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Externship Report

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Dedication

To all of the nonhuman animals that are part of this world and make it such a wonderful place to live.

Acknowledgements

To my **Father,** my idol, who boosted my passion for wild animals and helped me to pursue and fight for it, who taught me what responsibility is, commitment, honesty, respect, confidence, humbleness, simplicity and who believed in me, in my convictions and in my life-goals. Dad, should all the girls of the world have a father like you so they could be prepared for all the disappointments that life bring us, face them, and smile the day after, just like you taught me to do so.

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Abstract

Externship report done in order to describe and inform about the activities followed during six months externship at three zoological institutions in the United States of America. These externships were performed in order to conclude the sixth and last year of the integrated master in veterinary medicine of the University of Evora, with the main goal of obtaining more knowledge and experience in this area of the veterinary field. From the more varied number of species, to the more complex procedure, by exemplification with a case of preventative medicine in a western lowland gorilla (*Gorilla gorilla* gorilla), this report provides information about some of the most important and/or interesting aspects of zoological medicine.

Key Words: externship, zoo, veterinary, gorilla, preventative

Resumo

Medicina das Especies Zoologicas

Relatório de estágio produzido com o intuito de descrever e dar a conhecer as actividades seguidas e realizadas durante seis meses de estágio em três entidades zoológicas nos Estados Unidos da América. Estes estágios foram realizados de forma a concluir o sexto e último ano do ciclo de estudos do mestrado integrado em medicina veterinária da Universidade de Évora, com o objectivo principal de obter maior conhecimento e experiência nesta área do ramo veterinário. Desde o mais variado número de espécies, até ao procedimento mais complexo, atraves da exemplificacao com um caso de medicina preventiva num gorila-do-ocidente (*Gorilla gorilla gorilla*), este relatório fornece informação sobre alguns dos aspectos mais importantes e/ou interessantes da medicina zoológica.

Palavras chave: estágio, zoo, veterinária, gorila, preventive

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ACRONYMS AND ABBREVIATIONS LIST

AAZV- American Association of Zoo Veterinarians

ALP- Alkaline phosphatase

AZA- American Zoological Association

BAR- bright, alert, responsive

BCS- Body condition score

BE- Base excess

BID- *bis in die* (twice daily)

BNP- B-type Natriuretic Peptide

BP- Blood pressure

bpm- beats per minute

BUN- Blood urea nitrogen

CAT- Computed Axial Tomography

CBC- Complete blood count

CHD- Coronary heart disease

CNS- Central nervous system

CO2- Carbon Dioxide

CPA- Cardiopulmonary arrest

CPCR- Cardiopulmonary cerebral resuscitation

CPR- Cardiopulmonary resuscitation

CRI- Constant rate infusion

CRT- Capillary refilling time

CV- Cardiovascular

DC- District of Columbia

DV- Dorso-ventral

ECG- Electrocardiogram

ET- Endotracheal

ETCO2- End-tidal carbon dioxide

GI- Gastrointestinal

G/U- Genital-urinary

HDL- High-density lipoprotein

H/L- Heart and lungs

HR- Heart rate

HVRDDS- High velocity remote drug delivery system(s)

ICU- Intensive Care Unit

IM- Intramuscularly

IO- Intraosseous IT- Intratracheal

IU- International Units

IV- Intravenously

LDL- Low-density lipoprotein

LRS- Lactate Ringer Solution

MBP- Mean blood pressure

MCI- Manually controlled infusion

MM- Mucous membranes

MR- Magnetic resonance

M/S- Muscular-skeletal

Neuro- Neurological

NPPE- Negative pressure pulmonary edema

oxLDL- low-density lipoprotein-producing oxidized phospholipid

PaCO2- Partial pressure of arterial carbon dioxide

PCV- Packed cell volume

PM- Pre-molar

PO- *per os*

PO2- Partial pressure of oxygen

PPG- Procaine penicillin G

PPV- Positive pressure ventilations

PTH- Parathyroid hormone

RL- Right lateral

rpm- respirations per minute

RR- Respiratory rate

SECORE- sexual coral reproduction

SOAP- Subjective, Objective, Assessment, Plan

SPO2- Blood oxygen saturation

TB- Tuberculosis

TIVA- Total intravenous anesthesia

TP- Total protein

US- Ultrasound

USA- United States of America

UV- Ultraviolet

VD- Ventro-dorsal

Vet- Veterinary/Veterinarian

Vit.- Vitamin

WNL- Within normal limits

1,25(OH)2D- 1,25-dihydroxy vitamin D

25OHD- 25-hydroxy vitamin D

1. Introduction

Zoological medicine is a wide and complex field of veterinary medicine. The large spectrum of species, their specific biology, and health, makes this a challenging area, requiring deep study and training periods until a good level of medical practice can be achieved. In order to obtain baseline knowledge and experience, a six-months length externship was done in three different institutions, giving the opportunity to contact with new species, new ways of medical care, as well as with different equipment, drugs, and new specific team-training, so that qualified personal can be capable of dealing with a variety of situations.

From the very beginning of this experience, there were innumerous challenges found every day, which also contributed for this "journey" to be more than a "zoo medicine lesson"- it was also a way of gaining the autonomy to find how to solve new problems, many times about unknown topics. All of this was done in a foreign language and a foreign culture, which provided an "extra" enrichment to this experience, as there was the opportunity of communicating with people with different mentalities but working with equal goals and ideologies.

2. SPECIFIC GOALS

Much can be said about zoological medicine; however, there are "key-points" that are essential for the practice of a good animal care. The specific goals of this externship are a "mirror" of those subjects, and obtaining baseline knowledge and experience in each one of those "key-points" was a general rule applied during all the externship period and in all the visited institutions, so that in the future, if progress in this area can be made, it will be done with better capability and skills. Here is the list of the externship specific goals:

- To obtain knowledge about:
  - Biology, anatomy and physiology of zoological species;
  - Preventative medicine;
  - Quarantine programs;
  - Physical and chemical restraint;
  - Nutrition;
  - Behavioral enrichment;
  - How to use/apply complementary diagnostic tests to zoological species;
  - Treatment of diseases;
  - Management of clinical cases;
  - Management of zoological collections;
  - Pathology.

