A period of acclimatization is recommended to limit the stress and give the opportunity to the animals to get acquainted. This period can be short or long, depending on the behaviour of the animals. It is recommended to use a 4 steps process (regardless of a recommended quarantine process):

- First step: Visual contact. The new animal is installed in a box allowing mutual observations with the residents.

- Second step: Adjoining boxes. The new animal is transferred in an adjoining box that of the residents. The wire mesh allows the first physical contact. Double wire is preferred, to avoid biting in fingers.
- Third step: Switching and exchanging environments. In turn, the arrival(s) and the resident(s) have access to the same environment. The goal is to decrease stress and exchange of odours.
- The fourth and final step corresponds to the physical introduction. The keepers have to be careful at the beginning and be ready to intervene in case of an escalating conflict.

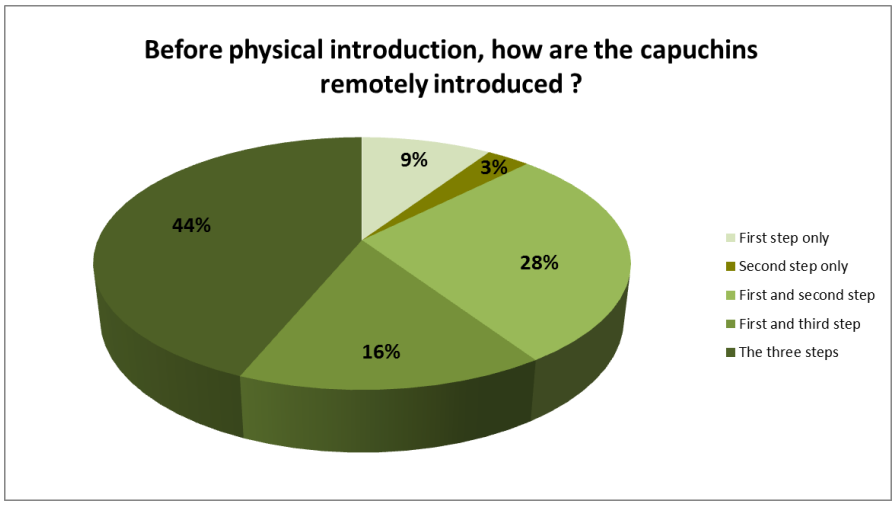


Figure 17: Methods of introduction in EAZA zoos

The figure 17 shows how the capuchin holders of EAZA zoos manage the introduction of a new animal. Because they do not have the facilities to do it, or because it works in another way, several institutions don't use the 4 steps process; nevertheless, 44% of the capuchin holders follow this process and the experience showed that it's the best method to make the introduction a success.

4) Mixed species enclosures

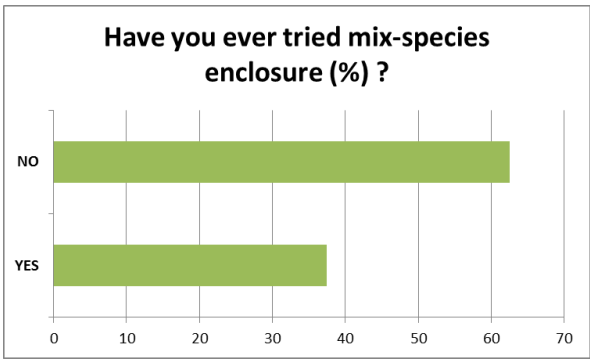


Figure 18: Percentage of institutions that already tried mixed-species enclosures

Nowadays, mixed species enclosures are commonly used in zoos. It is possible to make a group of capuchins living in an enclosure with another species, but the experience has shown that this is not always successful. The cohabitation between squirrel monkeys and capuchins is the most common and is generally successful. Beside potential animal welfare benefits, it can also be a good exhibition from an educational perspective to present species that can share the same environment in the wild. There are also some institutions that mix successfully capuchins with capybaras, others try with woolly monkeys but it worked only half of the time. We have also some examples of

successful cohabitation with *Pithecia pithecia, Saguinus labiatus* and *Ateles sp*. We encourage the zoos to try mixed species enclosures, but it is important to keep in mind that all the situations are different and that the examples mentioned here are just to give an idea of what is done in EAZA zoos. All trials (successes or failures) should be reported to the EEP/ESB coordinator or to the TAG chair. Finally, mixed species enclosures increase the stimuli for the animals and may function as enrichment, but research into the benefits or negative impacts should be evaluated on case by case basis and will aid to determine if something is enriching or not.

Figure 19: Mixed species enclosures with capuchins and capybaras in Salzburg zoo (©Salzburg zoo)

Figure 20: Mixed species enclosures with capuchins and Squirrel Monkeys in Le Pal (©Le Pal)

4. Breeding

1) Reproductive strategies

To manage effectively the reproduction of a capuchin group, it is important to understand the reproductive status of each individuals: a group can be composed of young, mature, non-reproductive, or elderly animals for instance. In captivity, we have to take precautions to avoid that mature offspring enter a breeding relationship with their parents or other members of their family.

2) Pregnancy and parturition

There are no physical exterior signs of oestrus in the capuchin females. Therefore, it is difficult for humans to detect it. However, the capuchin males can understand the reproductive status of the females by chemical cues in her urine.

When the keepers find cues, or even evidences, that the female is pregnant, they have to prepare the environment for the parturition: indeed, they have to be careful about food leftovers, and don't hesitate to give more food than before. If the female is primiparous, the video monitoring can be used.

3) Development of the cub

The average weight of a new-born capuchin is 220-270 gr. At this moment, it is sometimes difficult to distinguish male and female because external genitalia are similar in appearance. The clitoris tends to look like a penis at the beginning of the female's life and becomes shorter when she grow older. However, with some experience sex diagnosis is easily achievable.

Once the infant (or rarely the twins) is born, he or she clings to the belly of the mother; and later on the back. Usually, other group members don't care about the mother and her infant during and immediately after parturition. Few days after, they begin to become more interested in the infant (approaching the mother, trying to touch the new born). Mothers allow the members of their family to approach the infant more than unrelated animals. The social rank of the mother impacts how often she allows others to come near her infant; higher-ranking females are less tolerant of others approaching than low-ranking females (O'Brien and Robinson 1991). After a period of three months the young capuchin starts to explore the environment, but still relies very much on its mother. The young capuchin begins to eat solid food after three months and the weaning occurs after 416 days (Fragaszy and Adams-Curtis 1998) or even before in captivity.

Figure 21: Mother capuchin and her infant (©Michel Foos-Mulhouse zoo)

4) Hand-rearing

Hand rearing is not recommended in general. Very specific cases should be discussed with the EEP/ESB coordinators. It's really important to consider very well the possible negative effects before resorting to hand-rearing; the risks can be important, with the development of behavioural abnormalities and aggressiveness towards keepers. The situation must be monitored carefully, and the infant must go back to his group as soon as possible.

5) Sustainability of EEP and ESB populations

The Yellow-breasted capuchin EEP population only represents 15% of all of the capuchins of different species in European zoos and is the only one of conservation value (Vermeer & Lernould, 2011). In 2015, the Yellow-breasted capuchin EEP population was composed of 190 animals held in 28 institutions. With 13 founders (supposed to be not related), the genetic diversity had a good rate of 0,92 (the inbreeding rate was relatively high with 3,6 %, due to the size of the founding population).

It is important to maintain and intensify conservation efforts by implementing protective measures in the wild, and we must hope that the zoos will continue to give their support to this. Even if some actions will depend on the Brazilian government, the involvement of zoos and conservation NGOs will remain a determining factor to make further forward progress (Lernould, 2012).

"The species is attractive for visitors as capuchins are always active and much behaviour is are interesting, such as use of tools, fur rubbing or nuts breaking for example. Capuchins are often known by visitors because of its use in movies or in television soaps. White-throated capuchins are kept in Europe for educational purposes. As the taxonomy of the genus has been changed (Boubli et al., 2012), and as most founders of the European captive population probably came from Central America, their correct name may be *Cebus imitator*. Genetic studies would give us certainty on the identification of the animals, but as the role of this species is education, there is no urgent need for genetic analysis. So the official name of the manage species of white-throated capuchin in Europe is still *Cebus capucinus*. This capuchin population should not compete for space with the more endangered yellow-breasted capuchin (*Sapajus xanthosternos*). The ESB population is stable since few years, thanks to holders who stick very well to the recommendation to limit breeding. Castration helps in the management of (surplus) males." (Guéry, 2017)

5. Behaviour management

1) Environmental enrichment

Today it is commonly accepted that enrichment has the potential to improve animal welfare, but as any other aspect of an animal care and welfare program, it has to be evidence-based to confirm its positive impact on the studied species. Enrichment has to be goal-oriented and aims to promote optimal animal welfare, including physical and psychological aspects, focusing on predominantly positive welfare. Enrichment should also play an important role in avoiding undesired behaviours such as passivity, self-mutilation and stereotypic behaviour.

New activities and items should be planned and implemented, ideas and activities can be simple but should also be designed to generate interest by matching their cognitive capacities. Knowing that capuchins spend half of the day foraging; much effort should be done to simulate and extend foraging time. Meals should be given in a variety of ways, and be part of the extended environmental enrichment program, including for example in hidden in toys or spread randomly in the enclosure. It is important to keep in mind that the food enrichment must be done with a part of the daily diet and not with additional food.

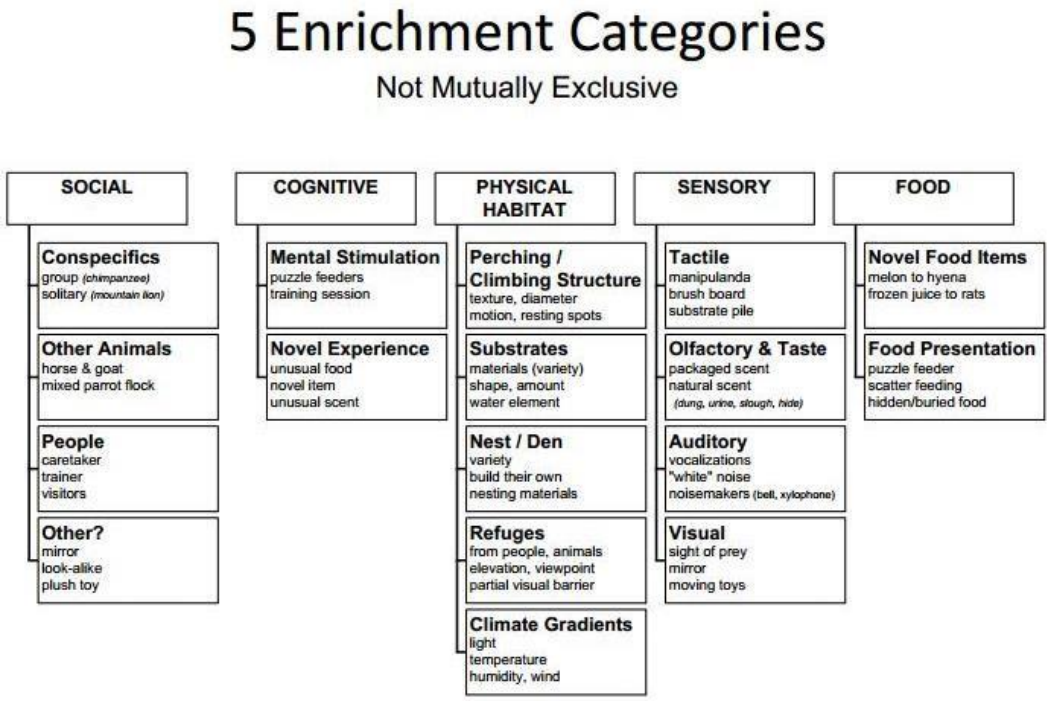


Figure 22: Taken from The shape of enrichment 2011

Figure 16 summarizes the different types and subtypes of enrichment, offering a huge diversity of possibilities. Capuchin holders must try to diversify enrichment proposed to the capuchins as often as possible to keep them from losing interest in one of these stimulus. Efforts should also be made to gain insights into which enrichment are indeed enriching and which ones are not. The BPGQ shows that the frequency of enrichment is really high in EAZA zoos, 50% of capuchin holders use enrichment at least once a day. A high frequency of diverse enrichment is needed to promote optimal capuchin welfare.

Figure 23: Capuchins with pumpkin as enrichment in Gaia zoo (©Gaia zoo)

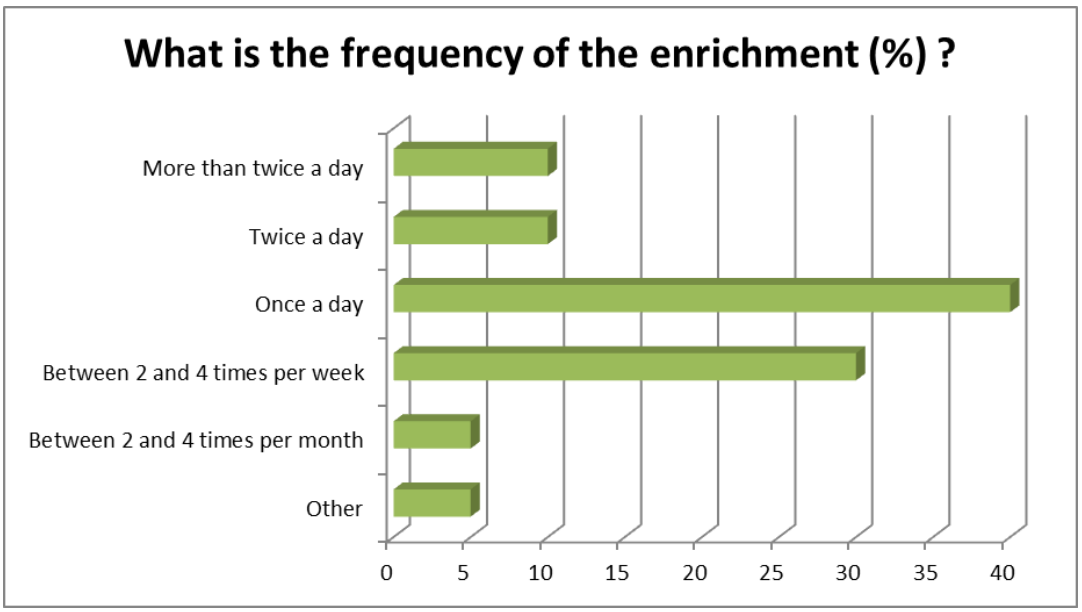


Figure 24: Frequency of the enrichment in EAZA zoos

Although the food enrichment is the most common (used by 90% of the capuchin holders (BPGQ)), and maybe the most successful, it is often provided in the same way. However, some holders build and use original enrichments: below we present an overview of what is done in different zoos.

	Long firehose forage strips. Each length of firehose has holes cut into it that are stuffed with woodwool or browse and any other desired food item. These can be attached to higher beams or placed on their roof mesh to encourage foraging behaviour at higher levels.
	Large drilled barrels that the capuchins have to rotate to release food items.

	Carpet tube or drainpipe with holes drilled in the sides. Bamboo placed through holes to wedge food parcels inside the tubes.
	Puzzle boxes. First, the capuchin must find a piece of wood (a branch) that can pass through the holes of the puzzle. Boxes made of Perspex with Perspex shelves put inside. Holes drilled so that capuchins need to move food items along shelves to finally drop the item through a hole at the bottom that they can take out of the box.
 	Holes and furrows in wood Food can be hidden in these holes and furrows. The capuchin has to find a branch to get out and take the food.
	Coconut The capuchin spends time to break the shell of the coconut. Not recommended for the enclosures with glass windows (the capuchin can throw the coconut in the glass).

2) Animal training

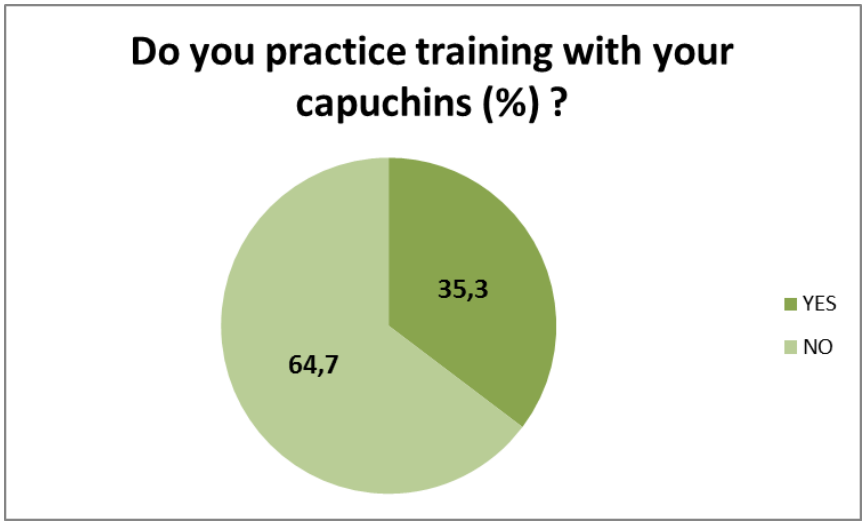


Figure 25: Capuchin training in EAZA zoos

Formal training for voluntary medical and husbandry behaviours is used in a wide variety of species. It consists of learning specific behaviours in order to avoid situations that could represent a risk for for the animals, or human care staff. It also provides choice and control for the animals, to activily choose to voluntarily collaborate with the caregivers. Originally, medical training was mainly used with large mammals (e.g. elephants, rhinoceros, sea lions, …). Nevertheless, it has been extended to other animals, including capuchins. For these species, the idea is more to exploit their intelligence to stimulate them and use it to conduct veterinary examinations as well as other management practices easily and positively for all involved.

Usually, the keepers use the positive reinforcement. Positive reinforcement is the application of a desired consequence in order to effectively maintain or increase the likelihood that this specific behaviour will reproduce again, this through the addition of a motivating or enhancing stimulus such as a piece of food, or a desired object. For more details, see medicine chapter.