- To get mentorship that would allow clarification of questions and that would incite the study with new subjects;
- To improve the ability of becoming integrated in a team, learning how to work in a multitask environment where every person has defined responsibilities and is well trained to do it, so that a team, as one, can work in a coordinated manner, obtaining the best results.

3. LOCATION OF THE EXTERNSHIP

The selection of the place to perform this externship was based on several factors. The main goal was to have the opportunity to contact with the widest variety of animal species as possible, as well as being at hospitals with high case-loads. On the other hand, it was intended that zoos had within their collections certain animal species, which the author had a special ambition to work with. Here is the list of species that were specifically looked for when searching for places where to perform the externship: bottlenose dolphin (*Tursiops truncantus*), polar bear (*Ursus maritimus*), giant panda (*Ailuropoda melanoleuca*), lion (*Panthera leo*), elephant (any specie), okapi (*Okapia johnstoni*) and gorilla (genus *Gorilla*).

The reasons for choosing these animals were the fact that they are emblematic (from a public point of view), endangered (from a conservation point of view), and are animals that have an interesting biology, anatomy and physiology which makes them challenging and, at the same time, fascinating from a medical point of view.

Another important criteria for the choice of places was the "quality" (a subjective assessment, of course) of the zoos. Research was made in order to find the "best" zoos in the world, taking into account visitor's evaluation, the quality of facilities, type of species in the collection, and many others parameters. A list of those zoos was done and all of them were contacted in order to ask for an externship opportunity.

The reason for choosing this country was based only on professional reasons, and did not take into account culture, touristic interests or any other topics besides the ones related to veterinary training.

For the most part of the entities (except the Smithsonian's National Zoological Park, which also required a transcript), the application process consisted in filling an application form (provided by the institution), writing a letter of intent (where the student justifies why she/he wants to do the externship) and send three recommendation letters from people who know the student's performance.

Three zoological institutions where chosen for performing the 6 month-length externship:

- Brookfield Zoo (Chicago Zoological Society, Illinois, USA)
- Omaha's Henry Doorly Zoo (Omaha, Nebraska, USA)
- Smithsonian's National Zoological Park (Washington, District of Columbia (DC), USA)

Brookfield Zoo

The Brookfield Zoo, a member of the Chicago Zoological Society, opened in 1934, and since then has been improving and becoming a "gold-of-standard", regarding animal welfare and conservation, as well as for public education. It is located in Brookfield, state of Illinois and comprises 56,7 hectares; it's home of over 3,500 animals, belonging to 450 different species and divided into 18 exhibits thoroughout the zoo. Veterinary science, behavioral endocrinology, behavioral research, behavioral husbandry, animal husbandry, environmental quality, animal nutrition and population genetics are all departments whose job is to guarantee the good management of the zoological institution.

Regarding the veterinary hospital, the building was opened in 1952 and, since then, as well as the rest of the zoo, has undergone remodeling in order to provide updated ways of health care for the animals on the zoo's collection. It comprises, besides the hospital staff offices, locker rooms and the kitchen, a conference room (with a veterinary library), three laboratories, one sample-storage room, a pharmacy, a sterilization room, four storage rooms, being one specifically for protected equipment (for safety reasons), a treatment room, an intensive care unit (ICU), a radiology suite (with two ultrasound machines available - one portable-, a dental x-ray, a mammography, a digital x-ray and an endoscopy machines), a scrub room, a surgery room, a Computed Axial Tomography (CAT) room, a kitchen for animal food preparation and hospitalization rooms (adapted for reptiles, amphibians, birds and mammals). At the back of the building, there are also three quarantine sections and the pathology room (containing necropsy material, a freezer, a small office and a small laboratory).

At the time of the externship, the hospital team was composed by two vice-presidents of the zoo, two associate veterinarians, one resident veterinarian, one environmental quality manager, one hospital laboratory technician, five veterinary technicians, one manager and one administrative assistant. Besides the hospital personnel, usually there were two or three veterinary students performing externships and helping on the daily veterinarian activities.

The daily routine was marked by “morning-rounds”, where the hospital staff met at the conference room, discussing all the quarantined animals status, as well as updates on cases at the park and hospitalized patients; the schedule for the day was also discussed, regarding veterinary services as well as other important events and any other relevant information was shared between team members. These morning meetings proved to be extremely valuable, enabling continuous monitoring of all medical cases by all the team members on an equal manner, and having all team members discussing important decisions and suggestions regarding animal care, which is very useful for guaranteeing that all the staff involved in the care of a certain patient are acting according to the same decided rules and standards.

Regarding the mentoring of the externs, this was done by all the team in order to provide a good learning experience; a desk and a computer were provided to the students, so that reading about medical cases, doing research and writing medical reports could be assured. The student’s presence was requested for all medical procedures, being a proactive part of them, providing help and assistance to the vets and technicians; they usually were incited to perform certain procedures and answering questions about the cases observed. If animals had to be seen at the park, the students would prepare the material needed for the procedure and provide assistance to the veterinarians. Unless the contrary was told, all medical records would be written by the students and sent to the responsible clinician to correct any possible errors and entering the report into the electronic system.

Every other week, a journal club for literature review was performed, having the participation of the hospital doctors, residents and students, as well as the Shedd aquarium and University of Illinois residents and post-graduate students. On alternate weeks of journal club, a graduate course in advance topics was also organized. This type of learning involving the teaching of new topics, revising and discussing important subjects concerning zoological medicine proved to be extremely valuable.

The author spent 12 weeks at the Brookfield zoo, working six days a week, usually between 8:00h and 19:00h.