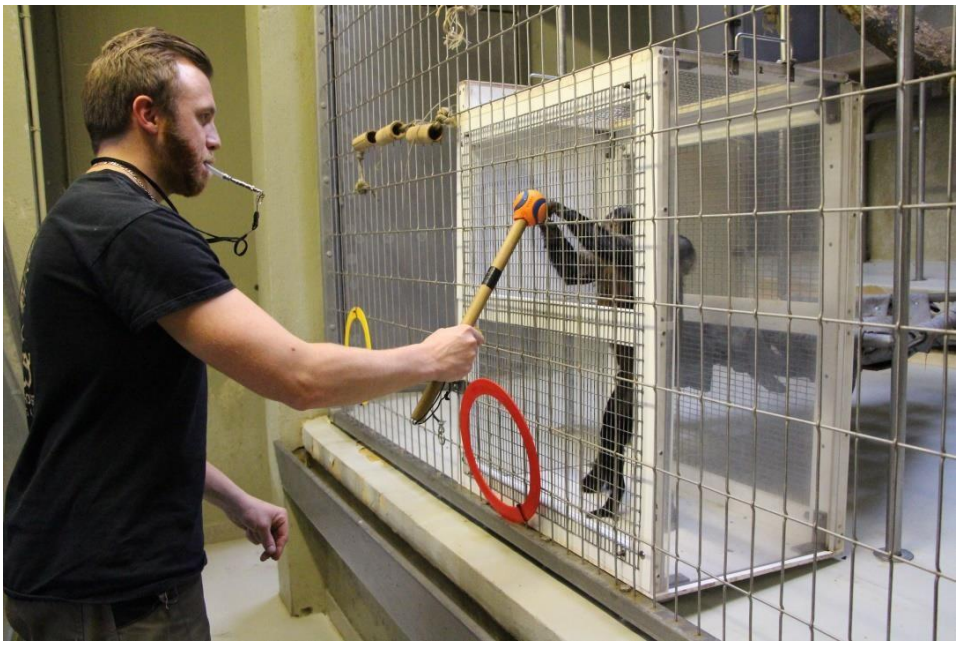


Figure 26: Crate training in Mulhouse Zoo

3) Animal welfare (By Sabrina Brando)

Approaches and assessment

Animal welfare science and practice focuses on the welfare of individuals. We have an ethical responsibility to provide animals in zoos with environments that allow them to experience good welfare (Brando & Buchanan-Smith, 2018). Professional zoos and aquariums (henceforth zoos) have seen a significant evolution, today promoting "cradle-to-grave", birth to death (Seidensticker & Doherty, 1996) and "24/7 across lifespan" (Brando & Buchanan-Smith, 2018). The term 'professional' is advanced animal care and welfare programs, incorporating the latest best practice, rooted in science and evidence-based approaches. Being professional means having an up-to-date theoretical and practical knowledge of animal welfare related topics (Brando & Coe, 2019). Professional also means having an auto-critical approach as well as a dynamic approach as science and best practices are evolving and changing dependent on available information, and might require to breaking institutional habits (Olle, 2018). The ability to challenge the status quo through the review of emerged scientific evidence is needed and an important aspect in the process of changing long held believes or practices. Being professional is to continue to ask if this is the best that we can be, if this is what is in the best interest of the animal 24/7 and an 'animal-first' approach, and to achieve the goals of education, research, conservation and recreation goals (Brando & Coe, 2019). The terms "animal welfare" and "animal well-being" have both been used over the years (Moberg 2000, p. 1), to describe the state of the animal, and are used in this section interchangeably.

Earlier animal welfare approaches highlight an animal's ability to lead a natural life (e.g. Duncan and Petherick, 1991), how the animal feels (e.g. Dawkins, 1998; Duncan and Petherick, 1991), and the biological functioning approach (e.g. Broom, 1986), and are now seen as dynamically integrated elements within the whole animal. The science of animal welfare has an extensive history. Even if the term "animal welfare" has not always been used, people have long been aware that animals are affected by their environment, nutrition, housing and handling, social structure, and interactions with humans (Hemsworth & Coleman, 2010). Contemporary animal welfare thinking is approached from a holistic perspective and encompasses physical, behavioural and psychological aspects, and is increasingly emphasizing the promotion of positive states and the centrality of the animal feelings (Wemelsfelder, Hunter, Mendl, & Lawrence, 2001; Wemelsfelder, 2007; Mellor & Beausoleil, 2015; Mellor, 2016; Veasey, 2017; Brando & Buchanan-Smith, 2018). Welfare concerns the individual, positive welfare is not something we give to animals, but something they experience; through a holistic approach, professional zoos promote optimal welfare for all animals in their care.

The assessment of the welfare of zoo-housed animals has benefitted from the frameworks and approaches used for farm animals. For example, in 2004 a large multi-country and multi-institution project identified four key welfare principles and 12 welfare criteria (Welfare Quality, 2009). Brando and Buchanan-Smith (2018) adapted and expanded this framework to promote optimal welfare for captive wild animals cover 14 points. Their framework has an increased focus on behaviour and positive emotions.

One major trend gaining global support is to consider the animals' lives in terms of the Five Domain Model (Mellor & Beausoleil, 2015). The Five Domain Model is at the core of the Animal Welfare Strategy of the World Association of Zoos and aquariums (Mellor, Hunt, & Gusset 2015). It concerns four physical/functional domains: nutrition, environment, physical heath and behaviour, and one mental domain which includes the positive and negative experiences of animals across each of the physical/functional domains. The interaction of these five domains results in the welfare status of the animal. A major feature of this approach is that animal welfare must be assessed in an integrated and holistic manner.

Scientific monitoring of animal behaviour is a long-standing tool used to measure zoo animal welfare (Kleiman, 1992). Welfare science primarily addresses individuals in terms of the whole animal. As scientists, we identify inputs, the independent variables that impact their experience, look at the overall expression of the individual, and assess outputs, the dependent variables that tell us how animals react to inputs across time to gauge how animals. Different software to monitor and evaluate animal welfare such as ZIMS Care and Welfare, ZOOMONITOR, Welfaretrak and TRACKS can be used, as well as technologies such as dataloggers recording e.g. locomotion, sleeping, location and social preferences.

The consistent use of animal-based or outcome measures to assess animal welfare is fairly new in both farm and zoo animals even if animal-based assessment has been frequently for specific aspects of animal care, such as the effectiveness of environmental enrichment or reduction in stereotypic behaviour. Practical animal welfare assessment should include outcome-based measures from the animal to provide insight in the individual's welfare states (Meagher, 2009). New to zoo animal welfare approaches is the use of animal-based assessment based on the observations, knowledge, and skills of animal care staff. These animal-based measures include positive and negative indicators that can be observable either directly or indirectly. Observable behaviour may include play, rest, high vigilance, and/or fearful cries. Indirect observable evidence may include bite marks, a well-built nest, an empty foraging device, and/or diarrhoea. The science relies heavily on keeper knowledge as they know these individuals better than anyone else and balances the art and science of animal care; from daily keeper reports qualitatively describing an animal's day, to quantitative assessments, we aim to incorporate objective data wherever possible. "Quantitative monitoring of animal-based monitoring that captures the individual's perspective and subjective experiences, including positive events and feeling, by validating zookeeper's qualitative assessments." A combination of resource- and animal-based assessment approaches, considering the individual subjective experiences and positive affective states aid in the efforts striving to provide the best possible care (Whitham & Wielebnowski, 2013).

Different yet collaborative tools for animal welfare assessment also further optimal welfare. Whitham and Wielebnowski (2009) and Kagan and Veasey (2010) discuss the importance of an integrated approach to zoo animal welfare, including both resource-based (input) and animal-based (outcome) assessment tools. Subsequently Kagan, Carter and Allard (2015) present a zoo animal framework based on science, compassion and sustainability, centred on a universal outline consisting of 1) Institutional Philosophy & Policy, 2) Programmatic Structure & Resources, 3) Execution, and 4) Evaluation to ensure great welfare for each animal in AZA-accredited zoos. The authors stress that "Staff must understand the difference between inputs (what is provided for animals) and outputs (what animals experience) and why assessing each is important." An animal welfare risk assessment process (Sherwen, Hemsworth, Beausoleil, Embury, & Mellor, 2018) can be used to identify risks and determine priorities.

Contemporary animal welfare assessments include quantitative and qualitative approaches. Animal-based or outcome assessments such as the presence or absence of wounds, and/or the use of enrichment items are generally quantitative. Qualitative assessment is the subjective assessment of animal welfare through a focus on subjective experiences, e.g. boredom and/or pleasure. Integrating direct observations, indirect observations, outcome assessments, and qualitative and quantitative assessment is particularly necessary when optimizing off-hours primate welfare. It allows staff and researchers to balance observational requirements without necessarily increasing manpower and staff presence overnight.

Professional animal welfare programs today strive to operate on an evidence-based approach as set out by Maple and Lindburg (2008) for the "empirical zoo" and including evidence-based animal welfare programs (Melfi, 2009). These programs reflect best practice processes of care

and conducting research, to e.g. exhibit design (Fuller et al. 2016), nutrition (Hulbert, Hunt, & Rose, 2017), the use of environmental enrichment (Bashaw, Gibson, Schowe, & Kucher, 2016), and positive reinforcement training (Spiezio, Vaglio, Scala, & Regaiolli, 2017) to manage animals in their care, and the importance of good human-animal relationship and interactions (Hosey & Melfi, 2012).

Choice and control

Professional zoos endeavour to provide animals with choice and control to meet their own needs and preferences when they want to. The potential benefit of choice and control have been well described as long ago as Chamove and Anderson (1989); Snowdon and Savage (1989), Brando (2009), and for a recent review see Allard and Bashaw (2019). There is considerable empirical evidence that not having control of one's environment leads to behavioural and physiological problems (e.g. Mineka & Hendersen, 1985; Perdue, 2014). Several studies have shown simply having choices, whether or not they are acted upon, is rewarding to animals (e.g. Owen, Swaisgood, Czekala, & Lindburg, 2005; Leotti, Iyengar, & Ochsner, 2010; Kurtycz, Wagner & Ross, 2014).

Thus, a common goal of these approaches is to allow animals far greater control (agency) over their own lives with less dependence on caregivers (Brando & Buchanan-Smith, 2018; Coe, 2018; Allard & Bashaw, 2019). This is not to say that this is an all or nothing concept that could be used to rationalize not completing certain tasks that optimal well-being is reliant upon. The concept should be used proactively yet judiciously. The choice should be meaningful to the animal, and the animal care staff must be accepting of with whatever choice the animal selects. If we provide an animal with a choice of two non-preferred social partners, does it really count as a choice to improve their welfare experience? Sure, it would mean they have an opportunity to control this segment in time, but if both choices potentially lead to negative outcomes, does that feel like control? (Brando & Coe, 2019).

Contemporary animal welfare thinking encompasses physical, behavioural and psychological aspects, is increasingly emphasizing the promotion of positive states (Mellor & Beausoleil, 2015) and the centrality of the animal feelings (Veasey, 2017). Professional zoos globally are reconsidering their animal welfare standards, evolving from surviving (early modern zoos) to coping (better present zoos) to thriving and promoting optimal animal welfare. Another model than the Five Domain Model (Mellor & Beausoleil, 2015), proposes the "5 C's +N" welfare concept (Coe, 2018), which revolves around an animal's ability to achieve Competence, have Choice, take Control, engage in Complexity, and Challenges, and to experience Novelty.

Multiple zoos have introduced animal-first approaches to welfare; each with their own perspective: (1) NZP/SCBI (Moore et al., 2013) presented their Animal First approach as a proactive take on communication channels to provide a safe environment in which animal care staff may identify and address welfare concerns. (2) Lincoln Park Zoo (2019) introduced their "animal-first" philosophy with changes in programming for ambassador animals. Programs are only deemed to be an "animal-first" program if animals are deemed to have choice and control in participating in an activity, can remain in the comfort of its habitat, and the program is to the benefit of the animal. Any programs not meeting these criteria are in the process of phasing out. The effect of all zoo activities, interactions and relationships need to be carefully considered and animals should be provided with options to exercise choice and control over their environment (Brando & Herrelko, 2019).

Finally, promoting, monitoring and assessing animal welfare outside regular working hours deserves specific attention, especially when animals are locked in the back-of-house. On average a working day consists of 8 working hours during which zoos are open. Animals who are housed in back-of-house areas during the hours that the zoo is closed, who do not have 24/7 open access, will

spend on average 16 hours inside in the back-of-house facilities. A quick calculation illustrates the time an animal spends in the BOH facilities :

365 x 16 ÷ 24 = 243 days a year

> "…there is a lack of comprehension about primate behavior, welfare, and needs during the hours in which caregivers are not present. A quick survey of the literature suggests that only around 2% of studies addressing primate welfare specifically discuss night time behaviors. However, primates habitually spend up to 60% of their time in the absence of a full care staff." Brando and Sharpe (in press).

Providing complex and enriching environments that offer choice and control is a core building block of professional primate care. These programs have made advances through research and the implementation of best practices in veterinary care, nutrition, habitat design, animal training, and environmental enrichment. However, welfare at night, when staff are not present or only a few staff out present ("off hours") is not usually discussed. This is worrying, because animals also require and deserve the choice, complexity, and control of their environment during these hours, and their needs may differ during these hours, too. Humans, like most primates, are diurnal. As such, humans involved in animal welfare tend to focus on changes made during the daylight hours. Video cameras and recording systems make behavioural observation of primates during off hours feasible, by analysing recordings, or via live feeds such that staff can monitor primates in real time from off-site.

Zoos play a crucial role in the conservation of our world, and professional zoos today have advanced animal care and welfare programs, incorporating the latest best practice, rooted in science and evidence-based approaches. Basic research is useful, and it is the applied research and practice that helps zoos evolve. An 'animal-first' approach highlights the attention to promoting optimal animal welfare as a condition for all the goals zoos have (Brando & Herrelko, 2019).

6. Handling

1) Identification

All the animals in zoos should be clearly identified. The main goal of the identification is to avoid a misidentification of the individual. It is recommended to use a transponder which has a unique code. This transponder is implanted under the skin (generally inter-scapular); it can be done when the veterinarian realizes the first medical check-up of the young animal. It allows to follow him during all his life. Finally, it's important to keep records (individual, specimen and medical) up to date to ensure a good transmission of information between all the institutions, especially when transfers occur.

2) Capture, immobilization and transport

- The capture:

Capture is a stressful intervention for the animal. The efficiency of the zookeepers must be as high as possible to limit the time spent to catch the animal. The time of capture has not a great importance for capuchins, but it is better to avoid the middle of the day in summer, when the temperatures can be high. Generally, the time of capture is chosen in terms of how long the capuchin will be restrained, and doing it early in the morning leaves the possibilities to:

- do it without public,
- follow the animal behaviour for the rest of the day.

All the zoos have at least one indoor enclosure and it is generally easier to catch the animal inside than in an outside enclosure where the capuchin will climb to the high parts of the enclosure.

Using blow darts on animals below 15kg mass is not recommended: there is a high risk of injury (impact trauma, damage to an eye, the face, body cavity or internal organ) and the animals are too fast and small to be good targets (Tribe and Spielman, 1996)).

A net is a good tool to catch the animal but certain characteristics must be considered:

- It must be robust, with a strong construction,
- The diameter must be approximately 50-70 cm,
- It must have padded rims to prevent damage to the animal,
- The holes must be woven small enough (to avoid that the head or limbs can pass through). A solid fabric is better to avoid any tangling but makes retraining of the animal by the keeper more difficult as he cannot see the animal,
- When the net is deep enough, you can just turn it (to be sure that the capuchin cannot escape).

Medical and other husbandry training is recommended for the capuchins, including voluntarily entering crates to reduce capture events. Training animals to willingly cooperate provides animals with more choice and control, and is useful with basic procedures such as transport or routine inspections. This way, the stress is limited, and the zookeeper can work to place the capuchin in a restraint or transport container. This container should represent a part of the global environment (to become familiar and comfortable) of the capuchins so time and patience are needed.

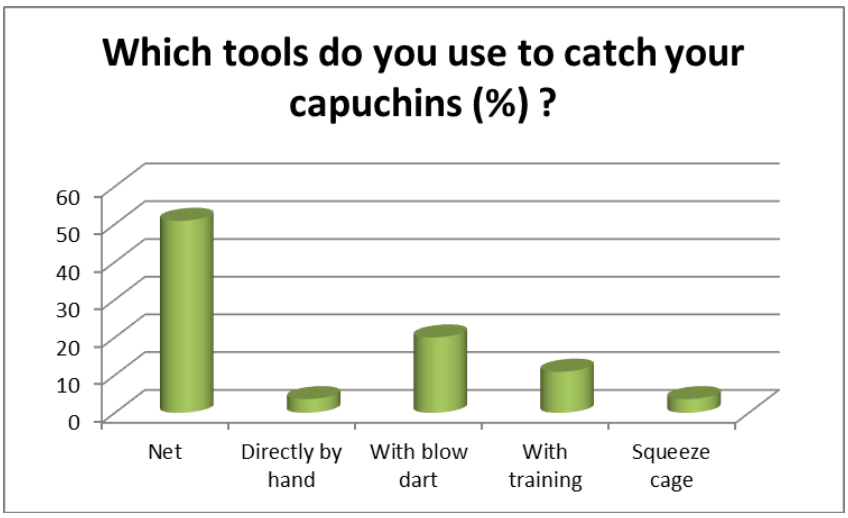


Figure 27: Tools used to catch the capuchins in EAZA zoos

No matter the technique used to catch the animal, the keepers must be careful at each capture and never underestimate the dangers posed by the intelligence and the physical abilities of the capuchin monkey. Above, the figure 24 shows the tools used by capuchins holders in EAZA zoos. The LNWM TAG recommends practicing training and use training cage or induction box preferentially to catch the capuchins (see picture 46 in the vet part). Catching animals in nest boxes or other closed sleeping, hiding or resting places is not advised, and it is also important to consider where animals will wake up, as some medication can make the animal feel strange and or nauseous and it should be avoided that these negative sensations become associated with the catching crate, tunnels or other places that are critically for management as well as maintaining and promoting optimal animal welfare.

Figure 28: Training cage (left) and induction box (right) in Mulhouse zoo (©Mulhouse zoo)

- Immobilization:

The keepers must wear restraining gloves during immobilization. Some of them prefer to add surgical gloves to avoid disease transmission. Some others prefer thick, elbow length gloves to have a strong barrier between the animal and themselves. The problem of these heavy gloves can be the loss of dexterity and sensitivity that increases the risk of injury for both the animal and the keeper.

The capuchins must be restrained with both upper arms pinned behind the back (never by only one arm to avoid bite and spiral fracture of the humerus). Besides, one finger must be kept between the arms. This position limits the movement of the head and prevents the risks of bite. The grip should be restrained all along the manipulation without any fall of vigilance (even the animals seems to accept the immobilization).

Figure 29: Good immobilization of a capuchin monkey (©C.Fiore)

- Transport:

Usually, the capuchins are transported individually or group members can be transported in a large crate separated in partitions (there are some exceptions like the mother and infant). Pregnant females in their last trimester, diseased and too young animals should not be transported. Stressed animals are more sensitive to temperature changes so all the precautions must be taken to avoid illness and the journey is generally done in temperate hours of the day.

The capuchins travel in a transport box. This box can be in wood or in iron (only non-toxic materials) but in all cases, it must be strong and robust to prevent the animal from escaping. When the animal is in transit, it should be able to stand up, turn around and lay down. The box must be composed of air vents located at least on three sides to avoid blocking the ventilation during the storage of the boxes. It is important that there are no sharp edges (nails, for example) that could cause injury to the animal. The sticker "Live Animal" must be clearly displayed on box along with "right way up" arrows. All relevant animal records and identification must also be displayed, along with any quarantine permits or special requirements (Littlefield, 2009).

Capuchins are quite messy so the floor should be with wire mesh: if there is an excess of waste, this can fall through the gaps. The bottom of the box must be sealed to avoid spillage of excrements if it does not have a droppings tray. It is also recommended to install an absorbent bedding material and a resting shelf can be installed.

Water is only required for long journeys (more than 24 hours). However, a fruit or a vegetable rich in water should always be placed in the box. Concerning the food, monkey pellets and non-citrus fruits are recommended and if the animal is given water during the transport, the water container must be removed when the monkey has finished drinking. The food and water containers must be installed with an external access. For longer journeys (more than 24 hours), the stick "Give water" should be painted in black on the box outside each cup. If traveling by air, food for 2 extra days should be included (Honeysett, 2006).