Omaha's Henry Doorly Zoo

The second visited institution was the Henry Doorly Zoo, located in Omaha, state of Nebraska. It opened as the Riverview Park in 1984 and in 1963 it received its new name (Henry Doorly) in honor to the name of a late husband of a donor. It has evolved until becoming the great institution that is nowadays, composed by 22 exhibits where about 17,000 animals belonging to 962 species live. It was classified as the "Top Zoo in the World" by TripAdvisor in August 2014 and has an associated wildlife park, where the public can make safaris in their private vehicles and observe American indigenous fauna. It has several educational programs, directed to a wide range of people, from three years old children until internships for graduated students. Regarding conservation, it's an entity with a big impact on species preservation, having several programs and specialized people working in conservation medicine, conservation genetics, nutrition husbandry, behavioral husbandry, reproductive sciences, technology transfer, amphibian conservation, butterfly conservation, salamander conservation, sexual coral reproduction (SECORE) and even a rare plant research department.

The medical facilities, located at the Grewcock Center for Conservation and Research, opened in 1996 and are constituted by the clinical laboratory, the pharmacy, two storage rooms, the treatment room, the radiology suite (equipped with digital x-ray, mammography machine and two ultrasound machines- one of them portable), the scrub room, and two surgery rooms, one for small and other for large animals. There are also two areas designed for hospitalizations and quarantines.

At the time of the externship the medical team was composed by four veterinarians, one intern veterinarian, three veterinary technicians, two hospital keepers and one administrative; one or two veterinary externs would also join the team in every procedure.

Daily routine started with a morning meeting where the activities for the day were discussed, as well as any other important updates about the zoo. Students should assist and support procedures performed by the veterinarians (either at the hospital or at the park). Once a week, a staff meeting with other personnel of the zoo took place in order to inform and discuss updates about medical cases at the park, as well as any other procedures where veterinary assistance could be required.

The author spent five weeks at the Henry Doorly Zoo, with a daily schedule from 8:00h to 17:00h.; when there was free time between procedures, it was used to study subjects related with the patient's species or clinical cases, which allowed the author to have a good understanding of the procedures throughout this externship.

Smithsonian's National Zoological Park

The last visited zoo was the National Zoological Park, a part of the Smithsonian Institution, the world's largest museum and research complex. The zoological park is the home of about 2,000 animals belonging to nearly 400 different species, being the giant pandas the most popular residents. It was founded in 1889 and assures opportunities for research, conservation and education about wildlife and sustainability. It has six science centers, which work daily in order to be a part in conservation: animal care sciences center, center for conservation and evolutionary genetics, conservation ecology center, conservation education and sustainability center, migratory bird center and the center for species survival.

The medical facilities are located at the Department of Wildlife Health Sciences, and include, besides the kitchen, offices and a meeting room, the treatment room, a radiology suite (with a digital x-ray machine and two ultrasound machines- one portable), two storage rooms, a surgery room, a scrub, a sterilization room and hospitalization areas for any type of animal. At the lower level, there were also laboratories and a library.

The hospital staff was composed of four veterinarians, one veterinarian resident, six veterinary technicians, three laboratory technicians and one veterinary student.

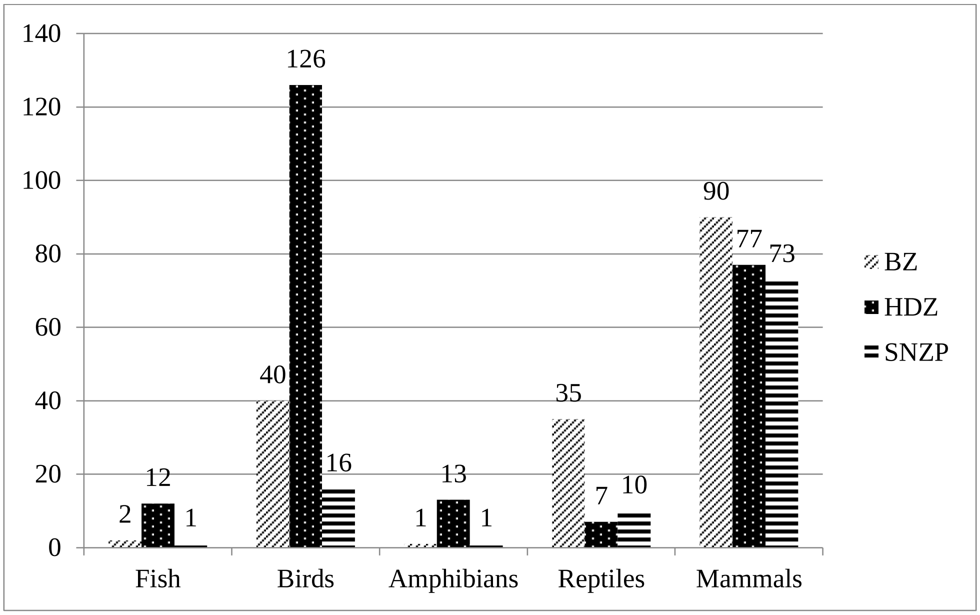
Daily schedule included the assessment of all hospitalized cases before 7:30 and the registration of all important data on their hospitalization records using the subjective, objective, assessment, plan (SOAP) methodology. After that, veterinarians and the extern would meet and briefly discuss cases from the previous day and plans for the current day schedule. Three days per week, clinical rounds were performed with all the hospital staff and the curators of the park where clinical cases and important updates about the zoo were discussed. From 8:30h to 18:00h the extern would work on clinical cases with the veterinarian on duty and would be responsible for writing the medical records.

The learning experience was also supplemented with teaching modules about fundamental aspects of zoological medicine (provided through documents with questions to answer that would be then revised with a veterinarian), journal clubs (with also the presence of the Baltimore Aquarium intern veterinarian and extern) and a preparation of a preceptor project, where a particular topic should be addressed after an adequate research and presented at the end of the externship in a 45 minutes-length presentation to the zoo staff. The author, with the guidance of the veterinary team, decided to explore and develop her project about elephant's anesthesia, not only because mega-vertebrates anesthesia is a very attractive and complex topic, but also because she had the chance to assist with procedures on elephants at the zoo at the same time that she was doing her research about this topic.

4. CASE SERIES

Thorough the externship, all daily cases were recorded in order to express the case-load on tables and graphics. The animals were divided into five big categories: **fish, amphibians, reptiles, birds and mammals**; for each zoo, a table with the case-load for each of these groups is presented. The animal's common name in English as well in Latin is provided below each table; due to lack of information, some Latin names could not be found. In these cases, order, family or genus name is provided. All data is available on tables provided as attachments.

Graphic 1 shows the distribution/number of cases according to the institution in which they were seen as well as their category:



BZ- Brookfield Zoo; HDZ- Henry Doorly Zoo; SNZP- Smithsonian's National Zoological Park

Graphic 1 (Tables 1A to 15A) - Number of cases observed in each zoo.

Overall, mammals was the category where the biggest case-load was observed, followed by birds and reptiles; both fishes and amphibians had equal number of consults/procedures done.

Differences between amount of cases and /or species between zoos can be explained by several factors, such as the collection composition of each institution, the amount of time spent on each place, the time of the year (affecting animal's housing conditions, shipment procedures, and others), as well as the type of husbandry measures adopted by each entity. As an example, the high number of bird cases seen at the Henry Doorly Zoo is due to the fact that the externship occured during the vaccination time of the year for most of these species and because the zoo also has a wildlife safari park with a large amount of birds.

In order to simplify data organization and information analysis, the remaining of this report will consider globalized data from all the externship experience, with no differences or discernments being made according to the institution where cases were observed.

Due to the large number of species, a grouping of these was made for each category, in order to obtain the most commonly performed procedures and/or the most commonly found diseases for a certain group of species. According to species anatomy and physiology, Orders would be the most appropriate way of grouping, however, as more detailed distinctions were needed, the following grouping was decided for each category:

- **Fishes**: Order
- **Amphibians**: Family (to distinguish between frogs and toads)
- **Reptiles**: Suborders (to distinguish between snakes and lizards)
- **Birds**: Orders
- **Mammals**: being the category with the highest number of cases, they are presented in four tables (table 3 and tables 19A, 20A and 21A which can be consulted at the Attachments section). The first one has all species grouped by Orders and graphic 4 presents data about the three Orders with the biggest caseload. Although Order *Rodentia* presented one more case compared to Order *Artiodactyla*- due to the amount of cases of routine vaccinations-, *Artiodactyla* was considered to be the third Order with more cases considering the number and variety of these ones, along with *Carnivora* and *Primata*.

Tables with the information described above can be consulted in the attachments, and the following tables and graphics provide information about the more common type of problems/area of cases observed.

Table 1- Fish: number of cases observed in the main clinical typology.

Procedure/Problem	1*	2*	3*	4*	5*	6*	7*	Total
Euthanasia	1				1			2
Buoyancy		1		1				2
Dermatology	2		2					4
Pathology		1				1		2
Behavior		3	1				1	5
Total	3	5	3	1	1	1	1	**15**

1* Order *Syngnathiformes*
2* Order *Anguilliformes*
3* Order *Myliobatiformes*
4* Order *Scorpaeniformes*
5* Order *Characiformes*
6* Order *Atheriniformes*
7* Order *Carcharhiniformes*

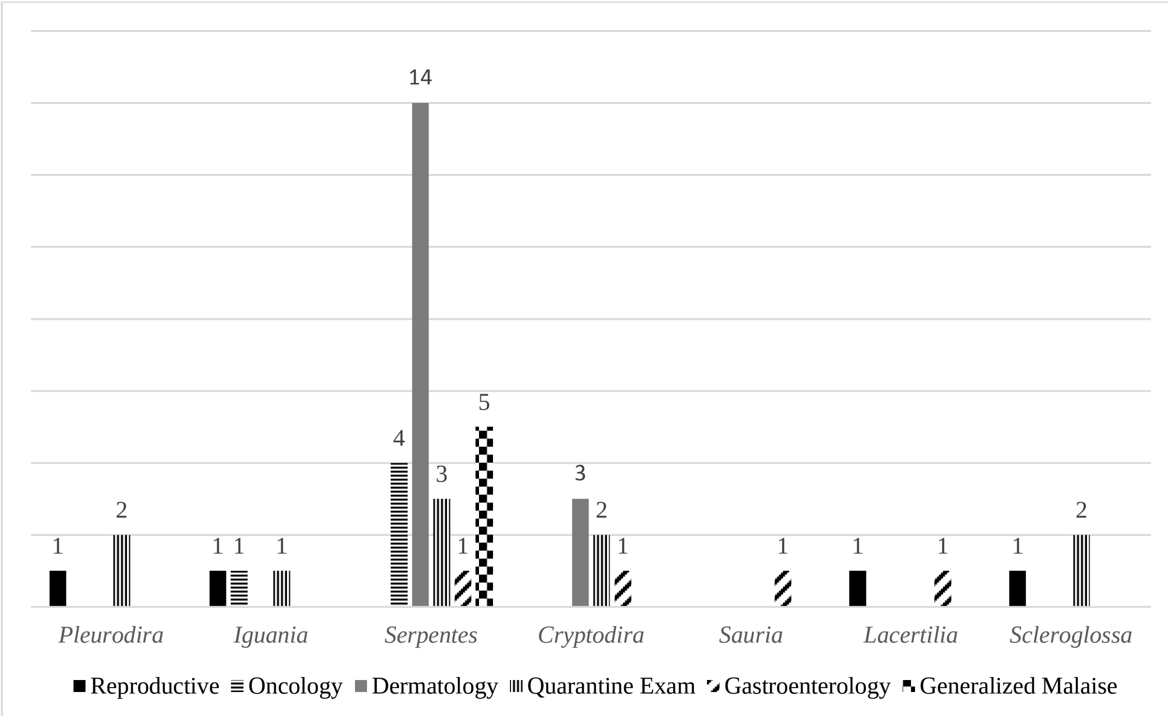
Table 2- Amphibian: number of cases in the main clinical typology.