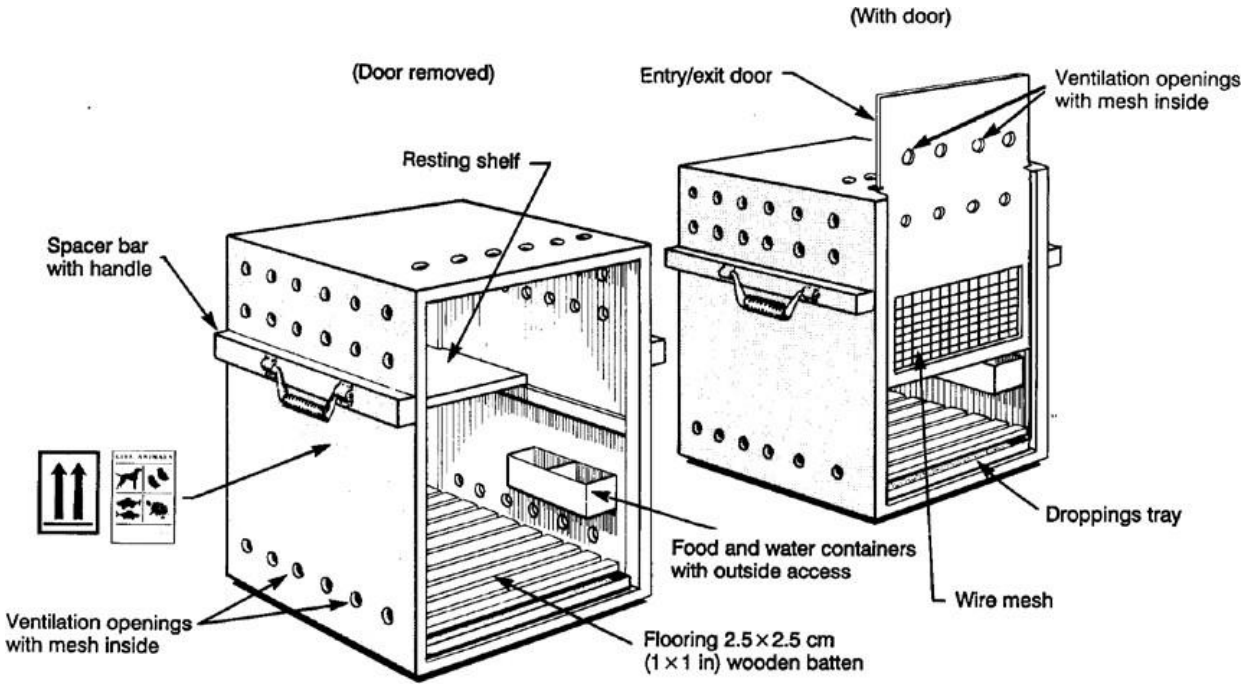


Figure 30: Transport box for capuchin (©IATA)

7. Veterinary: Considerations for health and welfare

1) Routine health inspection

a) Daily health observations

The daily observations of the animals are the fundamental pillar of a good preventive medicine (Abee *et al.*, 2012, Fortman *et al.*, 2018, Honeysett, 2006 & Veeman, 2003). The regular monitoring of the animals allows an early detection of diseases. The capuchins are susceptible to a wide range of contagious and non-contagious diseases and their health can deteriorate rapidly without an appropriate treatment. Therefore, the capuchins health should be monitored daily. These observations should be considered as a vital part of the husbandry activities.

The zookeepers have to check at least once a day the behaviour of the capuchins under their responsibility, including appetite and water consumption, urine and faeces output (Fortman *et al.*, 2018 & Honeysett, 2006). They have to be aware that the capuchins can mask their illness in the presence of humans and that the behavioural changes can be subtle (Fortman *et al.*, 2018). There is also difference in characters between two individuals of the same species. It is better for the capuchin monkeys to be cared by the same keepers in a long term. This allows the keepers to be familiar with the normal behaviour of the capuchins they take care of, and so to detect early the abnormal behaviours (Fortman *et al.*, 2018). The feeding is a privileged moment because the keepers can observe closely the capuchins and their behaviour. Observations of potential illness should be promptly reported to the supervisory staff and to the veterinarian (Abee *et al.*, 2012).

b) Signs of illness

The common signs of acute illness are a poor appetite, a decreased activity, an abnormal behaviour or even lethargy or a prostration (the animal stands in a crouched posture with the knees folded into is abdomen) (Abee *et al.*, 2012 & Honeysett, 2006). Capuchin monkeys are active species. Therefore, if an individual seems to have a decreased activity or is not interested in food, it should be notified. These are indeed the earliest clinical signs of illness. It is also important to check the quantity and aspect of urine and faecal output. Diarrhoea and constipation could possibly indicate a gastrointestinal disease. Changes in urine may indicate renal or endocrine disease or urinary tract infection. Then, the keepers should do a complete visual physical examination of all the capuchins, with a special care of the hands, feet and tail, which are often hurt during a social conflict, the anus for diarrhoea and the nose and the eyes for discharge.

As in other primates, the behavioural changes may be the last signs of an underlying illness to appear. Indeed, chronic disorders are less obvious and they could be difficult to detect. That is the reason why for these conditions, the regular monitoring of body weight and the body condition is a key point. They are excellent indicators of the global health of the animals. If the body weight decreases of 10% or if the animal becomes too thin, this should be notified to the veterinarian.

c) Training

Which medical behaviour do you train to the capuchin monkeys?	Number of responses	Percentage
None	32	82%
Injection	1	3%
Urine/Faecal sample	1	3%
Positioning	1	3%
Weight	2	5%
Box	2	5%
Mouth: Open/Hold it	3	8%

Table 8: Percentage of zoos (n = 39) that train the capuchin monkeys according to the BPGQ

18% of the EAZA zoos (7/39) trained the capuchin monkeys for medical training, but they generally train one behaviour, which is low (Table 8). It is very encouraged to train capuchin monkeys by using positive reinforcement training (Abee *et al.*, 2012). Indeed, the medical training can increase welfare of the animals, by reducing stress and enriching their environment, including training such as entering a crate reducing the need to handle and capture the animals for veterinary and management reasons. Other important benefits of the training are the reduction of the stress for the keepers, a better knowledge and understanding of the animals in their care. Moreover, capuchins monkeys have a big brain to body weight ratio and they can learn more than simple conditioning techniques (Honeysett, 2006). Capuchins can distinguish between different tones of voice and possibly words (Hubrecht, 2010).

The medical training facilitates the routine examination, the early diagnosis and the treatment (Abee *et al.*, 2012). For example, two EAZA zoos train “weighing”, one train “positioning” (Table 8), which is to come close to the trainer and a veterinarian, to present a specific body area and to remain stationary during a physical examination. Because of the high incidence of dental diseases in capuchin monkeys, it is useful to train to open the mouth (three EAZA zoos). It is also possible to sample urine/faecal (one EAZA zoo). It takes 1 month to train a female to urinate in a bin. Sometimes, more complex tasks can be asked to the capuchin monkey like giving blood or vaginal swab (Hubrecht, 2010). It also allows inducing anaesthesia without stress, like moving in an induction box (two EAZA zoos) or accepting an injection (one EAZA zoo). Finally, they allow treatment, like medication administration either by injection or orally.

d) Annual physical examination

The veterinarian should undergo health checks every time that a capuchin is anaesthetised (Abee *et al.*, 2012 & Fortman *et al.,* 2018). Annual injections like vaccines or tuberculin test and departure/arrival are often causes of physical examination. First of all, the physical examination begins with an observation of the behaviour of the individual in his usual enclosure and his general condition. Then, the capuchin monkeys should be anaesthetized for the clinical examination. That is the reason why the physical examination should be as short as possible (Perpiñán et al., 2017). The veterinarian should check the vital signs: the rectal temperature, heart and respiratory rates (Table 9). Then he should check the weight and the body condition score, the colour of the mucous membranes and the capillary refill time and perform a cardio-respiratory auscultation and an abdominal palpation. When thoracic abnormalities such as murmurs, wheezes, or crackles are detected, thoracic radiography, echocardiography, or an electrocardiogram should be performed, depending on the abnormal clinical sign.

Physiological measurement	Range of normal values
Body temperature	36,7 – 38,4 °C
Heart rate	165 – 230 beats per minute
Respiratory rate	30 – 50 breaths per minute
Weight	depends on the sex and the species

Table 9: Physiological data in capuchin monkeys (see part 3. Physiology)

Identification of the capuchin monkeys should be controlled after stabilisation of the anaesthesia by reading of the microchip. Then a complete physical examination, which includes the eyes, the nose, the ears, the oral cavity and especially the teeth, the skin and the articulations, should be performed. The capuchin should be weighted and evaluated for its body condition score. The dental diseases such as fractured teeth, ulcerative lesions, dental tartar, gingivitis and periodontal disease are common in capuchin monkeys. The skin and musculoskeletal system should be inspected for wounds, hair loss, superficial inflammation, masses or swelling. The presence of enlarged superficial lymph nodes could be indicative of neoplasia, tuberculosis or other contagious diseases. Blood should be sampled. Sera should be stored in a bank at -20°C for future studies. Clinical laboratory tests are an important part of the annual physical examination. Tests routinely performed include complete blood count, serum chemistry profile, and faecal examination for parasites, and urinalysis for older animals (Fortman *et al.*, 2018).

e) Records

Each capuchin, as any other animal in zoo facilities, should have his own history and medical file (Honeysett, 2006). Computerized data recording is highly recommended. The Zoological Information Management Software (Species360 ZIMS) is nowadays very common in zoological institutions. The file of the animal must include: common and scientific name of the species, name of the individual, local identifiers and number of the transponder, possible distinctive markings or band, date and location of birth, sex and breeding status, location in the facility and social group, provenance, details on previous owners, information on the parents (Honeysett, 2006 & Fortman *et al.*, 2018).

The medical history should include dates and results of health examinations, clinical notes, weights, samples and diagnostic tests, prescriptions and treatments, anaesthesia, contraception or breeding events, and ultimately necropsy findings. The veterinarian in charge of the medical care of the capuchins must be able to oversee and review individual records and medical history and should frequently update medical records. Keepers have to produce day-to-day reports to the responsible staff and to the veterinarian, in which they relate any problem with the animals or the facilities.

All the files should be kept safely during the life of the primate and then securely archived. Any transferred capuchin must be accompanied by copies of all relevant records that allow continuation in husbandry, diet and veterinary care. These records are also useful for the local group management, and afterwards to evaluate breeding programs and globally to write recommendations and guidelines.

2) Preventive health

a) Parasites management

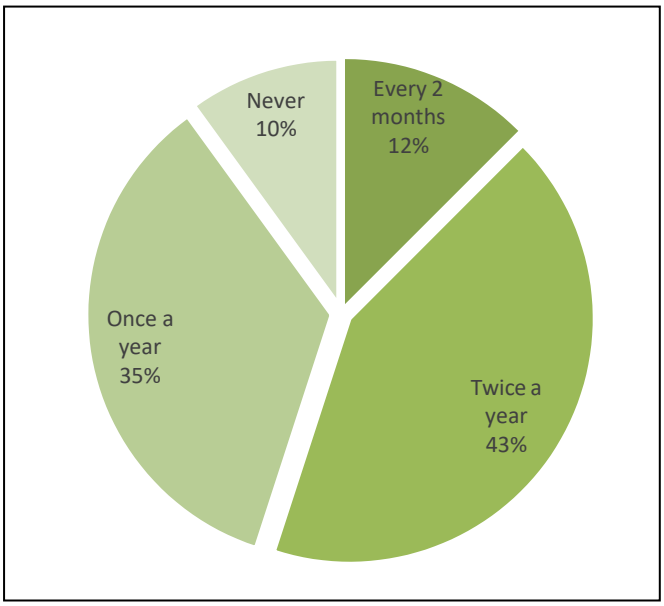


Figure 31: Frequency of routine faecal examination in EAZA zoos (n = 40)

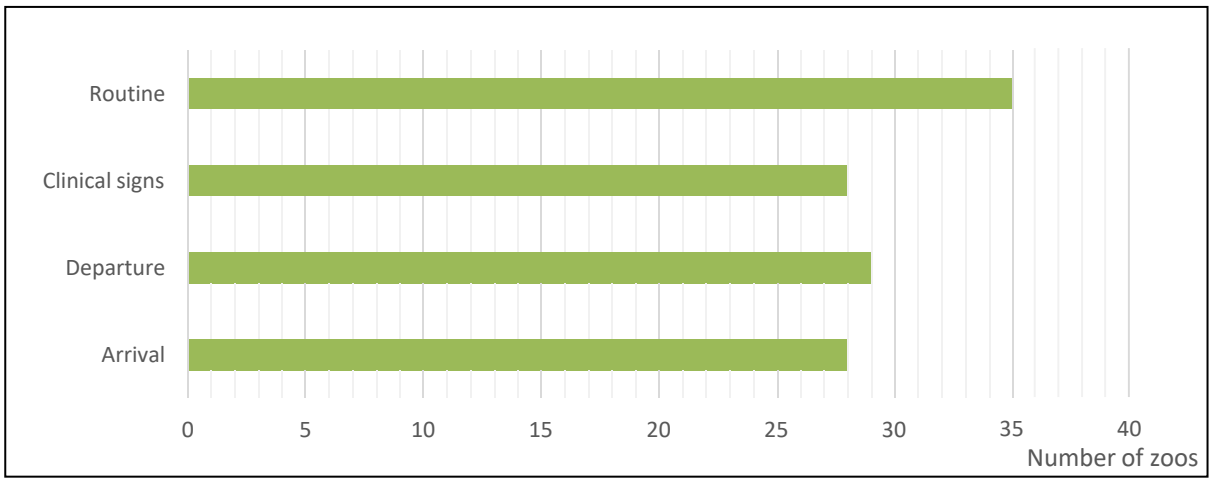


Figure 32: Reasons for performing a faecal examination in EAZA zoos (n = 40)

A large majority of EAZA zoos (35/40) performs routine faecal examination (Figure 31). The frequency of the routine faecal examination in EAZA zoos is on average once or twice a year (Figure 32), as it is generally recommended in nonhuman primates (Honeysett, 2006 & Veeman, 2003). The five EAZA zoos that never perform routine faecal examination, do it nevertheless when a capuchin shows clinical signs and at the departure or arrival. 70 % of EAZA zoos (28/40) run faecal examination on the presence of clinical signs. Clinical signs of parasite infestation are diarrhoeic, watery or bloody faeces (Abee *et al.*, 2012 & Honeysett, 2006).

A faecal examination in routine for parasites in capuchin monkeys is recommended between once and twice a year and at the departure or arrival of any capuchin monkey. The housing practices, the sanitation practices and the pest control are parameters to take in account in the intensity of the parasite surveillance (Abee *et al.*, 2012). It is also recommended to perform a faecal examination when a capuchin monkey shows chronic clinical signs of infectious digestive disease. The most common method for observation of parasites in the stool is the faecal flotation with a flotation

solution like zinc sulphate that allows observation of a wide variety of parasite ova (Abee *et al.*, 2012). If ova or larva of parasites are observed in the faeces and if the identified parasite has a high pathogenicity or the level of excretion is high, then an antiparasitic therapy should be prescribed (Abee *et al.*, 2012).

Routine antiparasitic therapies are not required for capuchin monkeys (Honeysett, 2006) and the choice of anthelminthic must be dictated by the identified pathogen (Abee *et al.*, 2012). Rigorous sanitation practices and elimination of the intermediate host (such as rodents) are essential in the control of both parasites with direct and indirect life cycle (Abee *et al.*, 2012).

b) Vaccination / Immunizations

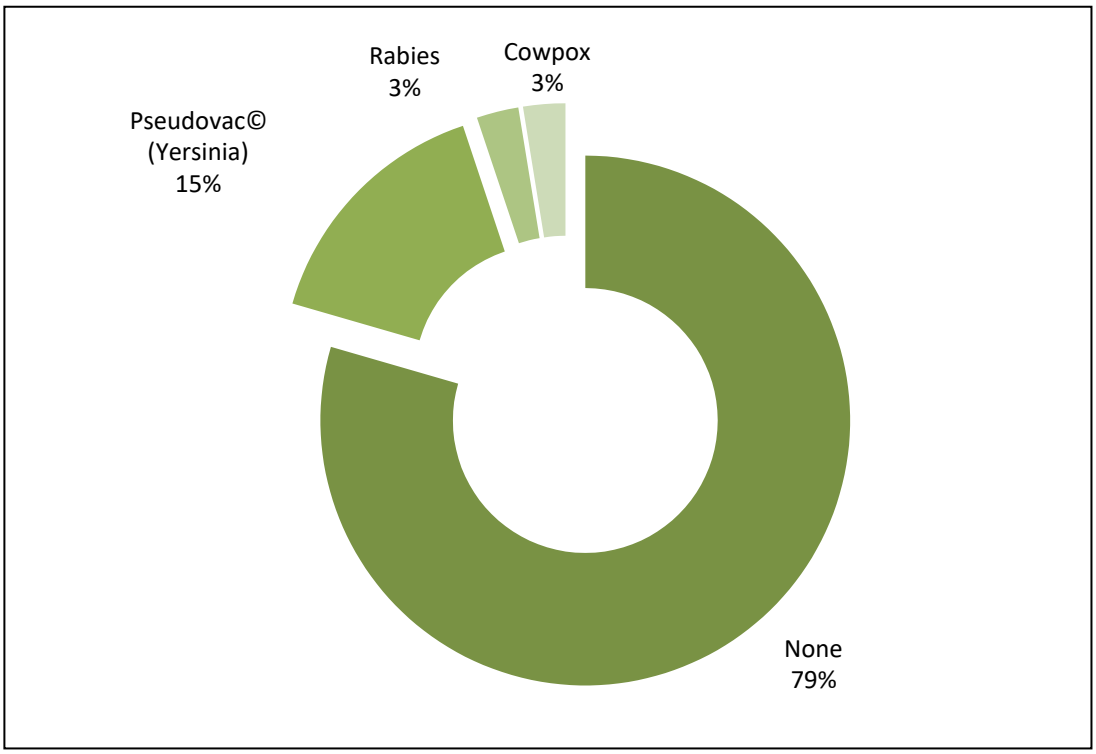


Figure 33: Immunization in EAZA zoos (n=40)

The majority of the EAZA zoos (31/39) never vaccinate their capuchin monkeys (Figure 33). Indeed, there is no universal recommendation for immunization in nonhuman primates (and so in capuchin monkeys). However, some vaccines in nonhuman primates can be classically included in vaccination programme like measles, tetanus and rabies (Fortman *et al.*, 2018 & Honeysett, 2006). The decision to immunize nonhuman primates depends on the risks, safety, cost and known efficacy of the vaccine (Fortman *et al.*, 2018 & Honeysett, 2006).

Pseudovac® is the most commonly used vaccine in EAZA zoos (6 of 31 zoos). Pseudovac® is a formalin-killed vaccine that contains different serotypes of Yersinia spp. and is used in the fight against Yersinia pseudotuberculosis. A dose of 0.5 mL is administered subcutaneously in the capuchin monkeys older than 7 weeks with a booster 3 to 6 weeks later. Then, the booster can be repeated every year. The vaccine and preventive measures revealed relevant in tamarins and marmosets (Bakker, 2007), but has never been proven efficient scientifically (Quintard, 2010).

Only one EAZA zoo vaccinates against rabies. Indeed, rabies is nowadays considered as a pathogen with a decreasing importance in Europe. In rabies-endemic areas, capuchins monkeys maintained in outdoors facilities could be vaccinated against rabies, with an injection of a killed vaccine every 3 years (Abee *et al.*, 2012). The modified-live rabies vaccine must never be used, because it can cause disease in nonhuman primates (Abee *et al.*, 2012).

One park vaccinates against cowpox, after the infection in another species of their collection. Measles is a highly transmissible virus of humans. Nonhuman primates are infected before a direct exposure to an infected human or another primate infected by a human. The exposition to humans increases the risk of transmission. The human measles and the canine distemper vaccines are effective to immunize nonhuman primates (Fortman *et al.*, 2018), but these vaccines can result in a false-negative tuberculin skin test and the incidence of the measles in human has declined (Bushmitz, 2009).

Tetanus can affect all nonhuman primates maintained in outdoors facilities. They could be immunized against the agent of tetanus (Calle *et al.*, 2015). There are two primary intramuscular injections of 0.5mL each, at an interval of 4-5 weeks, and a reinforcing 6-12 months later. Then the booster can be done at a frequency between 1 and 10 years. Capuchin monkeys in endemic areas of yellow fever could be vaccinated against it.

c) Tuberculin skin testing

Tuberculosis is one of the most important of the bacterial diseases in nonhuman primates (see part 7.5.a. Tuberculosis) (Abee *et al.*, 2012, Bushmitz *et al.*, 2009, Fortman *et al.*, 2018, Honeysett, 2006, Perpiñán *et al.*, 2017 & Veeman, 2003). New World monkeys seem to be more resistant to tuberculosis than Old World monkeys (Veeman, 2003), but larger New World Monkeys are considered susceptible to the disease (Coote, 2005). The tuberculin skin tests are essential for the detection of the tuberculosis, because the early diagnosis of tuberculosis is hard. It is based on the concept that any animal infected by tuberculosis is allergic to the proteins of the Mycobacteria. The tuberculin tests can be performed when a capuchin monkey is already anesthetized for another reason (like annual examination). In a second stage, chest radiographs may be used to detect characteristic lesions of tuberculosis like pulmonary nodules (Abee *et al.*, 2012).

Figure 34: Intradermal injection of tuberculin in an upper eyelid of a yellow-breasted capuchin (®Mulhouse Zoo)

The most common method of testing tuberculosis is the intradermal injection of bovine and avian tuberculins (Abee et al., 2012 & Perpiñán et al., 2017). Mammalian old tuberculin (MOT) can also be used. 0.1 mL is injected intradermally by inserting a 25-gauge needle just under the epidermis at an angle of approximately 10°, at the edge of the upper eyelid (Figure 34).

This site is preferred in nonhuman primates because of the ease of observation. The bovine tuberculin is injected in the left eyelid and the avian tuberculin in the right one. The eyelids of the capuchin monkeys should be examined at 24, 48 and 72 hours after injection and check for swelling or changing in colour that is a positive response to the test. The veterinarian should always think that the tuberculin skin tests are generally not very sensible and specific, so the false-negative and false-positive are common. Positive tuberculin skin test in a capuchin monkey must trigger the isolation of the animal and a battery of diagnostic tests such as chest radiographs, bronchoalveolar lavage smear and culture, gastric aspirate smear and culture, interferon-g assays, and PCR testing (Abee *et al.*, 2012). Bacterial isolation is the gold standard. All the nonhuman primates that were exposed to the tuberculin skin test positive capuchin should undergo skin tests to find other asymptomatic carriers (Abee *et al.*, 2012).

d) Dental prophylaxis

Dental diseases are very frequent in capuchin monkeys of EAZA zoos (Figure 35) (see part 7.4.c. Dental Diseases), so the teeth should be examined at the time of each physical examination (Abee *et al.*, 2012, Fortman *et al.*, 2018 & Perpiñán *et al.*, 2017). Dental diseases induce significant pain and thus poor appetite and weight loss, and sometimes periodontal abscesses including facial abscesses and cardiac valve disease (Abee *et al.*, 2012). The capuchin monkey should undergo dental cleanings under anaesthesia if there is an excess of tartar plaque or gingivitis. The teeth are scaled by a hand or ultrasonic scaler to remove plaque and tartar in the visible region and below the gum line (Abee *et al.*, 2012). All broken teeth or caries should be cured or extracted.

Figure 35: Oral cavity of a young and healthy yellow-breasted capuchin, on left and of an adult yellow-breasted capuchin with missing right upper canine, on right (®Mulhouse Zoo)

e) Recommendation on zoonotic diseases

Zoonosis from capuchin monkeys to humans are not frequently reported (Perpiñán *et al.*, 2017). However, New World monkeys are known to be carrier of a lot of zoonotic bacteria or parasites and in particular tuberculosis (see part 7.5. Infectious diseases). Moreover, it is important to follow basic rules of sanitation and hygiene to avoid injury and zoonotic disease transmission to protect zookeepers (Abee *et al.*, 2012, Fortman *et al.*, 2018, Perpiñán *et al.*, 2017 & Veeman, 2003). The keepers should avoid direct contact with the capuchin monkeys and contaminated fluids like saliva, food, water, urine or faeces, by using gloves. Therefore, they must wear disinfectable rubber boots and work clothes, ideally laundered at the work place. Handwashing must be frequent and performed before leaving the primate area, before eating, drinking or smoking. Eating, drinking or smoking should not be permitted in a nonhuman primate area. Work clothing should be changed when visibly soiled or contaminated. Leather gloves, nets and kennels should be cleaned and disinfected following each use, as well as surfaces such as treatment tables.

Regarding zookeeper vaccination with link to zoonosis risk, one should refer to its own preventive medicine department. An ill human should not prepare food for nonhuman primates or handle a capuchin. Any person that is injured by a nonhuman primate should cleanse the injury site with large amounts of water and disinfectant soap for 10-15 minutes, and then notify to its supervisor.

f) Pest control

Pest control program are essential in fight against transmission of diseases (Abee, 2012 & Veeman, 2003). Rodents are carrier of a lot of pathogens, like *Yersinia enterocolitica*, *Pseudotuberculosis*, *Salmonella*, *Toxoplasma gondii* and *Leptospira*. Cockroaches are intermediate host of acanthocephalan (*Prosthenorchis elegans*). Insects are mechanical vectors for various pathogens.

Maximize cleanliness, limit access of pests to waste or food (use big sealed bucket), and limit potential shelters are pillar of the pest control (Fortman, 2018 & Veeman, 2003). Daily cleaning and removing of the food waste decrease the attraction for the pest. To prevent the pest to entering in the exhibit, the enclosure should be sealed as tightly as possible. Eliminate site where pest live decreases their reproduction rate. If traps are used, they should be frequently inspected to remove the living animals. The use of poison should be used with a great caution because the capuchin monkeys sometimes predate small rodents (Veeman, 2003).

g) Quarantine & introduction

Quarantine is the separation of the incoming animals from the group already present in the zoo. It is essentially intended to prevent introduction of diseases, to protect capuchin and personnel of the receiving zoo (Fortman *et al.*, 2018 & Veeman, 2003). Quarantine in capuchin monkeys are similar to those for other primates. Duration could range 30-90 days (Fortman *et al.*, 2018 & Honeysett, 2006). Only the caretakers that provides maintenance and medical care should have access to the animals in quarantine. The visits by any other person should be restricted at the minimum and only for important reason.

The general principles of quarantine are separation of capuchin in quarantine and adequate personal protective equipment (Roberts and Andrews, 2008, Fortman *et al.*, 2018 & Veeman, 2003). The cages should be totally sealed from the external environment and cleaned daily. The quarantine

facility should be separated from the conditioned group as much as possible. Cleaning tools, food bowls and other equipment should not be shared between the quarantine and any other sector in the zoo. The cages and equipment must be thoroughly sanitized after the quarantine. It is better that the quarantine staff should be different from the staff that takes care of the group. It is also better if the quarantine is the last area cleaned by the staff. The keepers should wear protective clothing like a long-sleeved disposable gown, rubber boots or shoe covers, disposable gloves, a mask, a head cover and safety goggles. Coveralls should be laundered when dirty and after the animal leaves the quarantine.

Several tests must be performed before the introduction in a group of capuchin monkeys, such as tuberculin skin tests, faecal examination and all necessary test to assess the health of the capuchin. These tests should be performed by the shipping institution for practical reason. 71% of EAZA zoos perform faecal examinations when arrival and departure of a capuchin (Figure 32).

The Council Directive 92/65/EEC, also called "BALAI" directive, gives the conditions of trade and import of non-domestic animals of holdings approved by competent authorities. In Europe, zoo that are approved under the importation of live animals "BALAI" directive can introduce primates without a previous quarantine if they are transferred from another Balai-approved institution (Perpiñán *et al.*, 2017). The trade of primates between two approved facilities in European Union is authorised with only a veterinary certificate (TRACES or TRAde Control and Expert System) ensuring the good health of the primate. When a primate is transferred from a non-approved holding to an approved one, an official quarantine of at least 30 days is required by the minister of the receiving country.

h) Infirmary

Although it is not often possible to separate a capuchin monkey from his group because of the risk of aggression at reintroduction, very sick capuchin monkeys could be hospitalized in a hospital, well-separated from the quarantine, to avoid contamination of healthy capuchin monkeys and to ease access to medication. It should be seen at least twice a day. All animals that are suspected to suffer from an infectious disease should be isolated from the group.

i) Mixed-species exhibits

The capuchin monkeys are sometimes presented in a mixed exhibit. There are several general considerations to avoid transmission of disease to aberrant hosts (Fortman et al., 2018). It is strongly recommended to never mix New World monkeys like capuchin monkeys and Old World monkeys. Curative and preventive veterinary care should be regularly done to monitor cross-contamination (Veeman, 2003). Capuchin monkeys are sometimes mixed with squirrel monkeys in captivity, and they form regularly group together in the wild. Association with black-headed uakaris, white sakis, bearded sakis, woolly monkeys, spider monkeys and howler monkeys were also observed in the wild (Veeman, 2003). From a sanitary point of view, knowing the fact that herpesvirus saimiri 1 (HVS1) has no pathogenicity in the capuchin monkeys (Rabin, 1975), there is no objection to the mix of these two species of New World monkeys. However, the herpesvirus saimiri 1 is highly pathogen in marmosets, tamarins and owl monkeys (Eberle et al., 2017, Fortman et al., 2018 & Kaandorp, 2012). Thus, the capuchin monkeys, considered as potential asymptomatic carrier, should not be mixed with these species. It is possible to mix capuchin monkeys with other South American species (Honeysett, 2006) like spider monkey (*Ateles sp.*), howler monkey (*Aloutta sp.*), woolly monkey (*Lagothrix sp.*), saki (*Pithecia sp.*), capybara (*Hydrochoerus hydrochaeris*), coati (*Nasua sp.*), giant anteater (*Myrmacophagia trydactylus*) and Brazilian Tapir (*Tapirius terrestrius*).

However, the caretaker should be very cautious about the interspecific interactions. It is generally not easy to mix capuchins with other species because they can be aggressive (Veeman, 2003). Capuchin predation on *Callicebus sp.*, *Aotus sp.*, *Callitrichidae*, birds, bats, marsupials, rodents and squirrels have already been described in the wild (Buchanan-Smith, 2012 & Veeman, 2003). Cases of larger New World monkeys like howler or spider monkeys that attacked capuchin monkeys are reported (Honeysett, 2006).

j) Cortisol as measurement of well-being

Faecal cortisol measures are recommended as a non-invasive technique to monitor the psychological well-being of brown capuchins in captivity (Boinski *et al.* 1999). The plasma cortisol is more precise but invasive.

3) Overview of diseases in capuchin monkeys

a) Mortality of capuchin monkeys in European zoos

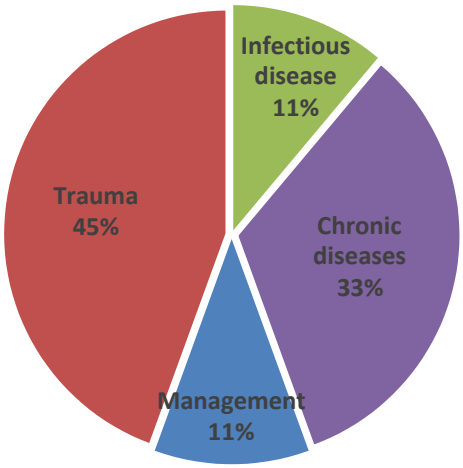


Figure 36: Mortality of capuchin monkeys in EAZA zoos (n = 5 respondents) according to the BPGQ

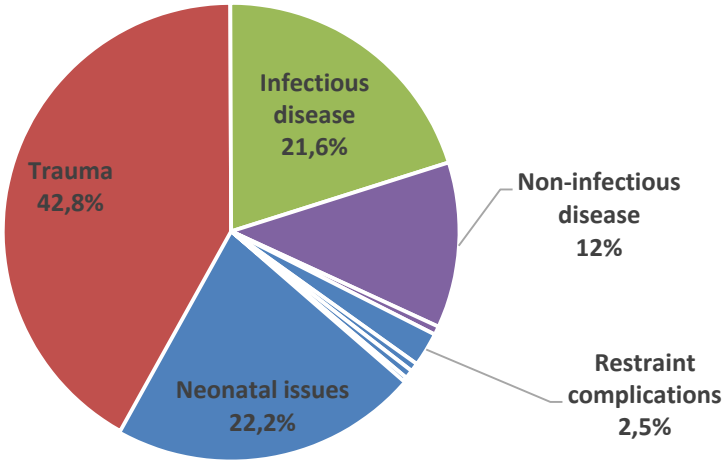


Figure 37: Mortality of capuchin monkeys (n = 325 animals) in zoos according to ZIMS (2018)

According to the BPGQ and to ZIMS (2018), the mortality of capuchin monkeys in captivity is highly explained by traumatic injuries, respectively 45% and 42,8% (Figure 36 and 37). The second reason of mortality capuchin monkeys is the management issues (11% according to the BPGQ). Neonatal issues, parental neglect, restraint complications, transfer complications and environmental issues are conditions that can be considered as management issues and represent 24% of the mortality according to ZIMS. Infectious diseases are not the main reason of mortality and account for 11% of deaths according to the BPGQ and for 21% according to ZIMS (2018). Non-infectious and chronic diseases account for 33% of the mortality according to the BPGQ and for 12,6% according to ZIMS (2018). These results confirm that a good husbandry and management are necessary to reduce the mortality of capuchin monkeys in EAZA facilities.

b) Diseases by system in capuchin monkeys in EAZA zoos

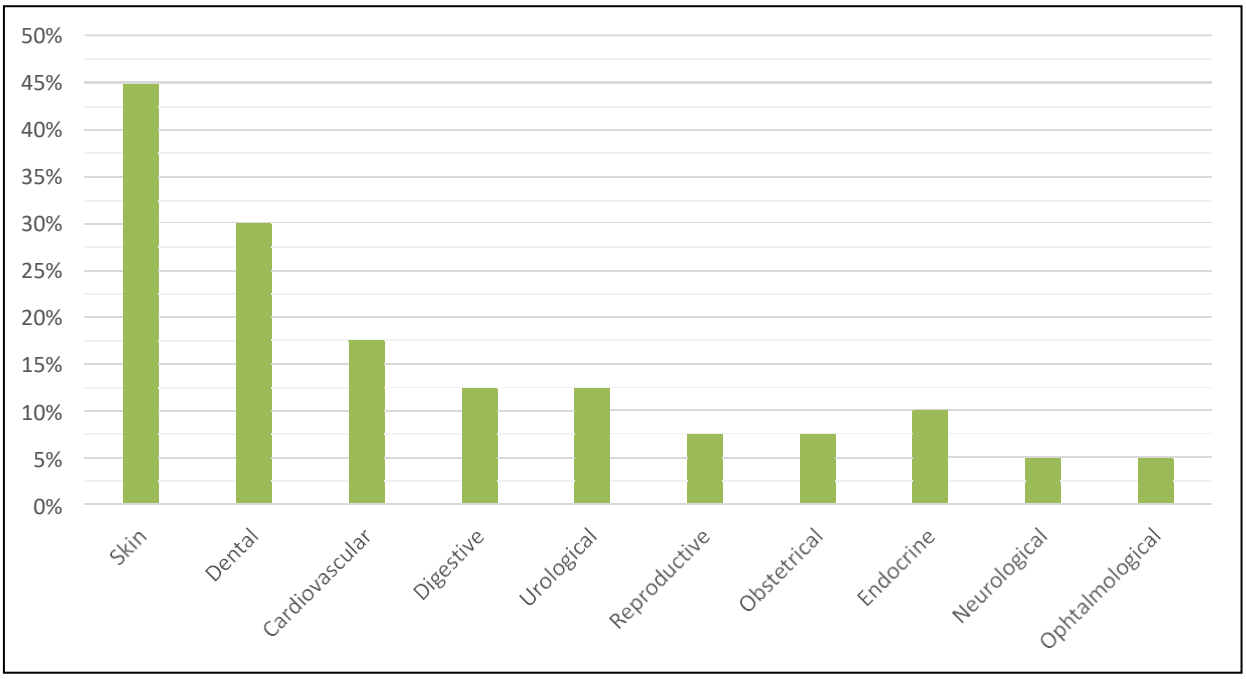


Figure 38: Frequency of diseases (infectious and non-infectious combined) by system in capuchin monkeys in EAZA zoos (n = 40)

Skin is the main system affected by diseases in capuchin monkeys with 45% of affected EAZA zoos (Figure 38), related to the elevated percentage of trauma. Capuchin monkeys are also highly sensitive to dental diseases (30%). Then, cardiovascular, digestive and the urogenital diseases are frequent in these species. Endocrine, neurological and ophthalmological diseases are rarer diseases.

4) Non-infectious diseases

a) Traumatic injuries

45 % of the mortality is explained by traumatic injuries according to the BPGQ, and 43% according to ZIMS. Wounds due to intraspecific aggressions are common in capuchin monkeys, that have sharp canines. Fight wound trauma are one of the most frequent causes of morbidity in nonhuman primates housed in social groups (Abee *et al.* 2012). Fight wounds may consist of lacerations, bruises, abrasions, punctures or crushing injuries, commonly localized in the face, the tail

and the extremities of the limbs. Wounds can be lethal when thoracic cage is perforated, when a major blood vessel is severed, when haemorrhages are massive, when a massive release of myoglobin causes acute renal failure or when wounds are contaminated by purulent bacteria, gangrene or tetanus.

The treatment of these wounds is the same as in domestic animals. The holder should understand the hierarchy of the capuchin monkeys to manage the group and to prevent the traumatic injuries (Perpiñán, 2017). Capuchin monkeys are actually social animals with frequent aggressions. Sometimes, the lowest-ranking individual can become the target of repeated aggressions. To reduce the consequences of social aggressions and so traumatic injuries, it should be ensured that subordinates have adequate access to resources and facilities should be designed so that the rejected animal cannot easily be trapped during aggression. Veterinary treatment like anaesthesia should be shorter as possible. The reintroduction method should be respected (see part 7.6.b. Anaesthesia). Removal is not always possible because of several drawbacks: the individual is isolated and he could not reintegrate the group. The holder has to deal with the physical and social health of the victimised individual and with the constraints of managing a social group of capuchins in the facilities (Anderson, 2010).

Fractures and dislocations are also common, because of the nervous nature of the capuchin monkeys (Perpiñán, 2017). The housing should be adapted to avoid the risks of hurts. The keepers should be cautious of the tail of the animals when closing a trap. When housing on islands, it is better to install electrified fence to decrease the risk of drowning.

b) Skin pathologies

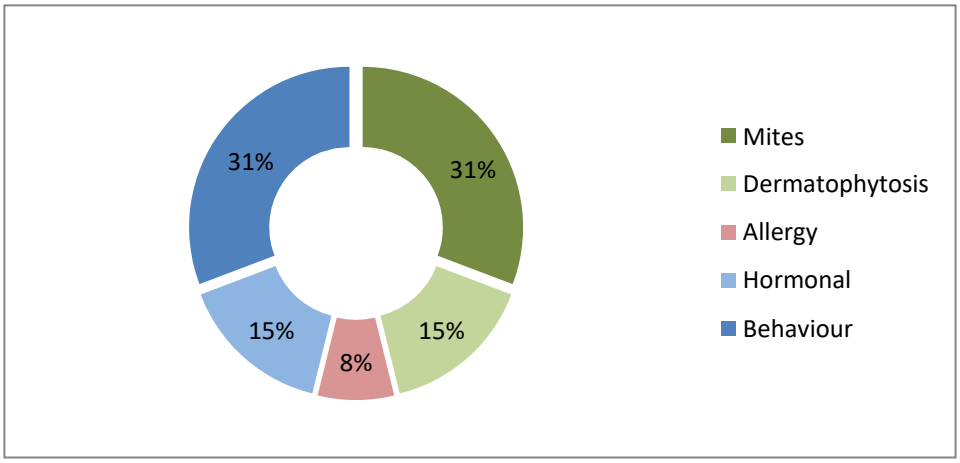


Figure 39: Aetiologies of skin pathologies in EAZA zoos (n = 13)

Skin pathologies are highly prevalent in EAZA zoos, with a percentage of 45% institutions that have been confronted to these pathologies according to the BPGQ (Figure 38). Half of these conditions are non-infectious conditions.