Procedure/Problem	1*	2*	3*	4*	Total
Ophthalmology	2				2
Coelomic Distension	1	1			2
Podology			1		1
Reproductive	1			1	2
Dermatology	7				7
Pathology				1	1
Total	11	1	1	2	**15**

1* Family **Bufonidae** **3*** Family **Pyxicephalidae**

2* Family **Typhlonectidae** **4*** Family **Ranidae**

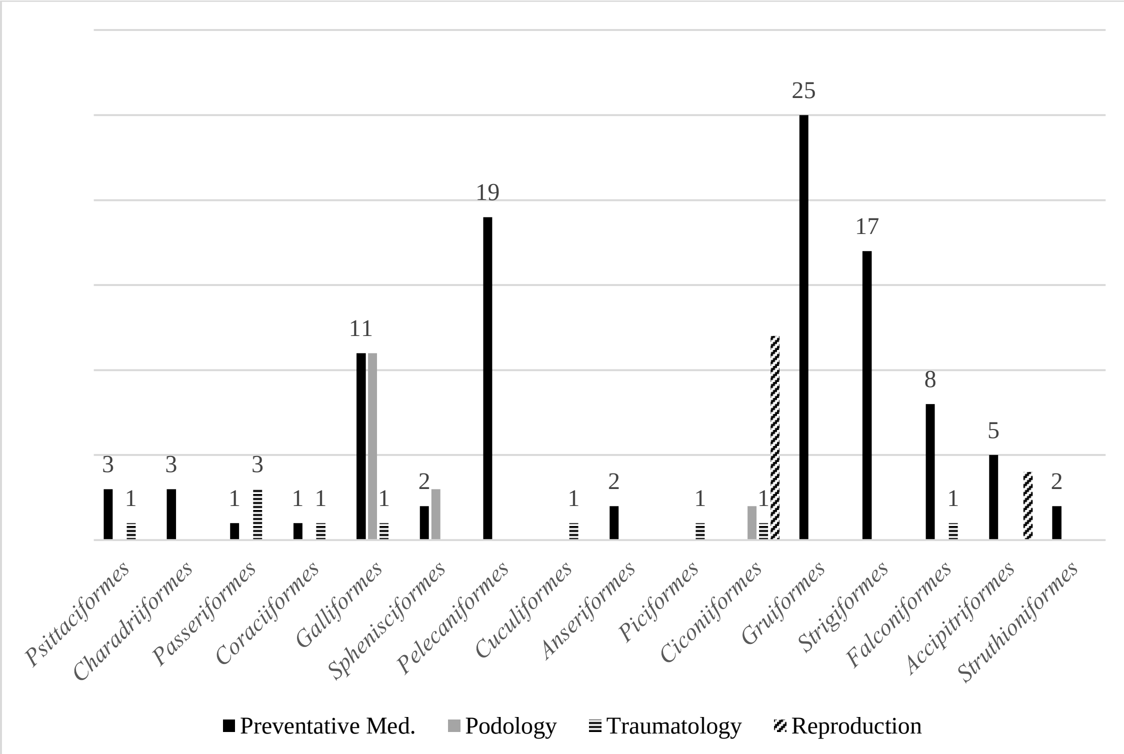
Dermatology was the field of veterinary medicine were the majority of fish and amphibian cases was observed, with the exception of behavior category which was also included in the fish cases table (Table 1). Behavior cases consisted in training sessions were eels (Order *Anguilliformes*), sharks (Order *Carcharhiniformes*) and stingrays (Order *Myliobatiformes*) were trained with positive reinforcement techniques and targeting, in order to make them acclimated with routine manipulation so that veterinary procedures and husbandry could be performed in a more efficient and less stressful way. Regarding dermatology, although diagnostic procedures may be somewhat challenging and many times impractical with this type of animals (especially with fish) due to its biology, patients were usually treated empirically with therapeutics against bacterial and fungal infections; occasionally, skin biopsies and cultures would also be done. Regarding animal species, eels and toads (Family *Bufonidae*) were the type of animals with which the author had the most contact within the fish and amphibian categories, respectively.



Graphic 2 (Table 16A) – Reptiles: number of cases observed in the main clinical typology.

Within the reptile's category, dermatology was the category with the biggest case-load (17 cases), followed by quarantine examinations (10 examinations). Dermatology issues in captive reptiles were mostly related with fungal infections, UV-light burns and shedding abnormalities, which would be treated with appropriate antimicrobials (after skin biopsies and cultures), and topical lotions for skin regeneration as well as husbandry modifications for the last two. Quarantine examinations were performed in the 10 animals received at the institutions while the author was doing her externship there. These procedures were done to guarantee the good health status of the new animals during the quarantine period, before being introduced at their new exhibits. It would include full physical examinations, blood work (hematology and biochemistry) and full body radiographs. If any abnormalities were detected, further diagnostics were then pursued.

Regarding the type of animals contacted, snakes (Suborder *Serpentes*) were the most common reptile on clinics (58%), followed by tortoises and turtles (Suborder *Cryptodira* – 13%) and lizards and geckos (Suborder *Scleroglossa*- 9%).



Graphic 3 (Table 17A) – Birds: number of cases observed in the main clinical typologies.

Of a total of 181 cases of birds consulted, 99 were preventative medicine cases, followed by podology and reproduction each with 16 cases and traumatology with 10 cases. In the preventative medicine category, vaccine administrations were included, and because the author spent part of her externship in a zoo with a wildlife safari, animals within that park housed indoors during winter were all vaccinated before being released for the summer again. Because of that, from the 99 preventative medicine cases, more than 50% (61 cases) were vaccinations. Other preventative medicine procedures were mostly composed by annual physical examinations (including blood work, x-rays and other necessary diagnostics). In the podology field, pododermatitis was the most common presentation and is mostly attributed to differences between grounds of zoo exhibits when compared with natural fields. Regarding reproduction, most of the procedures assisted included endoscopic sexing of birds as well as sampling of feathers for the same purpose.