31% of the skin pathologies in EAZA are behavioural (Figure 39). The causes of these diseases are diverse and sometimes not fully understood. The most common cause of local alopecia in nonhuman primates in captivity is the behavioural stress due to overgrooming (Bernstein, 2009). Inadequate environmental and social conditions can induce self-mutilation (Littlefield, 2009). A suitable enclosure, adequate veterinary care and physical and social enrichments are necessary to decrease these behaviours. Skin lesions can appear following abnormally high frequencies of scent marking. There must be sufficient scent absorbing materials (few perches and branches) left in the

enclosure to retain scent-mark secretions. Indeed, cleaning too often will disrupt scent marking (Abee et al., 2012 & Veeman, 2003).

One EAZA institution reported a seasonal alopecia in the late summer in all capuchins and one other a self-limiting alopecia during pregnancy. This latter could be explained by the effect of steroid hormones on folliculogenesis.

A suspected case of allergy was successfully treated with antihistamines and then corticosteroids.

c) Dental diseases

Dental diseases are common in capuchin monkeys, with a prevalence of 30% according to the BPGQ (Figure 38). The main issues were carries and dental abscesses. The canine teeth are the main affected site reported in the BPQG, with calculus accumulation, abscesses and even fractures. Moreover, it seems that the dental problems are underestimated by the holders. Fecchio et al. (2008) studied the oral cavity of 34 capuchin monkeys in captivity in Brazil. 72% of the animals presented dental calculus. The periodontal disease was very widespread among these capuchins: 66% showed gingivitis (erythematous or oedematous gingiva), 18% gingival retraction. The teeth were fragile with dental absence in 28% capuchins, fracture in 27%, dental mobility in 26%, dental wear in 16%. This study showed the poor dental health of capuchin monkeys in captivity and warned professionals about the importance of a good dental prophylaxis including good nutrition. Other studies have found similar results (Hillson, 1991 & Costa et al., 2012). Gingivitis and periodontitis were associated with black-pigmented Gram-negative anaerobes (Porphyromonas and Prevotella) in capuchin monkeys (Gaetti-Jardim Jr, E., *et al.* 2012.).

Dental radiographs are useful for the application and the monitoring of the treatment (Fecchio et al., 2008). The treatment of the periodontal disease is the scaling or calculus removal, with sonic or hand scalers. The cleaning of the subgingival space is particularly important. Extraction is required when the tooth has lost its supporting tissues (end-stage of periodontal disease), is fractured or decayed. An endodontic treatment is possible when only the dental pulp, the internal portion of the tooth, is injured. Antibiotics are required when there are signs of general infection, and change in diet is recommended if the prevalence of dental diseases is high.

d) Cardiovascular diseases

Cases	Treatment
Heart murmur/Cardiomegaly with pulmonary oedema	Furosemide (Dimazon®) 2mg/kg q12h 3 days then 1 mg/kg q12h 7 days Now on Benazepril (Nelio®) 2,5 mg SID ad vitam
Heart murmur with no physical repercussion	Treatment not useful
Cardiomegaly with pulmonary oedema	Torasemide (Upcard®) 0,75 mg SID PO & Enalaprid (Enacard ®)0,5 mg SID PO
Myocarditis/Right heart failure	Necropsy findings
Senile Cardiomyopathy	Propentofylline (Karsivan®)

Figure 40: Aetiologies and established treatments of reported cardiovascular diseases in EAZA zoos (BPGQ)

17,5% of EAZA zoos have cardiovascular diseases in their capuchin monkeys. Chronic right heart failure with cardiomegaly seems to be the most common cardiovascular disease in old capuchins. A pulmonary oedema could be associated. Cardiovascular diseases such as cardiomyopathy and myocarditis were described in old capuchin monkeys (Courtney, 2013). Several cases successfully managed were reported by the EAZA institutions in the BPGQ (Figure 40). Further researches are needed to fully understand the specificity of heart diseases in capuchin monkeys.

In a study (Alves *et al.*, 2012), the radiography of the thoracic cavity in Cebus apella revealed easy to perform, enabling visualisation of the lungs and heart. Similarities with dogs and cats were described, and the values are available (Alves *et al.*, 2012). Echocardiographic examination in capuchin monkeys is possible and the parameters are well correlated with those of domestic species (De Souza *et al.*, 2018 & Larsson *et al.*, 2012). They have a small cardiac muscle mass, therefore the values of waves duration and intervals and the amplitude of the QRS complex are lower (De Souza *et al.*, 2018 & Larsson *et al.*, 2012).

e) Digestive diseases

The digestive diseases are frequent in capuchin monkeys (12,5% of EAZA zoos but maybe underestimated). There are three main aetiologies of diarrhoea in capuchin monkeys in captivity: infectious diseases (see part 7.5.b. Infectious digestive diseases), diet-induced and stress-induced diarrhoea. One hepatic hemangiosarcoma has been described with an icterus and elevated hepatic enzymes.

Dietary change or indigestion is a common cause of diarrhoea, mostly caused by an excess of fruit in the diet or selective feeding (Perpiñán, 2017). A stressful event can cause an acute, of short duration but sometimes repeated episodes and self-limiting diarrhoea in primates (Perpiñán, 2017). If the animals lose weight, infectious causes of diarrhoea must be ruled out.

The nutritional diseases (vitamin C deficiency or scurvy or metabolic bone disease) were not reported. Indeed, these conditions are nowadays rarely observed in well-cared primates' colonies (Calle, 2015).

f) Uro-genital diseases

Cases	Treatment
Renal chronic disease	Benazepril (Nelio®) 2.5 mg SID/ (Lespedesia PA®) 100mg BID
Renal Amyloidosis	Necropsy findings

Figure 41: Aetiologies and established treatments of renal diseases in EAZA zoos (BPGQ)

The frequency of urological diseases 12,5% in EAZA institutions is intermediate (Figure 38). Reproductive diseases and obstetrical manipulations (C-sections) are reported by 15% of EAZA institutions. One case of genital bleeding during the pregnancy, with an hydramnios visualized by ultrasound have been reported, without repercussion on the gestation and the delivery.

Little is known about urogenital diseases in capuchin monkeys. A study describes the histopathological lesions of nephritides in *Cebus apella* (Borda, 1999). The authors report three cases of glomerulonephritis, a chronic interstitial disease and a chronic pyelonephritis. Carandina da Silva (2016) said that there are few reports about diseases of the urinary tract in the capuchins. A case of chronic renal disease was reported in the BPGQ and managed with benazepril (Figure 41).

The main reasons for C-sections are dystocia, pre-term births and twins. Six C-sections performed on 293 births were reported in the last decade. Delivery for primiparous female capuchins might be long and tiring (Anderson *et al.,* 2010) and C-sections are then necessary. Epidural

anaesthesia with lidocaine and possibly morphine or dexmedetomidine is safe and easy to perform in capuchin monkeys (Cordeiro, 2014 & Schäffer, 2017).

g) Endocrine diseases

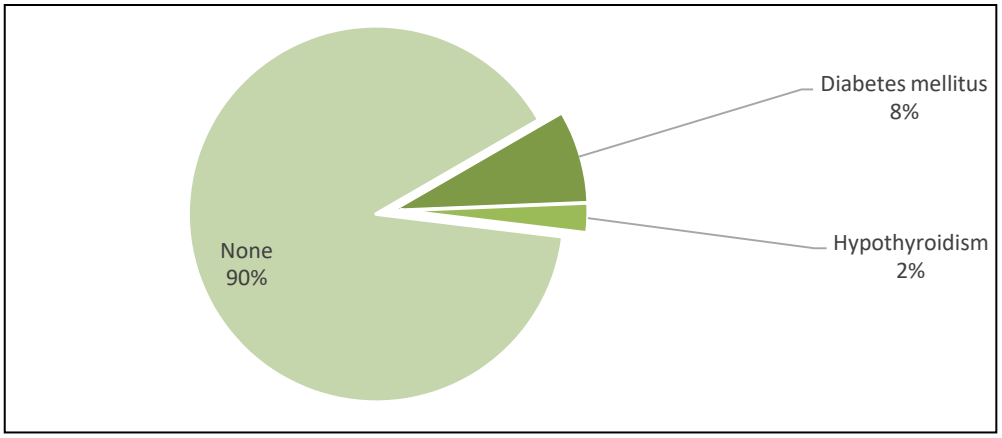


Figure 42: Endocrine diseases in EAZA zoos (BPGQ)

Endocrine diseases are rare in EAZA zoos (Figure 41). Four cases were reported, three diabetes and one hypothyroidism. To treat diabetes mellitus, the association of Metformin and Glimepiride has been used by EAZA zoos according to the BPGQ and seemed to be efficient. The type 2 diabetes mellitus is associated with obesity in captive capuchin monkeys (Hardwood, 2012) thus this is critical to monitor the weight of these animals. The diabetes mellitus in primates leads to death with the development of macrovascular diseases (atherosclerosis, thrombosis) or microvascular disease (diabetic nephropathy, vasculitides…).

h) Neurological diseases

One case of presume peripherical neuropathy of the hindlimb has been described in the BPGQ. Full recovery one month after the treatment based on antibiotics, SAID's and Vitamin B. One case of toxoplasmosis has also been reported in the BPGQ. Neurological diseases are not a big issue in captive capuchin monkeys.

i) Ophthalmological diseases

A case of cataract and a case of conjunctivitis were reported in the BPGQ. Ophthalmological diseases are not a big issue in captive capuchin monkeys.

5) Infectious diseases

a) Tuberculosis

Tuberculosis is an infection of nonhuman primates caused by a bacterium from the genera *Mycobacterium* (Calle *et al.*, 2015). The majority of cases in primates results from exposure to infected humans or Old World monkeys. The disease is contagious, usually transmitted by the inhaled aerosols between two individuals in regular close contacts. There are other ways of transmission (indirect contact by food, water or inert supports). Thus, tuberculosis is one of the most

important zoonotic disease encountered in capuchin monkeys. However, the incidence of tuberculosis has decreased thanks to the testing (tuberculin skin tests). Moreover, New World monkeys are more resistant than Old World monkeys (Abee *et al.*, 2012, Courtney, 2013 & Veeman, 2003).

The classical form of the disease is a chronic pulmonary disease, with granuloma into the lungs. The disease can involve a multitude of organ systems and atypical presentations exist depending on the affected system like digestive disease, osteomyelitis, cutaneous abscesses. Nonspecific signs such as chronic weight loss, diarrhoea and enlarged lymph nodes are earlier (Abee *et al.*, 2012). Late clinical signs are respiratory including exercise intolerance, persistent cough, exertional dyspnoea; digestive signs include diarrhoea, kyphosis, abdominal pain.

The diagnosis of the diseases is difficult. Regular skin tests are usually the first step in diagnosis (see part 7.2.c. Tuberculin skin testing) (Abee *et al.*, 2012). Chest radiographs can also be performed if there are suspect respiratory clinical signs. Nodules at the radiograph could indicate a granuloma and a tuberculosis. For a better resolution, a CT-scan of the chest can be performed.
Treatment of the tuberculosis is complicated, regarding the high incidence of the antimicrobial resistances and the high risks of the pathogen for humans and other primates (Abee *et al.*, 2012). Euthanasia is recommended most of the times. The fight against tuberculosis is principally based on the prophylaxis, e.g. tuberculin skin tests, quarantine and regular physical examinations.

For more information, please refer to the Guidelines for the prevention and control of tuberculosis in non-human primates edited by the European Primate Veterinary Association Working Group on Tuberculosis (Bushmitz *et al.*, 2009).

b) Infectious digestive diseases

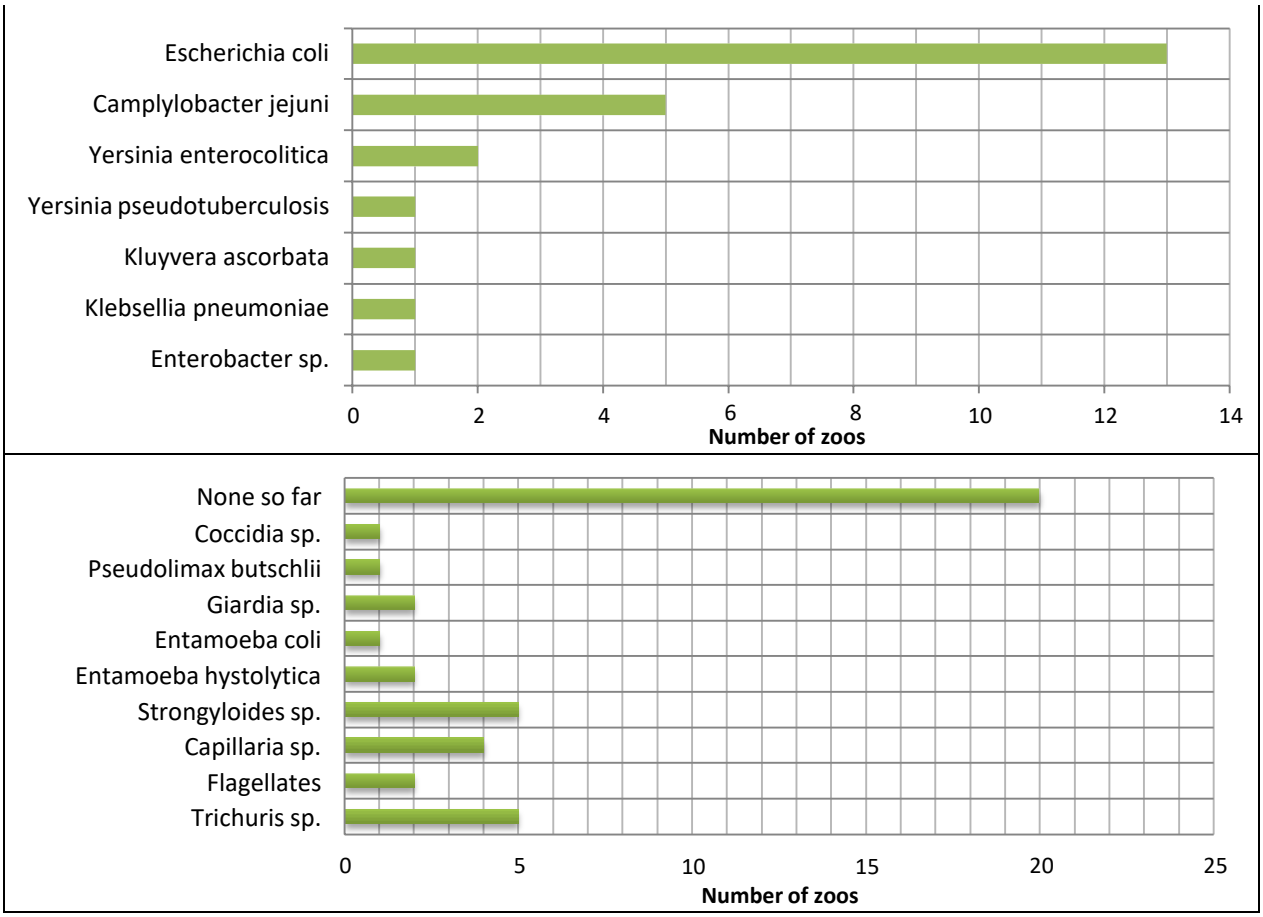


Figure 43: Bacteria and parasites classically found by EAZA institutions

According to the BPGQ, 62% of the EAZA zoos found bacteria during faecal examinations and half of zoos found various parasites (Figure 43). The most frequent isolated bacteria were *Escherichia coli* and *Campylobacter jejuni*, followed by *Yersinia enterocolitica*.

Infections by Gram-negative enteric bacteria or parasites are common in New World primates (Calle *et al.*, 2015, Perpiñán *et al.*, 2017 & Veeman, 2003). *Shigella sp., Campylobacter sp., Escherichia coli, Salmonella sp*. and *Yersinia enterocolitica* and *Yersinia pseudotuberculosis* are the main bacterial pathogens of the gastrointestinal tract in nonhuman primates. *Shigella* is one of the most identified causes of diarrhoea in nonhuman primates, especially in *Cebus albifrons, Cebus apella* and *Cebus capucinus* (Honeysett, 2006), although it was not reported in the BPGQ. *Campylobacter* is more frequent in New World monkeys (Calle et al., 2015). Sometimes there are asymptomatic carriers, source of infection for other primates. All bacterial diarrhoeas are similar (Honeysett, 2006): the clinical signs classically include diarrhoea sometimes watery or bloody, depression, anorexia and dehydration. The diagnosis is based on clinical signs and isolation of the bacteria.

The treatment of bacterial gastroenteritis is based on supportive care (like intravenous fluids), and only when the disease is not self-limiting, on post-antibiogram chosen antibiotics. One case due to flagellates was successfully treated with metronidazole 50mg/kg/day during 3 days. One case infected by Strongyloïdes sp. was successfully treated with fenbendazole 50 mg/kg/day during 5 days. Those pathogens are transmitted by the faecal-oral route between nonhuman primates, so the faeces, contaminated food or water, rodents are the main sources of infection (Honeysett, 2006 & Veeman, 2003). That is the reason why sanitation and hygiene are very important in prevention of these bacterial gastrointestinal diseases.

The endoparasites include many different types of protozoa, roundworm, hookworm and tapeworm (Calle *et al.*, 2015 & Littlefield, 2009). The early clinical signs of gastrointestinal infestation are changes in faeces such as diarrhoea, constipation, change in colour, presence of blood. The clinical signs of parasites' infestation are chronic contrary to the bacterial gastrointestinal infection. They include an anorexia or in contrary an increased appetite associated to weight loss, itching of anal area, lethargy, abdominal pain. The infestation by endoparasites is diagnosed by examination of faeces. Treatment consists generally in a broad spectrum anthelminthic, preferentially delivered after a positive test result of faecal examination. Like bacterial digestive diseases, the parasitic digestive diseases are transmitted by the faecal-oral route. The good hygiene practices such as daily removal of faeces and food, daily cleaning are important parameters to take into account in prevention. A low level of infection with gastrointestinal protozoa is often present in captive nonhuman primates, but rarely a cause of clinical disease. The intestinal protozoa do not need not to be treated unless there is associated clinical signs.

c) Skin diseases and external parasites

External parasites account for about the half of skin diseases (Figure 39, in green colour). There are many ectoparasites that affect capuchin monkeys such as fleas, lice, mites and ticks (Calle *et al.*, 2015 & Littlefield, 2009). There is a wide range of skin parasites and 31% of skin pathologies were caused by mites and 15% by dermatophytosis. The principal clinical signs are itchiness or scratching, alopecia, overgrooming, dermatitis. The dermatological diseases are generally detected early because of their obvious aspect. In case of severe disease, lethargy, weakness, anorexia, dehydration or weight loss could be observed. The diagnosis is based on skin scrapings and scotch test. The treatment consists in parasiticide (malathion, pyrethrin, ivermectin) depending on the infection. Cases of external parasites or fungus reported in the BPGQ were successfully treated with the suited treatment (ivermectin against mites, enilconazole against dermatomycosis). One case of allergy was successfully treated by antihistamine and corticoids.

d) Viral diseases

On the particpating 38 EAZA zoos, none have been confronted to general viral disease on their capuchins (Annex 4). It is surprising to notice that none of the participants have ever been confronted to general viral diseases compared to the serological data of the BPRC (Biomedical Primate Rescue Centre).

Among the herpesvirus of nonhuman primates, the capuchin monkeys are very sensitive to herpes B virus, an alpha herpesvirus (Calle et al., 2015). Although lethal infections have been reported, a colony of capuchin monkeys presented persistent but asymptomatic infection by the herpes virus B (Abee *et al.*, 2012 & Honeysett, 2006). They are asymptomatic reservoir host for the *Saimiriine* Herpesvirus 1 (also called herpesvirus T or tamarinus). One capuchin monkey was positive in serology and PCR for the HHV1, Human herpesvirus-1 (or herpes simplex). HHV1 is a common infection of humans (cold sore) and produce similar disease as *Saimiriine* Herpesvirus 1 in capuchin monkeys. Both viruses provoke similar clinical signs: usually, the capuchin monkeys do not develop clinical signs of infection, but occasionally oral ulcerative lesions anorexia, dehydration and depression are reported (Fortman *et al.,* 2018). Both viruses are lethal for owl monkeys and callitrichids (Abee *et al.*, 2012, Calle, 2015, Honeysett, 2006, Littlefield, 2009 & Rabin, 1975).

One third of the capuchin monkeys were positive to CMV. CMV or cytomegalovirus is a common infection of mammals, principally transmitted by rodents (Abee *et al.*, 2012 & Littlefield, 2009). The disease is generally asymptomatic but can result in a myocarditis then a sudden death and there is no treatment available. The control of rodent infestation is the most effective way to control the spread of the virus.

6.6% had antibodies anti-HAV (hepatitis A), which is low compared to other studied populations (Setzer *et al.*, 2014). A study of Setzer *et al.* (2014) suggests that the hepatitis A virus circulate among capuchin monkeys that are frequently in contact with humans, but not in free-ranging capuchin monkeys. Authors also suggests that the transmission of this pathogen in captive capuchin monkeys is explained by the oral-faecal transmission and the behaviour of these species, which spend a lot of time on the ground with contaminated food or object. The infection is usually inapparent but can induce jaundice (Honeysett, 2006). No individual was positive for the hepatitis B virus, one of the most important human pathogens that causes liver cirrhosis and hepatocellular carcinoma without possible cure (Souza *et al.*, 2018). A novel hepadnavirus called “capuchin monkey hepatitis B virus” (CMHBV), was described by Souza *et al.* (2018) in five wild capuchin monkeys. All were apparently healthy.

Exposure to rabies antigens in 4 on 22 capuchins is very hard to explain, but maybe the result of previous immunisation.

Polyomaviruses are a common latent infection in Old World Primates (Abee *et al.*, 2012) and 29,4% of the capuchin monkeys were seropositive.

The capuchin monkeys exhibited no infection by the retrovirus SIV, STLV-1, SRV, but two individuals were positive for foamy virus SFV. These viruses are the only exogenous retroviruses that have been identified in New World Monkeys, but no one presented clinical signs (Muniz *et al.*, 2013). Moreover, these viruses are rare in zoo collections (Calle et al., 2015).

One individual was positive for POX virus, but the infection seems localized in primates (Abee *et al.*, 2012).

A serological survey (Oliveira-Filho, 2018) showed presence of antibodies against flaviviruses in South America but it is not an issue in European countries. Moreover, capuchin monkeys seem to be the most resistant monkey to yellow fever virus infection (Calle et al., 2015 & de Oliveira-Filho, 2017).

To conclude, these results suggest an abnormal circulation of pathogens between the captive capuchin monkeys and humans, and between the captive capuchin monkeys and Old World

monkeys. It is important to remember that the contacts between capuchin monkeys and Old World monkeys or some New World monkeys (owl monkeys or callitrichids) are risky, and that the pathogenicity of these infections is not completely understood yet.

e) Infectious respiratory diseases

4 on 21 capuchin monkeys were seropositive to Influenzavirus type A (see Annex 4). Capuchin monkeys are only susceptible to this influenza virus (Calle *et al.*, 2015 & Veeman, 2003). It is highly contagious and transmitted by aerosols. The clinical signs are a febrile syndrome with fever, anorexia, depression, lethargy, but also nasal discharge, conjunctivitis and coughing. The infection by influenza could be complicated by bacterial infections, such as *Bordetella bronchiseptica, Klebsiella pneumoniae*, and *Pasteurella sp.* In this case, a supportive treatment and antimicrobials should be given.

No capuchin was infected by the RSV (respiratory syncytial virus). The virus is highly contagious, transmitted by aerosols. (Veeman, 2003) The capuchin monkeys are infected by humans, but the contrary is rare. The disease is usually mild with anorexia and non-specific upper respiratory signs, such as coughing, sneezing and mucopurulent nasal discharge. The treatment is supportive.

Pneumonia is frequent in nonhuman primates (Courtney, 2013). However, pneumonia is more prevalent in Old World than New World monkeys (Fortman *et al.,* 2018).

f) Toxoplasma

One case of toxoplasmosis associated with neurological signs has been reported in the BPGQ (See part 7.4.h Neurological diseases). New World monkeys are very susceptible to toxoplasmosis (Perpiñán *et al.*, 2017). The disease is transmitted by cysts in infected bird or rodents or oocysts in cat faeces or contaminated food (Honeysett, 2006). The clinical signs are anorexia, lethargy, depression, fever, diarrhoea, coughing, tachypnea, dyspnea, ocular and nasal discharge or epistaxis. There are neurological signs such as circling, grasping, incoordination, paresis, convulsions. In acute toxoplasmosis, death may occur in 3-21 days post-infection, sometimes without warning signs. The lesions are a respiratory failure with a pulmonary oedema, splenomegaly, hepatomegaly, mesenteric lymphadenopathy and disseminated haemorrhages. The serology helps to confirm the suspicion, and histology is the gold standard. The treatment consists in antibiotics. Freezing the meat decreases the parasitic load and cat population control prevent from toxoplasmosis.

g) Hemoparasites

Wild capuchin monkeys can be affected by many haemoparasites, which is not the case in European zoos (except for imported animals). *Plasmodium sp.* is the agent of Malaria that cause anaemia. *Trypanosoma cruzi* is responsible of Chagas Disease (Honeysett, 2006). Capuchin monkeys are reservoir hosts. It is a blood parasite, which causes oedema, anaemia, lymphadenitis, depression, anorexia, weight loss and dehydration. The diagnosis is based on blood smear, serology and histology. Unfortunately, there is no treatment or this disease.

6) Clinical techniques

a) Identification

The identification method used for the capuchin monkeys is the same as for any other primate in EAZA zoos. A small radio frequency microresponder, also called implantable transponder or microchip (Abee et al., 2012 & Veeman, 2003). They are small sealed cylinders of a few millimetres, that are permanently implanted subcutaneously between the shoulder blades (Figure 44) and that give a coded digital signal if activated by a radio transmitter.

Figure 44: Microchip implantation in a young yellow-breasted capuchin (®Mulhouse Zoo)

b) Anaesthesia

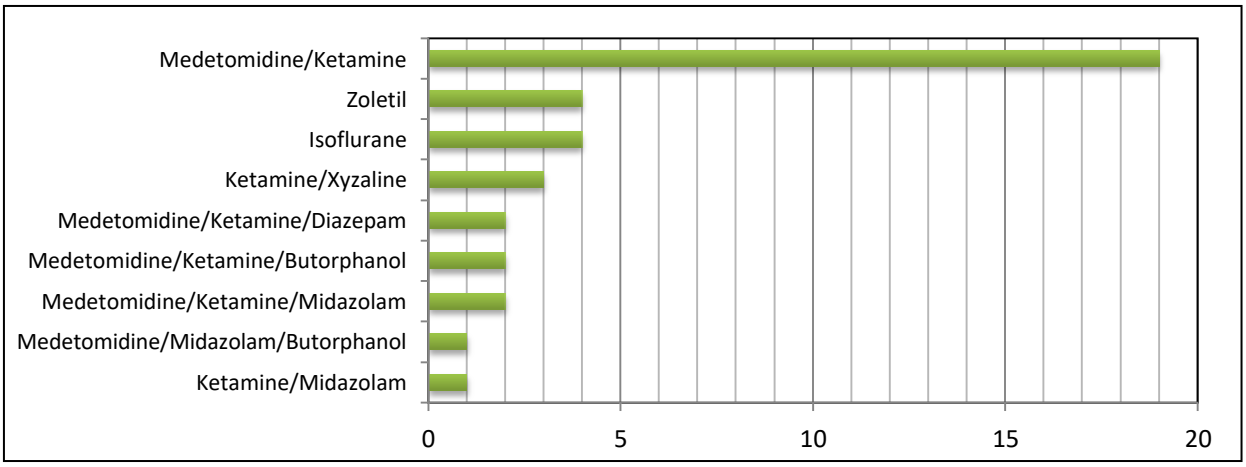


Figure 45: Overview of immobilization protocols used in EAZA zoos

- Inhalation anaesthesia

According to the BPGQ, inhalation anaesthesia with isoflurane is not the most frequent method in capuchins in EAZA zoos (10 %). This is really surprising because isoflurane is considered as the safer, the easier and the best way to induce small primates for short anaesthetic procedures. Isoflurane is

commonly used for induction with a facemask on a manually restraint capuchin monkey or with an induction box for a trained capuchin (Figure 45), and then for maintenance in an intubated individual.

Figure 46: Yellow-breasted capuchin in induction box (®Mulhouse Zoo)

The inhalation anaesthesia with isoflurane revealed efficient and sure in capuchins monkeys. The isoflurane is eliminated by the expired air, so it has a fast reversibility (Ølberg, 2014). Another advantage is the supply of pure or concentrated oxygen as a carrier gas, that prevent severe hypoxemia due to anaesthetics (Ølberg, 2014). If inhalants have dose-dependent cardiovascular effects as in other species, in capuchin monkeys these cardiovascular effects are lower (Vasconcellos, 2000). Indeed, with the inhaled isoflurane concentration increasing, the heart rate decreases but the arterial blood arterial pressure is constant. There is a dose-dependent effect in tidal and minute volume, whereas respiratory rate is constant. The pH, the blood gazes, the oxygen saturation are also constant. However, some individuals can present apnoea during this induction protocol.

The use of isoflurane for short procedures is the recommended way to anaesthetise the capuchin monkeys in routine. The medical training is recommended to induce the capuchin monkeys with minimal stress.

- Injectable anaesthesia

Physical restraint is unfortunately necessary to give the injectable anaesthetics to the capuchin monkeys, because darting is very risky (see section 6.2. Capture, Immobilization and transport). In the wild, where capture is not possible, darting is necessary to anaesthetise the animal for a medical examination (Ølberg, 2014 & Vnuk, 2009). Nevertheless, the use of projectile syringe

for captive capuchin monkeys is not recommended. Darts have some disadvantages including stress, pain and sometimes traumatic injuries. Moreover, the capuchin monkeys can be difficult to hit (Ølberg, 2014). They have small target areas and they are good jumpers and runners; therefore, they can easily dodge the darts. Medical training is strongly recommended to decrease the stress of a capture and so the risks at induction.

Drug	Dosage(mg/kg)	Reversal Agent
Ketamine	4-10	None
Medetomidine / Ketamine	0.04-0.10 / 4-10	Atipamezole
Xylazine / Ketamine	0.5 / 5-10	Yohimbine (Atipamezole)
Midazolam / Ketamine	1 / 10	Flumazenil
Medetomidine / Midazolam / Ketamine	0.02-0.05 / 0.2-0.4 / 10	Atipamezole / Flumazenil
Medetomidine / Midazolam / Butorphanol	0.03 / 0.2-0.4 / 0.02	Atipamezole / Flumazenil
Tiletamine - zolazepam	4.4	None
Diazepam (PO 1h before) / Medetomidine / Ketamine	0.35 0.07 / 7	Atipamezole

Table 10: Injectable protocols used successfully to anaesthetize capuchins (BPGQ & references in the text)

#	Drug Protocols	DOSAGE				COMPLICATIONS			Abnormal Recovery	Died in Recovery	Multiple Issues	Anesthesia Events	Body Weight Range (kg)
		Mean	Median	Range	Units	Minor	Major	Fatal					
1	Ketamine	3.66	3.53	3.00 - 6.78	mg/kg	1 (0.76 %)	0 (0.00 %)	0 (0.00 %)	0 (0.00 %)	0 (0.00 %)	0 (0.00 %)	132 (8) Animals	1.10 - 4.70
	Medetomidine	0.037	0.035	0.030 - 0.07									
2	Dexmedetomidine	0.022	0.022	0.017 - 0.032	mg/kg	1 (4.00 %)	0 (0.00 %)	0 (0.00 %)	4 (16.00 %)	0 (0.00 %)	1 (4.00 %)	25 (8) Animals	1.00 - 4.50
	Ketamine	4.35	4.32	2.56 - 6.10									
3	Ketamine	18.53	20.04	2.20 - 33.33	mg/kg	1 (2.78 %)	0 (0.00 %)	0 (0.00 %)	1 (2.78 %)	0 (0.00 %)	1 (2.78 %)	36 (16) Animals	1.00 - 4.54
4	Ketamine	10.89	10.43	5.00 - 19.23	mg/kg	1 (5.00 %)	0 (0.00 %)	0 (0.00 %)	1 (5.00 %)	0 (0.00 %)	0 (0.00 %)	20 (9) Animals	2.60 - 4.31
	Midazolam	0.15	0.12	0.05 - 0.40									

Table 11: Overview of injectable protocols used in 30 white-throated capuchins (ZIMS, 2018)

Anaesthesia protocol of ketamine and medetomidine has been proposed at the dose of 0.03-0.06 mg/kg and 5-7 mg/kg (Perpiñán, 2017). The ZIMS institutions used the same range of doses except the dose of ketamine which was lower on average at 3-4 mg/kg (Table 11). The combination of medetomidine and ketamine administered intramuscularly at the dose of 0.15-0.20 mg/kg and 4 mg/kg provided safe, rapid and reproducible anaesthesia in captive capuchin monkeys (Theriault, 2007). These latter doses are extrapolated based on phylogenetic relationship, rather than body mass (Theriault, 2007). The combination of medetomidine and ketamine has the advantage of a quick and calm onset and a complete immobilization with the absence of corneal and pedal reflexes.

Indeed, the medetomidine allows an excellent muscle relaxation and analgesia, balances the undesirable effects of ketamine, decreases the required dose of ketamine and can be antagonized by atipamezole (Ølberg, 2014 & Theriault, 2007). The induction time is within 10 minutes of administration. The recovery is smooth and fast and capuchin monkeys can feed 9-75 minutes immediately after reversion, without nausea or vomiting (Ølberg, 2014 & Theriault, 2007). The disadvantage of the α2-agonists is their dose-dependent cardiovascular depressant effects (Ølberg, 2014).

Other alpha-2 agonists can be used with ketamine but it seems to be less efficient. Ketamine (15 mg/kg) and xylazine (0.5 mg/kg) induced poor muscle relaxation (Raposo, 2015) and the recovery was too fast (Ølberg, 2014). Medetomidine is a more selective, potent and specific α2-agonist than

xylazine (Ølberg, 2014). Ketamine (15 mg/kg) and dexmedetomidine (0.005 mg/kg) protocols allow excellent myorelaxation but the number of recovery incidents is high (Raposo, 2015 & ZIMS, 2018). Decreasing the dose of ketamine (5 mg/kg) and increasing the dose of dexmedetomidine (0.010 mg/kg) produces better and longer anaesthesia with good muscle relaxation and is preferable for cardiorespiratory stability in *Leonpithecus chrysomelas* (Selmi, 2004). Maybe this observation could be extrapolated for capuchins.

Opioid agonists are powerful analgesic agents, but they have a strong ventilatory depressive effects (Ølberg, 2014). Fentanyl induces respiratory depression at a low dose (2µg/kg). Butorphanol has also respiratory depression effects. Buprenorphine seems to be a safer molecule in monkeys.

Finally, combinations of a dissociative agent and a benzodiazepine were described in capuchins. Ketamine (10-15 mg/kg) and midazolam (0.5-1 mg/kg) revealed efficient in capuchins (Ølberg, 2014, Schäffer, 2017 & Raposo, 2015), with excellent sedation and excellent muscle relaxation. The induction time is 1 minute on average and the sedation time is 67 minutes on average (Raposo, 2015). The Tiletamine-Zolazepam protocol ensure a quick induction. The induction period is 1-12 minutes, with an average of 5 minutes in capuchin monkeys (Crofoot, 2009). A dose of 17.5 mg/kg, used in wild capuchins, induces deep anaesthesia (Crofoot, 2009). A dose of 5 mg/kg is sufficient to induce a light anaesthesia in captive capuchins, with good but not excellent muscle relaxation (Cordeiro, 2014 & Raposo, 2015). The issue with this protocol is that the prolonged recoveries are common and ataxia is sometimes observed (Ølberg, 2014 & Raposo, 2015). Practicing medical training with the capuchin monkeys in order to accept the induction or squeeze box is recommended rather than intramuscular injection by physical restraint or even darting (Figure 46).

- Maintenance and monitoring

Isoflurane is excellent for maintenance once induction is achieved (Ølberg, 2014). For all procedures, an endotracheal intubation should be performed (Ølberg, 2014). The tongue is gently pulled outwards to visualize the glottis with a laryngoscope. Then, the topical application of lidocaine on the glottis will reduce laryngospasm. The dose must not exceed 4 mg/kg. Care must be taken to the small length of the trachea in capuchin and a selective intubation that could easily be done. A cuffed tube ranging in size from 2.0 to 4.0 mm is usually appropriate for capuchins (Figure 47).

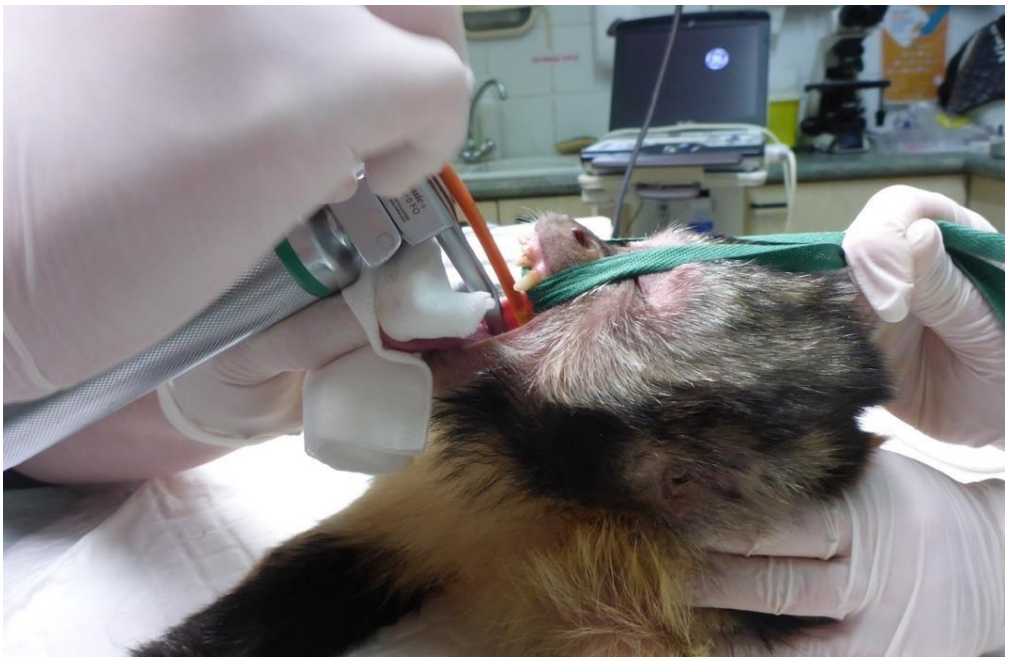


Figure 47: Endotracheal intubation in a yellow-breasted capuchin (®Mulhouse Zoo)

The capuchins are small primates with a high metabolic rate and a high ratio of superficial area to body mass, therefore they are very sensitive to hypothermia, hypoglycaemia, hypovolemia and dehydration (Ølberg, 2014 & Schäffer, 2017). Anaesthetics such as isoflurane and alpha-2 agonists cause a peripheral vasodilatation and depress the thermoregulation centre in the hypothalamus (Ølberg, 2014 & Schäffer, 2017). Moreover, inhalants as well as injectable anaesthesia lead to decrease in cardiovascular and respiratory systems in capuchin monkeys (Raposo, 2017 & Vasconcellos, 2000).