The Order *Galliformes* was the one with the biggest amount of cases observed (18%), which included domestic chicken and Guinea-fowls among others, followed by Order *Ciconiiformes* (16%) which includes storks, cattle egrets and ibis. Time of the year (most of *Galliformes* consulted were animals housed outside during winter) as well as ongoing procedures (scientific studies) with specific animals (cattle egrets) might explain these numbers. *Sphenisciformes* (i.e. penguins), *Passeriformes* (e.g. starlings, buffalo weavers, red bird-of-paradise) and *Psittaciformes* (i.e. macaws, conures, cockatiels) each represented 9% of the total bird cases with the remaining Orders representing the 39% left. Vaccinations were generally done on a high number of individuals of the same species, and because the repetition of this procedure does not provide any further knowledge increase about species biology, numbers regarding vaccinations were excluded from data evaluation in order to provide more accurate information regarding species with which the author had more contact.

Mammals was the area with the biggest case load observed during the externship. A total of 250 different cases (from 82 different species belonging to 15 different Orders) was seen, with *Carnivora*, *Primata* and *Artiodactyla* presenting as the Orders with the biggest case load (see Graphic 4).

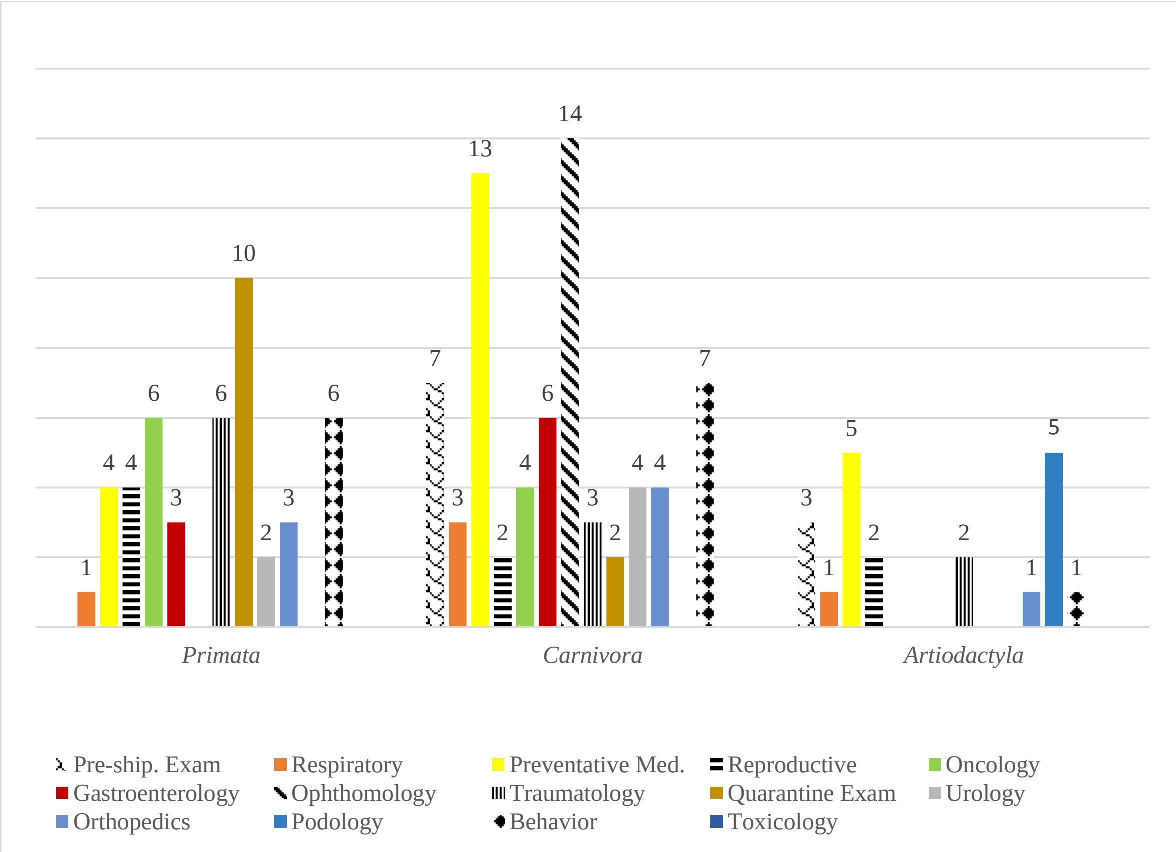
Most of veterinary procedures were done as part of the preventative medicine program of each institution. Traumatology was the area with the second higher number of cases observed (mostly primates), followed by Dermatology, Behavior and Pre-shipment/Quarantine examinations.

Table 3 shows data about all the mammal cases seen, providing information about the typology of cases as well as the mammal Order to which they belongs.

Table 3- Mammal: total cases (by Order)

Procedure/Problem	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*	12*	13*	14*	15*	Total
Pre-ship. Exam	1			7	2				3	2						15
Respiratory		1	1	3					1	2						8
Preventative Med.			4	13	2	1			5	10	9	1				45
Cardiology				5												5
Reproductive		5	4	2					2							13
Oncology			6	4						1						11
Gastroenterology			3	6	1								1			11
Ophthalmology				14												14
Pediatrics		2		3					2							7
Dermatology	2	1	2	1		2			1	2	3		3			17
Dentistry	1			2		2			1	2						8
Infectious				1												1
Traumatology	1	1	6	3			3	3	2			1				20
Quarantine Exam			10	2								3				15
Urology			2	4						1			1			8
Obstetrics		2		1												3
Orthopedics			3	4					1							8
Neurology								1		1						2
Podology									5		1	1				7
Endocrinology				1							1					2
Behavior		1	6	7					1	1	1					17
Euthanasia				1						1						2
Toxicology										1						1
Pathology			2	2				2		1				1	1	9
Wild Control														1		1
Total	5	13	49	86	5	5	3	6	24	25	15	6	5	2	1	**250**