Thus, the rectal temperature, heart rate, respiratory rate, capillary refill time, mucous membrane colour, peripheral pulse, and airway should be monitored (Littlefield, 2009 & Ølberg, 2014). The use of a pulse oximeter, on the ear cartilage or on the tongue for example, is necessary to evaluate the oxygen saturation throughout the procedure (Figure 48).

Figure 48: Oxygen saturation and heart beat monitoring in a yellow-breasted capuchin (©Mulhouse Zoo)

The supply of supplemental pure or concentrated oxygen, the use of heating system like mat or hot water bags are also recommended.

- Recovery

The recovery should be cautiously monitored, in a quiet and confined space, without possibility to climb (Ølberg, 2014). Heat loss can be prevented by a towel or treated by a warming system. The individual should not be reunited with its group until he has fully recovered to prevent the aggression by the rest of the group or the fall in the enclosure (Ølberg, 2014).

c) Evaluation of the Body Condition Score

The body condition score is an excellent indicator of general health status (Fortman et al., 2018). Different scoring systems exist like a body condition scoring system that was developed on *Macaca mulatta* (Clingerman, 2005). A simple system is the palpation of the muscle around the lumbar vertebra (Littlefield, 2009). A normal body condition score (3), is when the lumbar vertebrae are slightly prominent, smooth and rounded, the lumbar muscle are deep, with few fats and the horizontal processes are detectable with firm pressure.

d) Injections, administration of treatments

Oral administration is a good way to give medications, because it does not require a restraint of the animal (Abee et al., 2012). It is often a challenge to entice a nonhuman primate to voluntarily consume the agent. The drug can be mixed with usual or palatability food, that will mask its flavour and appearance, like banana paste, peanut butter, apple sauce, yogurt or fruit juice. However, the capuchin monkeys can quickly learn how to leave the drug so it could be difficult to respect the compliance of the treatment. Thus, it is very encouraged to train the capuchin monkeys to voluntary take the drug.

Injectable administration of drugs ensures the compliance of the treatment. Intramuscular injections are a common route of administering drugs to nonhuman primates (Abee et al., 2012). Injections are done in the muscles of the cranial thigh, caudal thigh, deltoid, or the longissimus of the back. Injections into the caudal thigh muscles should be avoided especially in small nonhuman primates, because of the risk of damaging the sciatic nerve. The limit volume of an intramuscular injection in capuchin monkeys seems to be around 0.5 mL and around 1.0 mL for biggest males. The tip of the needle is placed deeply into the muscle. It is important to aspirate before injecting to ensure that the needle is not in a blood vessel and then to inject slowly. Subcutaneous way is very useful for repeated injections, especially with monkeys that were trained to accept injections (Abee et al., 2012). It is generally considered painless. The needle is inserted at a 45° angle into pinched up skin of the back.

The femoral vein is the site of choice for intravenous injection (Figure 49) (Abee et al., 2012 & La Salles, 2017). The saphenous vein is the site of choice to place a catheter in capuchin monkeys for rehydration (Perpinan, 2017 & La Salles, 2017). Indeed, in capuchin monkeys, the caudal saphenous vein is large, has a long course away of the joints and is stable. For very small or dehydrated capuchin monkey, an intraosseous catheter can be placed in the tibia (Perpinan, 2017).

Figure 49: Catheterization of the saphenous vein in a yellow-breasted capuchin (©Mulhouse Zoo)

e) Venepuncture

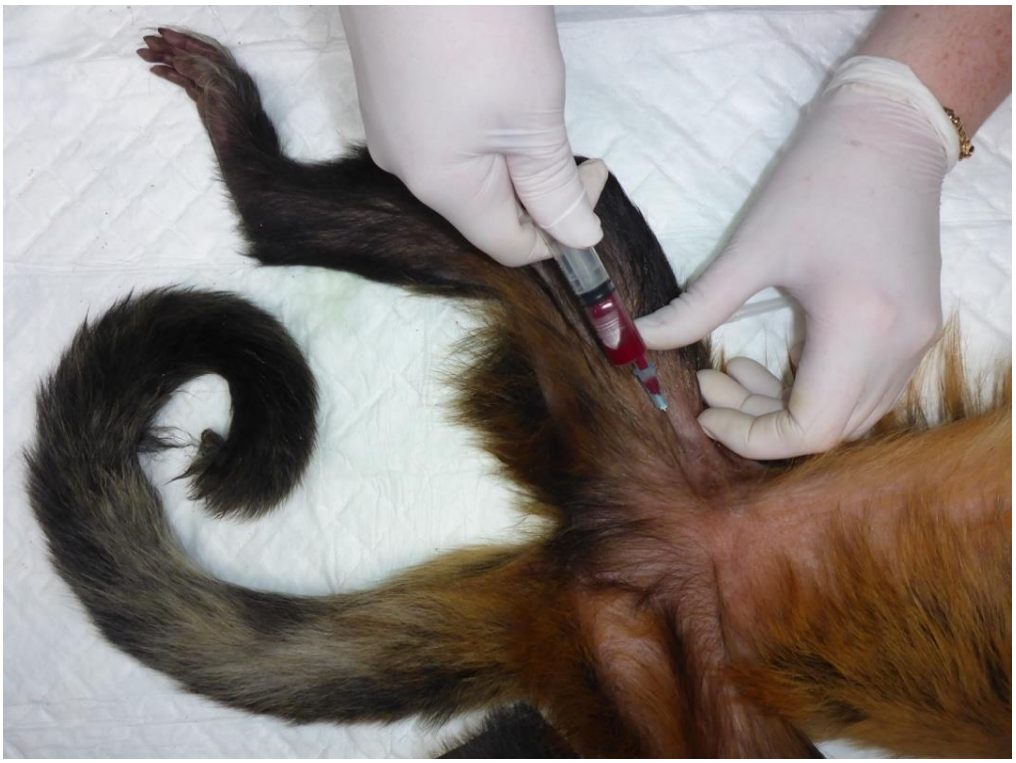


Figure 50: Venepuncture at the femoral vein (in the region of femoral triangle) in a yellow-breasted capuchin (®Mulhouse Zoo)

In capuchin monkeys as in other nonhuman primates, blood is usually collected from the femoral vein (La Salles, 2017, Perpiñan, 2017 & Veeman, 2003). The femoral vein has an adequate diameter, easy access location (in the femoral triangle) and is very stable. The animal is placed in dorsal recumbency with the hindlimbs in extension. The skin of the femoral triangle must be cleaned with 70% ethyl alcohol. A clean and gloved finger is placed in the femoral triangle to find the pulse of the femoral artery. A 0.4-0.5 mm diameter (25 or 27-gauge) needle mounted on a 1 ml or 2.5 ml syringe is inserted at a 30–60° angle to the skin with the needle bevel side up and a few millimetres medial to the pulse artery (Figure 50). Then, a slight negative pressure is applied to the syringe plunger until blood enters in the syringe. Blood is aspirated by applying gentle suction on the syringe plunger to avoid collapsing of the vessel. Immediately after withdrawing the needle, the vein should be compressed for at least 30 seconds to prevent the formation of a haematoma. If an arterial sample is unfortunately taken, direct pressure must be applied for a minimum of 5 minutes to obtain adequate haemostasis. A haematoma can be lethal in small animals. A maximum of 1 % of the body weight can safely be taken (around 10 mL/kg). If a large amount of blood is taken, the blood volume needs to be re-established by administering intravenous sterile saline at 2–3 times the lost blood volume.

Blood can also be taken from the saphenous veins, but these veins tend to collapse. The antebrachial veins are well developed in capuchin monkeys (Perpiñan, 2017). The brachial vein is preferred to the cephalic vein, which has small diameter and breaks easily (La Salles, 2017). The external jugular vein is divided in linguofacial and maxillary veins in around 40% of the capuchin monkeys (La Salles, 2017). In 60% of the individuals, it forms one vessel, it is short and very mobile. For these reasons, the external jugular vein is not suitable for puncture in capuchin monkeys.

f) Haematology and biochemistry

Haematological and biochemical values have been established for *Cebus apella* (Coote, 2005 & Nunez, 2007), for *Cebus capucinus* and for *Cebus albifrons* (ZIMS, 2018). However, it is known that the haematological and biochemical values are individual dependent. Blood test results should always be analysed regarding the previous values of the same individual (healthy at the time of the blood sample).

Ketamine anaesthesia disturbs some haematological and biochemical values like AST, LDH and CK that are elevated (Coote, 2005 & Nunez, 2007). Differences in sexes and ages were established by two studies (Riviello, 2001 & Nunez, 2007). Females had lower values of erythrocytes, haemoglobin and haematocrit than males. This could be attributed to menstruation. Liver aminotransferases ALT and AST activities, GGT and urea nitrogen were lower in males. Creatinine were lower in female. Pregnant females had significantly lower indicators of iron status and lower liver ALT and AST and LDH activities. Juveniles had higher values of haematocrit, haemoglobin and lymphocytes than adults and fewer neutrophils. Albumin and alpha-1 globulin parameters displayed lower values in adults, while alpha-2 and globulin in juveniles. The liver aminotransferases ALT and AST, alkaline phosphatase, glucose, calcium, inorganic phosphorus, CPK were higher in juveniles.

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Taxonomy : Cebus capucinus / White-throated capuchin
Sex Type : All Sex types **Age Grouping** : All Ages **Restraint Type** : All Restraint types

HEMATOLOGY

Expected Result Type	Test	Units	Reference Interval	Mean	Median	Lowest Data Value	Highest Data Value	Sample Size	Animals	Sample Type
Global sp RI	Red Blood Cell count (automated)	*10^12 cells/L	4.59 - 7.10	5.86	5.87	3.97	7.43	219	48	Whole Blood
Global sp RI	Red Blood Cell count (manual)	*10^12 cells/L	4.60 - 7.13	5.88	5.88	3.97	8.35	226	49	Whole Blood
Global sp RI	Hemoglobin (automated)	g/L	118 - 183	151	150	99	190	243	53	Whole Blood
Global sp RI	Hematocrit (automated)	ratio	0.348 - 0.581	0.466	0.466	0.251	0.599	221	47	Whole Blood
Global sp RI	Hematocrit (manual)	ratio	0.355 - 0.573	0.467	0.469	0.251	0.599	259	54	Whole Blood
Global sp RI	Mean Corpuscular Volume (reported)	fL	68.7 - 101.6	82.3	81.0	68.0	103.0	67	14	Whole Blood
Global sp RI	Mean Corpuscular Volume (calculated)	fL	67.4 - 91.2	79.5	79.0	63.5	92.0	163	38	Whole Blood
Global sp RI	Mean Corpuscular Hemoglobin (reported)	fmol	1.32 - 1.86	1.58	1.58	1.27	1.91	52	11	Whole Blood
Global sp RI	Mean Corpuscular Hemoglobin (calculated)	pg	20.5 - 30.2	26.1	26.0	17.7	32.8	167	41	Whole Blood
Global sp RI	Mean Corpuscular Hemoglobin Concentration (reported)	g/L	285 - 356	320	320	280	356	60	13	Whole Blood
Global sp RI	Mean Corpuscular Hemoglobin Concentration (calculated)	g/L	271 - 386	327	325	252	390	175	45	Whole Blood
Global sp RI	Platelet count (automated)	*10^12 cells/L	0.019 - 0.534	0.272	0.269	0.004	0.605	170	46	Whole Blood
Basic Stats	Mean Platelet Volume (automated)	fL	N/A - N/A	12.9	12.5	8.9	19.6	29	19	Whole Blood
Global sp RI	White Blood Cell count (automated)	*10^9 cells/L	2.9 - 18.1	7.3	6.4	2.4	21.4	248	53	Whole Blood
Global sp RI	Lymphocyte absolute count (calculated)	*10^9 cells/L	0.841 - 6.921	3.101	2.658	0.476	9.576	229	51	Whole Blood
Global sp RI	Monocyte absolute count (calculated)	*10^9 cells/L	0.051 - 0.999	0.314	0.261	0.024	1.270	219	49	Whole Blood
Global sp RI	Segmented Neutrophil absolute count (calculated)	*10^9 cells/L	0.776 - 8.304	3.057	2.554	0.480	9.840	206	51	Whole Blood
Global sp RI	Eosinophil absolute count (calculated)	*10^9 cells/L	0.005 - 0.892	0.234	0.144	0.000	1.023	173	43	Whole Blood
Global sp RI	Basophil absolute count (calculated)	*10^9 cells/L	0.000 - 0.288	0.083	0.072	0.000	0.366	84	25	Whole Blood
Global sp RI	Lymphocyte percentage (automated)	%	10.4 - 74.6	45.3	47.0	1.1	83.0	254	54	Whole Blood
Global sp RI	Lymphocyte percentage (manual)	%	13.8 - 75.3	47.1	49.0	8.0	83.0	229	54	Whole Blood
Global sp RI	Monocyte percentage (automated)	%	0.0 - 12.0	4.8	4.0	0.0	18.0	238	52	Whole Blood
Global sp RI	Monocyte percentage (manual)	%	1.0 - 12.0	5.0	4.6	0.6	18.0	218	52	Whole Blood
Global sp RI	Segmented Neutrophil percentage (automated)	%	15.0 - 80.7	45.2	44.0	8.2	84.0	223	53	Whole Blood
Global sp RI	Segmented Neutrophil percentage (manual)	%	15.0 - 81.5	45.0	43.0	8.2	84.0	205	52	Whole Blood
Global sp RI	Band form Neutrophil percentage (automated)	%	0.0 - 1.8	0.2	0.0	0.0	2.0	46	23	Whole Blood
Global sp RI	Band form Neutrophil percentage (manual)	%	0.0 - 1.9	0.2	0.0	0.0	2.0	45	23	Whole Blood
Global sp RI	Eosinophil percentage (automated)	%	0.0 - 10.9	2.9	2.0	0.0	13.0	211	45	Whole Blood
Global sp RI	Eosinophil percentage (manual)	%	0.0 - 11.0	2.9	2.0	0.0	13.0	192	45	Whole Blood
Global sp RI	Basophil percentage (automated)	%	0.0 - 3.7	0.7	0.0	0.0	4.0	172	36	Whole Blood
Global sp RI	Basophil percentage (manual)	%	0.0 - 3.3	0.7	0.0	0.0	4.0	149	34	Whole Blood

CHEMISTRY/FLUID ANALYSIS

Expected Result Type	Test	Units	Reference Interval	Mean	Median	Lowest Data Value	Highest Data Value	Sample Size	Animals	Sample Type

Global sp RI	Sodium (automated)	mmol/L	137 - 153	146	146	132	156	182	50	Serum
Basic Stats	Sodium (automated)	mmol/L	N/A - N/A	144	144	135	156	21	13	Plasma
Global sp RI	Sodium (automated)	mmol/L	136 - 155	146	146	132	156	203	50	Serum or plasma
Global sp RI	Potassium (automated)	mmol/L	2.9 - 5.6	3.8	3.7	2.5	6.6	199	48	Serum or plasma
Global sp RI	Potassium (automated)	mmol/L	2.9 - 5.6	3.8	3.7	2.5	6.6	178	48	Serum
Basic Stats	Potassium (automated)	mmol/L	N/A - N/A	3.7	3.8	2.6	4.8	21	13	Plasma
Global sp RI	Sodium:Potassium ratio (calculated)	ratio	23.8 - 54.0	39.6	40.0	21.2	59.2	167	44	Serum or plasma
Global sp RI	Sodium:Potassium ratio (calculated)	ratio	23.5 - 51.4	39.3	39.7	21.2	59.2	161	44	Serum
Global sp RI	Chloride (automated)	mmol/L	103 - 122	113	114	96	124	165	45	Serum
Global sp RI	Chloride (automated)	mmol/L	104 - 123	114	114	96	131	182	45	Serum or plasma
Global sp RI	Total Carbon Dioxide (automated)	mmol/L	4.7 - 24.0	16.9	17.0	2.5	25.0	102	20	Serum or plasma
Global sp RI	Total Carbon Dioxide (automated)	mmol/L	3.5 - 24.1	16.6	17.0	2.5	25.0	85	19	Serum
Global sp RI	Anion Gap (reported)	mmol/L	7.9 - 28.2	17.6	18.0	7.0	30.0	57	14	Serum
Global sp RI	Anion Gap (reported)	mmol/L	7.5 - 27.9	17.3	17.0	7.0	30.0	60	15	Serum or plasma
Global sp RI	Calcium (colorimetry.automated)	mmol/L	1.9 - 2.5	2.2	2.2	1.6	2.6	204	50	Serum
Global sp RI	Calcium (colorimetry.automated)	mmol/L	1.8 - 2.5	2.2	2.2	1.6	2.6	225	50	Serum or plasma
Basic Stats	Calcium (colorimetry.automated)	mmol/L	N/A - N/A	2.1	2.1	1.6	2.4	21	13	Plasma
Global sp RI	Phosphorus (colorimetry.automated)	mmol/L	0.81 - 2.74	1.57	1.53	0.42	3.75	222	50	Serum or plasma
Basic Stats	Phosphorus (colorimetry.automated)	mmol/L	N/A - N/A	1.32	1.34	0.71	2.20	20	13	Plasma
Global sp RI	Phosphorus (colorimetry.automated)	mmol/L	0.81 - 2.71	1.59	1.55	0.42	3.75	201	49	Serum
Global sp RI	Calcium:Phosphorus ratio (calculated)	ratio	1.1 - 3.3	2.0	1.8	0.5	3.5	183	46	Serum
Global sp RI	Calcium:Phosphorus ratio (calculated)	ratio	1.1 - 3.3	2.0	1.9	0.5	3.5	189	46	Serum or plasma
Basic Stats	Ionized Calcium (automated)	mmol/L	N/A - N/A	0.68	0.31	0.28	1.28	35	9	Serum
Basic Stats	Ionized Calcium (automated)	mmol/L	N/A - N/A	0.68	0.31	0.28	1.28	35	9	Serum or plasma
Basic Stats	Magnesium (automated)	mmol/L	N/A - N/A	0.79	0.78	0.70	1.00	21	8	Serum or plasma
Global sp RI	Glucose (automated)	mmol/L	2.8 - 12.1	6.5	6.2	0.5	16.4	250	51	Serum or plasma
Basic Stats	Glucose (automated)	mmol/L	N/A - N/A	6.9	6.7	4.0	10.7	21	13	Plasma
Global sp RI	Glucose (automated)	mmol/L	2.7 - 12.1	6.5	6.2	0.5	16.4	229	51	Serum
Global sp RI	Urea Nitrogen (automated)	mmol/L	3.2 - 11.8	6.7	6.4	2.5	17.0	235	56	Serum or plasma
Basic Stats	Urea Nitrogen (automated)	mmol/L	N/A - N/A	5.8	5.4	2.5	10.6	21	13	Plasma
Global sp RI	Urea Nitrogen (automated)	mmol/L	3.6 - 12.0	6.8	6.4	2.7	17.0	214	56	Serum
Global sp RI	Creatinine (automated)	µmol/L	33 - 106	63	62	27	141	229	54	Serum or plasma
Basic Stats	Creatinine (automated)	µmol/L	N/A - N/A	51	53	27	88	21	13	Plasma
Global sp RI	Creatinine (automated)	µmol/L	35 - 106	64	62	27	141	208	54	Serum
Global sp RI	Urea Nitrogen:Creatinine ratio (reported)	ratio	15.4 - 71.2	33.1	31.7	12.5	76.7	72	19	Serum or plasma
Global sp RI	Urea Nitrogen:Creatinine ratio (reported)	ratio	15.4 - 71.2	33.1	31.7	12.5	76.7	72	19	Serum
Global sp RI	Urea Nitrogen:Creatinine ratio (calculated)	ratio	52.0 - 219.1	112.9	103.4	44.4	282.7	196	51	Serum
Global sp RI	Urea Nitrogen:Creatinine ratio (calculated)	ratio	52.2 - 217.6	113.5	103.4	44.4	282.7	202	51	Serum or plasma
Basic Stats	Uric Acid (automated)	µmol/L	N/A - N/A	150	131	61	280	22	12	Serum or plasma
Basic Stats	Uric Acid (automated)	µmol/L	N/A - N/A	150	131	61	280	22	12	Serum
Global sp RI	Alanine Aminotransferase (automated)	U/L	10 - 84	30	24	7	103	198	55	Serum
Global sp RI	Alanine Aminotransferase (automated)	U/L	10 - 84	30	24	7	103	209	55	Serum or plasma
Global sp RI	Aspartate Aminotransferase (automated)	U/L	16 - 95	40	34	10	135	194	51	Serum or plasma
Global sp RI	Aspartate Aminotransferase (automated)	U/L	16 - 96	39	34	10	135	177	51	Serum
Basic Stats	Lactate Dehydrogenase (automated)	U/L	N/A - N/A	306	252	111	930	32	20	Serum
Basic Stats	Lactate Dehydrogenase (automated)	U/L	N/A - N/A	306	252	111	930	32	20	Serum or plasma
Global sp RI	Alkaline Phosphatase (automated)	U/L	32 - 759	209	159	10	875	184	51	Serum
Basic Stats	Alkaline Phosphatase (automated)	U/L	N/A - N/A	153	124	39	317	21	13	Plasma
Global sp RI	Alkaline Phosphatase (automated)	U/L	32 - 689	194	146	10	793	202	52	Serum or plasma
Global sp RI	Gamma Glutamyltransferase (automated)	U/L	14 - 115	51	48	3	121	112	24	Serum or plasma
Global sp RI	Gamma Glutamyltransferase (automated)	U/L	13 - 119	51	46	3	131	96	24	Serum
Global sp RI	Amylase (automated)	U/L	47 - 1160	248	153	39	1249	91	27	Serum or plasma

Global sp RI	Amylase (automated)	U/L	46 - 565	181	153	39	789	80	26	Serum
Global sp RI	Lipase (automated)	U/L	6 - 64	21	18	6	68	55	18	Serum
Global sp RI	Lipase (automated)	U/L	7 - 148	35	19	6	154	65	19	Serum or plasma
Global sp RI	Creatine Kinase (automated)	U/L	54 - 945	334	255	0	1408	118	29	Serum or plasma
Global sp RI	Creatine Kinase (automated)	U/L	54 - 1420	366	283	0	1461	109	29	Serum
Global sp RI	Total Bilirubin (automated)	µmol/L	1.7 - 1.7	1.7	1.7	1.7	1.7	135	44	Serum
Global sp RI	Total Bilirubin (automated)	µmol/L	1.7 - 1.7	1.7	1.7	1.7	1.7	136	44	Serum or plasma
Global sp RI	Direct Bilirubin (automated)	µmol/L	0.0 - 3.4	0.9	0.0	0.0	3.4	75	24	Serum
Global sp RI	Direct Bilirubin (automated)	µmol/L	0.0 - 3.4	1.0	0.0	0.0	3.4	81	25	Serum or plasma
Global sp RI	Indirect Bilirubin (reported)	µmol/L	0.0 - 3.5	0.9	0.0	0.0	5.1	77	21	Serum or plasma
Global sp RI	Indirect Bilirubin (reported)	µmol/L	0.0 - 3.8	0.9	0.0	0.0	5.1	71	20	Serum
Global sp RI	Total Protein (colorimetry.automated)	g/L	54 - 83	68	68	47	89	231	54	Serum or plasma
Global sp RI	Total Protein (colorimetry.automated)	g/L	52 - 83	69	69	47	89	210	54	Serum
Basic Stats	Total Protein (colorimetry.automated)	g/L	N/A - N/A	67	68	57	73	21	13	Plasma
Basic Stats	Albumin (unspecified methodology.automated)	g/L	N/A - N/A	33	30	25	49	21	13	Plasma
Global sp RI	Albumin (unspecified methodology.automated)	g/L	21 - 53	39	40	16	55	192	55	Serum
Global sp RI	Albumin (unspecified methodology.automated)	g/L	21 - 53	39	39	16	55	213	55	Serum or plasma
Global sp RI	Globulin (reported)	g/L	17 - 42	28	28	4	44	196	52	Serum or plasma
Global sp RI	Globulin (reported)	g/L	18 - 42	28	28	11	44	186	52	Serum
Global sp RI	Albumin:Globulin ratio (reported)	ratio	0.6 - 2.6	1.5	1.4	0.5	2.9	119	25	Serum or plasma
Global sp RI	Albumin:Globulin ratio (reported)	ratio	0.6 - 2.4	1.5	1.4	0.5	2.9	113	25	Serum
Basic Stats	Osmolality (freezing point depression.automated)	mOsmol/kg	N/A - N/A	294	287	281	326	19	11	Serum or plasma
Global sp RI	Cholesterol (automated)	mmol/L	2.5 - 7.1	4.3	4.2	0.1	8.0	232	48	Serum or plasma
Global sp RI	Cholesterol (automated)	mmol/L	2.5 - 7.1	4.4	4.3	0.1	8.0	225	48	Serum
Global sp RI	Triglyceride (automated)	mmol/L	0.1 - 1.2	0.5	0.4	0.0	1.3	81	21	Serum
Global sp RI	Triglyceride (automated)	mmol/L	0.1 - 1.2	0.5	0.4	0.0	1.3	81	21	Serum or plasma

Figure 51: Haematological and biochemical values in white-throated capuchins (*Cebus capucinus*) (ZIMS, 2018)

g) Sexing

Sexing can be difficult in capuchin monkeys because of the poor sexual dimorphism, as in other New World monkeys. Sexing is easier in an anaesthetised animal, by everting the clitoris in female (Figure 51), which is not possible in male.

Figure 52: Sexing of a female yellow-breasted capuchin.
Clitoris in a physiological position (left) and everted (right) (®Mulhouse Zoo)

h) Contraception

According to the studbook (Quintard, 2017), most of the group of capuchin monkeys in EAZA zoos (87%) had births during the last 10 years. The number of births per institution during this period was on average 9.45. This demonstrates the high level of reproduction in the population of capuchin monkeys in EAZA zoos. Moreover, there was a good rearing by the mothers with infants that generally reached the age of 1 year. Indeed, capuchin monkeys have generally a good reproduction rates and it is a more complicated task to inhibit breeding than to get them to breed (Honeysett, 2006 & Littlefield, 2009). For all these reasons, birth control seems to be necessary to avoid exponential growth of the captive population of the different species of capuchin monkeys (Quintard, 2017). Regarding to the relative overcrowding of the capuchin monkeys in EAZA zoos, the reproduction of these species should be controlled according to the EEP coordinator recommendation. Contraception should also be used in the interest of the animal's health (frequent stillbirths). Nevertheless, it is also important for their welfare to maintain a social group (Honeysett, 2006 & Littlefield, 2009).

Do you use the method?	In males		In females		Never	
	Male	%	Female	%	n	%
Male / Female separation	2	5,1%	0	0,0%	37	94,9%
Castration / Sterilisation	5	12,8%	3	7,7%	32	82,1%
Vasectomy / Tubal Ligation	5	12,8%	1	2,6%	33	84,6%
Nexplanon ND (Etonogestrel)	0	0,0%	7	17,9%	32	82,1%
SUPRELORIN ND (Deslorelin)	0	0,0%	5	12,8%	34	87,2%

Table 12: Differences in birth control between males and females in EAZA zoos that use birth control (n = 39)

43,6% of EAZA zoos (17/39) use a method of birth control (Table 12). There are two group of males. Only physical castration is done in males (25,6%), contrary to the females, in which chemical castration is preferred (30,8% of chemical VS 10,3% of physical castration). 15,4% of EAZA zoos (6/39) use birth control in both females and males. 10/19 EAZA zoos have a birth control in males and 13/19 in females.

Is the method efficient?	Yes		No	
	n	%	n	%
Male/Female separation	2	50,0%	2	50,0%
Physical sterilisation	11	84,6%	2	15,4%
Nexplanon ND (Etonogestrel)	6	66,7%	3	33,3%
SUPRELORIN ND (Deslorelin)	4	80,0%	1	20,0%

Figure 53: Efficiency of contraception procedures according to EAZA zoos, regarding birth control and social management

Male/female separation is the most efficient method but questionable for welfare according to the BPGQ and EGZAC. Indeed, capuchin monkeys are social species with multimale/multifemale groups. Even if it is possible for several species, the isolation of an individual to avoid breeding is contrary to the basic social needs of most primates, so single-sex groups with more than one individual are recommended when other method are not applicable. Vasectomy is preferable than castration for the animal welfare, because males conserve their sexual and social behaviour without being able to reproduce. Moreover, castration induce a deficiency in grow, and the castrated males can become the targets of aggression, according to the BPGQ.

Figure 54: Implantation of a female yellow-breasted capuchin with ½ implant of etonogestrel (®Mulhouse Zoo)

The final sterilization is only practiced for animals with a low genetic value within the species and after the agreement of the coordinator (Quintard, 2017). Contraceptive implantation is the most common technique used to control breeding because it is easy to set up, effective and long lasting in capuchin monkeys (Honeysett, 2006 & Littlefield, 2009). There are two types of implants: GnRH agonists and synthetic progestagens.

The implants of synthetic progestagens, such as etonogestrel (Implanon ND or Nexplanon ND) or levonogestrel (Jadelle ND) are efficient in capuchin monkeys (Agnew M., 2019, EGZAC, 2014, Honeysett, 2006 & Nagle, 2009) are the most frequent way to control the reproduction of females. The recommended dose is ½ implant for Implanon ND or Nexplanon ND (EGZAC, 2014 & Quintard, 2016). The latency time is very low (1 day) and the duration is between 2 to 3 years. EAZA zoos reported in the BPGQ that the duration of effects is variable and that a whole implant is necessary for good birth regulation. They are fully reversible, and the side effects are low.

The implants of GnRH agonists, such as deslorelin acetate (Suprelorin ND), that temporarily suppress the reproductive endocrine system, and decreases the level of gonadal hormones (Agnew M., 2019, EGZAC, 2014 & Honeysett, 2006). Unfortunately, the deslorelin allows an initial increasing of GnRH (flare-up effects) before a down-regulation of GnRH receptors. The females could be aggressive until 1 month before application, as reported in the BPGQ, and they are considered fertile during 3 weeks following insertion (EGZAC, 2014). The females should be separated from the males during this period. Next implantations should follow the previous one without dead time to avoid this flare-up effect. The 4.7mg implant of Suprelorin ND is effective for a minimum of 6 months and the 9.4mg implant for a minimum of 12 months. The reversibility is extremely variable.

i) Euthanasia

Euthanasia must always be performed by a veterinarian. For animal welfare reasons, a previous sedation or anaesthesia with injectable or inhalants is necessary to properly perform the intravenous injection (Leary *et al.*, 2013). Intravenous administration of euthanasic agents in the femoral vein must absolutely be in the vessel because an accidental perivascular injection could cause a rapid onset of tissue necrosis and pain. It should be preferred to intracardiac, intrarenal or intraperitoneal ways, when it is possible. The most common solution for euthanasia is a barbiturates solution like saturated sodium pentobarbital solution.

j) Necropsy

All the animals that died in a zoo, captive or free, should be necropsied. Although the necropsy is first a tool to understand the circumstances of death, it is also useful in surveillance of infectious disease and zoonosis (Abee et al., 2012, Fortman et al., 2018). The duration between the death and the post-mortem should be minimal to reduce the autolysis and to improve diagnosis. Only trained and experienced veterinarian or pathologist should be allowed to conduct a nonhuman primate necropsy, because post-mortems of nonhuman primates pose significant hazards (Abee et al., 2012, Fortman et al., 2018). The close visual observation of all the organs and lesions with potential high concentration of pathogens, involve considerable risks. The aerosols created by the opened cavities and the fluids are significant potential for contamination. Nonhuman primates and humans share a lot of pathogens.

One should obviously follow the basic safety protocol during a post mortem of a nonhuman primate (Abee et al., 2012, Fortman et al., 2018). A dedicated necropsy facility is highly recommended, with dedicated necropsy instruments, tissue collection materials and a biological safety cabinet for infectious aerosols or splashes. During a post-mortem of a nonhuman primate, any personnel in the necropsy area must always wear personal protective equipment: facemask, safety goggles, disposable gloves, cleanable rubber boots or wastable shoe covers and lab coat. Precautions must be taken to avoid oral contaminations. After each post-mortem, the necropsy area and the instruments should be cleaned first, and then decontaminated with a suitable disinfecting solution. Dead nonhuman primates should be double-bagged or transported to the necropsy area in such a manner as to minimize the possibility of leakage of contaminated fluids in route.

The pathologist who performs the post-mortems should visually evaluate all organ systems and preserve samples of all the normal tissues and also abnormal tissues (Abee et al., 2012, Fortman et al., 2018). All the tissues should be cut and palpated to avoid missing lesions. A report must be written and recorded. The veterinarian can send the formalin tissues for histopathological analysis (Abee et al., 2012, Fortman et al., 2018). It is advised to conserve frozen tissues at -20°C and formalin tissues in a bank for potential further analysis (viral identification, PCR analysis, staining …) and future research.

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Appendices

ANNEX 1: *SAPAJUS* SPECIES (©Stephen Nash)

ANNEX 2: *CEBUS* SPECIES (©Stephen Nash)

ANNEX 3: NEW WORLD MONKEYS ST LAURENT PELLETS

Aliment extrudé

FORMULE N°1

St Laurent

Singes du Nouveau Monde

Taille : 13 x 40 mm

(Référence : 300015)

ANALYSE COMPLETE

Analyse (%)			Acides aminés (%)		
Protéines brutes	%	24.53	Arginine	%	
Matières grasses brutes	%	3.66	Lysine	%	
Cendres brutes	%	6.61	Methionine	%	
Cellulose brute	%	11.01	Cystine	%	
Humidité	%	12.59	Histidine	%	
Fibres totales (AOAC 985-29)	%		Threonine	%	
Energie (MJ/kg)			Isoleucine	%	
Energie Brute	MJ/kg		Leucine	%	
Minéraux (%)			Phenylalanine	%	
Calcium	%	1.12	Valine	%	
Phosphore	%	0.76	Tyrosine	%	
Sodium	%		Taurine	%	
Potassium	%		Glycine	%	
Magnésium	%		Acide aspartique	%	
Oligo-éléments (par kg)			Acide glutamique	%	
Fer	mg		Proline	%	
Cuivre	mg	16	Serine	%	
Manganèse	mg		Alanine	%	
Zinc	mg		**Vitamines (par kg)**		
Cobalt	mg		Vitamine A	UI	26600
Iode	mg		Vitamine D3	UI	5000
Sélénium	mg		Vitamine E	mg	410
Acides gras			Vitamine K (ménadione)	mg	15
C12 :0 Acide laurique	%		Thiamine (B1)	mg	48
C14 :0 Acide myristique	%		Riboflavine (B2)	mg	21
C16 :0 Acide palmitique	%		Acide nicotinique (B3)	mg	95
C18 :0 Acide stéarique	%		Acide pantothénique (B5)	mg	46
C14 :1 Acide myristoléique	%		Pyridoxine (B6)	mg	19
C16 :1 Acide palmitoléique	%		Biotine (B8)	mg	0.581
C18 :1 Acide oléique	%		Acide folique (B9)	mg	10
C18 :2 (w6) Acide linoléique	%		Cobalamine (B12)	mg	0.080
C18 :3 (w3) Acide linolénique	%		Vitamine C	mg	125
C20 :4 (w6) Acide arachidonique	%		Chlorure de Choline	mg	
C22 :5 (w3) Acide clupanodonique	%		Inositol	mg	

Calcul de ration journalière

Quantité / kg vif	Quantité / animal	Nb distribution / jour	Volume / semaine	Volume / mois

S.A.S. au capital de 80000€. - Siège social : 79430 La Chapelle Saint-Laurent - Tél. : 05 49 72 09 20 - Fax : 05 49 72 11 12
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ANNEX 4: Virus isolated in the last decade in European zoos (data by BPRC-Henk Niphuis)

#		European Zoos 2007-2017 n=94	Rescue centers 2015-2017 n=88
Capuchins			
	Anti- Alpha herpes virus*)	11/94 11.7%	17/84 20.2%
	Pan herpes virus PCR	1x HHV1	
	Anti- STLV**)	0/91	0/41
	Anti- SIV	0/91	0/38
	Anti- SRV	0/91	0/41
	Anti- Filo virus	0/44	0/24
	Anti- SV40	0/41	0/17
	Anti- Polyoma virus	5/17 29.4%	1/15 6.7%
	Anti- SFV	2/36 5.6%	1/20 5.0%
	Anti- CMV	4/12 33.3%	8/21 38.1%
	Pan herpes virus PCR	1x CMV cebus	
	Anti- EBV	0/18	0/18
	Pan herpes virus PCR	1x LCV	
	Anti- HHV6	1/10 10.0%	0/10
	Anti- Measles virus	0/27	0/18
	Anti- HAV	4/61 6.6%	2/27 7.4%
	Anti- HBV	0/66	1/31 3.2%
	HBV PCR/HBsAg		Negative
	Anti- HCV	0/14	0/03
	Anti- HEV	0/09	0/02
	Anti- VZV	0/11	0/20
	Anti- Rabies virus	4/22 18.2%	1/13 7.7%
	Anti- EMCV	0/03	
	Anti- RSV	0/04	1/11 9.1%
	Anti- Influ. A	4/21 19.0%	0/12
	Anti- YFV	0/03	
	Anti- DENV	0/14	0/17
	Anti- WNV	1/15 6.7%	3/17 17.6%
	Anti- USUV/ZIKV	0/08	0/06
	Anti- POXV	1/12 8.3%	3/9 33.3%
	Anti- hMPV	0/05	0/02
	Anti- SaHV2	1/33 3.0%	0/70
	Adeno PCR	1x Adeno PCR+	