1* Order *Macroscelidea*
2* Order *Cetacea*
3* Order *Primates*
4* Order *Carnivora*
5* Order *Lagomorpha*
6* Order *Tubulidentata*
7* Order *Diprotodontia*
8* Order *Chiroptera*
9* Order *Artiodactyla*
10* Order *Rodentia*
11- Order *Perissodactyla*
12- Order *Proboscidea*
13- Order *Afrosoricida*
14- Order *Didelphimorphia*
15- Order *Cingulata*



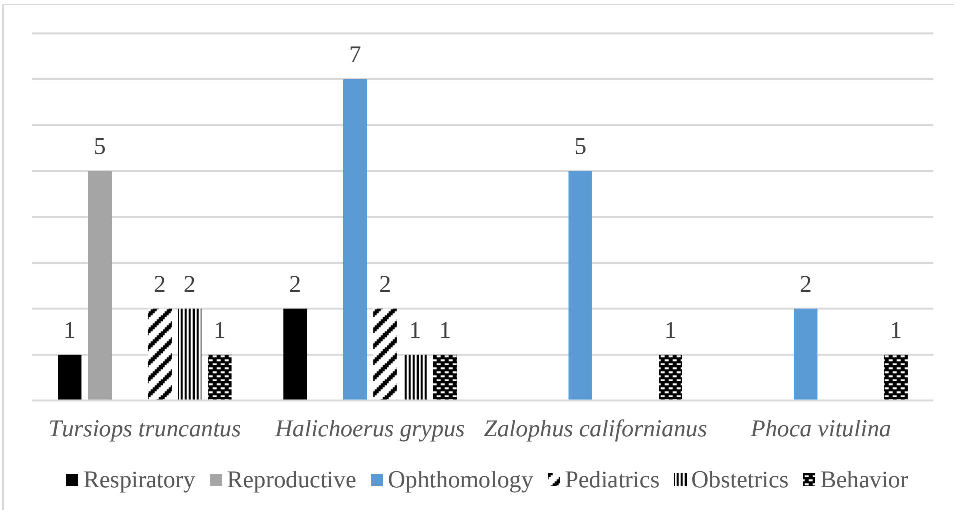
Graphic 4 (Table 18) – Mammals: number of cases in the three main Orders. (values from typologies with higher case-loads).

Of a total of 250 mammal cases, 66% were species belonging to Orders *Carnivora* (36%), *Primata* (20%) and *Artiodactyla* (10%). Most of *Carnivora* cases were ophthalmic problems, frequently observed in seals and sea lions, as these species appear to have a tendency to develop ophthalmic issues in captivity (which is not clearly known if can be related with the time they have their eyes exposed to the sun-even under water- or if can also be attributed to water quality issues). Preventative medicine was the second area with the biggest case-load, where most procedures included annual medical exams (complete physical examination, blood collection, and full-body x-rays, at the minimum). Pre-shipment exams (full physical examinations, similar with annual medical exams but with extra diagnostics tests done in order to confirm that the animal gathers all the health requirements to be transferred to another zoological institution) and behavior (which consisted in positive training sessions with the animals) had equal number of cases. More common *Carnivora* families presented on clinics were *Felidae* -32%- (e.g. lions, black-footed cats, tigers, leopards), *Phocidae* – 21%- (i.e. seals) and *Canidae* – 13%- (e.g. wolves, African hunting dogs).

Quarantine examinations were the most common procedures assisted with primates, which might be related with the period of time that the author spent at certain places where new animals had just been received. This type of examinations would include frequent physical examinations (frequency would vary according to the species), full body x-rays and also other specific diagnostic tests (adapted to the animal species in question) to guarantee that the animals were healthy and absent of infectious diseases that could infect other animals at the collection. Oncology and traumatology cases as well as behavior sessions were observed in equal number. While higher numbers of traumatology cases are expected to be observed within this Order (due to the temperament of primate species and the tendency towards trauma when this animals interact with violent behaviors), oncology might be related with the specific species that the author had more frequent contact with; certain primate species are prone to develop specific types of tumor, and the fact that the author had more contact with those species might explain the oncology case-load observed in this Order. Training, as it will be further developed in this report, is a powerful tool to manage primates in captivity, which explains why it was also a category with the second highest case-load. More common families within this Order were *Callitrichidae* -33%- (e.g. goeldi's monkey, gold-lion tamarin, cotton-top tamarin), *Cebidae* – 31%- (e.g. Common squirrel monkey, black capuchin) and *Lemuridae* – 9%- (e.g. ring-tailed lemur, black-and-white ruffed lemur, black lemur).

Regarding *Artiodactyla* preventative medicine (where procedures consisted in the same type of examinations as for *Carnivora*) and podology were the categories with the biggest case load. Similarly to domestic ruminants, the anatomy of the foot of wild ruminants make these animals as prone as cattle to develop foot problems when in captivity. Overgrowth, abscesses and laminitis were the most common problems seen in clinics. *Bovidae* – 46% (e.g. dama gazelle, scimitar-horned oryx, sitatunga), *Giraffidae* -33%- (i.e. giraffe, okapi) and *Hippopotamidae* – 13%- (e.g. hippopotamus, pygmy hippopotamus) were the most common families within the *Artiodactyla* Order.

Because of their special adaptation to the aquatic environment, marine mammals deserve special considerations in their medical care and thus, distinct training is needed in order to obtain a good level of practice with this type of animals. Therefore, a separate table (see Table 22A in Attachments) was made, collecting all cases of marine mammals observed. Grahic 6 adress the species and typology of cases:



Graphic 5 (Table 21A) - Marine mammal: number of cases observed in the main clinical typologies.

As seen before when *Carnivora* cases were discussed, ophthalmology was the most common problem presented by pinnipeds. The author had the chance of monitoring a pregnancy of a grey seal as well as the neonatal period of its pup. For bottlenose dolphins reproduction was the area with the biggest case load, and although the author only counted one ultrasound for each animal (i.e. one reproductive ultrasound for each individual of the group), this procedure would be repeated every week which gave the author the chance of assisting with many ultrasound screenings for reproductive status of each female of the group. Because at the time of the externship, there were two baby dolphins at the group (one being mother-raised and the other being hand-raised) the author also had the chance of assisting with all the techniques and care measures necessary for the success of this animals to thrive.

Of special note were the training sessions (behavior cases) assisted with the entire marine mammal group of species. Although the author only counted "one" case for each species, training sessions were observed daily (during three months), sometimes even more than once a day. At the institution where these sessions were witnessed, animals would be trained to cooperate with many veterinary procedures, including voluntary blood collections. Dolphin training session would also include behaviors to display at shows for the public.

Although each case has its own singularity and interesting facts, providing a full and complete description of every case observed during the externship is not doable. Thus, one single case was chosen to be described in a detailed manner; in parallel, and in a corresponding manner, other cases will be reported, bibliographically supported, and used as examples to highlight essential topics that must be considered in any procedure with zoological species and to demonstrate how zoological medicine works, and how every detail must be considered when working with wild species that require special attention and considerations.

PREVENTATIVE MEDICINE ANNUAL EXAM ON A WESTERN LOWLAND GORILLA (*Gorilla gorilla gorilla*)

History

A five year old female western lowland gorilla (*Gorilla gorilla* gorilla) was scheduled for its annual medical examination. The animal had no previous history of illness, however keepers and the veterinary (Vet) team had some concerns regarding the animal's weight and size, which was considered to be below normal limits for its age.

Restraint

A dart was prepared using an immobilization protocol with 4 mg/kg of ketamine and 1.4 mg/kg of Tilazol® (combination of Tiletamine HCL and Zolazepam HCL). Injection was made through a darting system, intramuscularly (IM) on the right thigh.

Eight minutes after the injection, the animal was supplemented with 1.6 mg/kg of ketamine, and after 13 minutes from the first administration, volatile anesthesia was provided with Isoflurane 5 % by facemask. Intubation was then attempted, with no success.

After 12 minutes from the initial darting, the animal started exhibiting signs of regurgitation and aspiration (coughing, endotracheal (ET) tube filled with mucous and saliva when tried to place) and so, the animal was moved from dorso-ventral (DV) to right lateral (RL) recumbency. A suction system was used to aspirate and clean the upper airway. At this point, the animal started exhibiting signs of cardiorespiratory arrest, with the heart rate decreasing rapidly; 0,17µg/kg of glycopyrrolate were administered IM in order to increase the heart rate (HR). Continuous attempts of intubation were still unsuccessful and 39 minutes after darting, the animal was taken to the hospital.

Due to the number of attempts for intubation, mild injury was done to the oro-pharynx and glottis area and so, to decrease inflammation and facilitate intubation, dexamethasone were sprayed orally pointed to those areas.

Isoflurane between 2-5 % was administered by facemask between intubation attempts and after 82 minutes of darting the animal, intubation was successfully performed with a 6,5 ET tube. The animal was then maintained on Isoflurane between 2.25-3 %.

Positive pressure ventilations (PPV) were performed 31 minutes after darting and thorough the whole procedure, until gas anesthesia was turned off.

Anesthesia monitoring was accomplished with a pulse-oximeter and a capnograph, recording the following data:

- HR: 96 - 168 beats per minute (bpm)
- Respiratory rate (RR): 20 - 60 respirations per minute (rpm)
- End-tidal carbon dioxide ($ETCO_2$): 4,0- 7,6 mmHg
- Blood oxygen saturation (SPO_2): 75- 94%
- Mean blood pressure (MBP): 32- 58 mmHg
- Body temperature: 97.2- 98.7 F (36,2- 37 ºC)

Heat ventilators and blankets were used to help maintain patient's temperature within normal limits (WNL).

After two hours and eight minutes from darting, the animal was taken back to its enclosure and two hours and 39 minutes from darting the animal started exhibiting signs of ET tube intolerance (coughing and moving).

Physical Examination

- Subjective assessment: bright, alert, responsive (BAR) before darting
- Weight: 30 kilograms
- Body condition score (BCS): 4/9
- Mucous membranes (MM): pink and moist followed by mild cyanosis that was noted and was associated with breathing difficulty (when the animal started showing signs of regurgitation and aspiration).
- Capillary refilling time (CRT): < one second
- Hydration status: WNL
- Ophthalmologic examination: WNL
- Ears examination: WNL
- Nares: slightly mucous, WNL

- Oral cavity: right mandibular pre-molar (PM) I coming in. Mild tartar noted in all teeth, but no gingivitis or excess of tooth wear. The back of the oral cavity had the redounded tissue inflamed (due to several intubation attempts).
- Cardiovascular (CV) examination (heart and lungs (H/L)): heart auscultation WNL. Lungs auscultation prior to intubation yielded significant stridor and hard listening of lung sounds. After intubation, lungs auscultation remained WNL.
- Dermatological examination: WNL
- Muscular-skeletal (M/S) examination: WNL
- Neurological (Neuro) examination: WNL
- Genital-urinary (G/U) system: WNL
- Gastro-intestinal (GI) system: intestinal content (digesta) noted on palpation. No masses, organomegaly or other abnormalities palpated.

Diagnostics

- Radiographs (Figures 1 and 2): two ventro-dorsal (VD) views performed. The first one showed moderate opacity of the left lung which was thought to be due to pulmonary collapse. Closer observation showed a deviation of the ET tube to the right side, what could be explained by accidental intubation of the right primary bronchus. The ET tube was slightly pulled out and a new radiograph was taken. The second image showed the ET tube within the trachea and fully air-filled lungs, excluding the hypothesis of a lung collapse. Heart with normal size and position. Some air noted within gastric field but with no pathological evidence. No abnormalities noted.

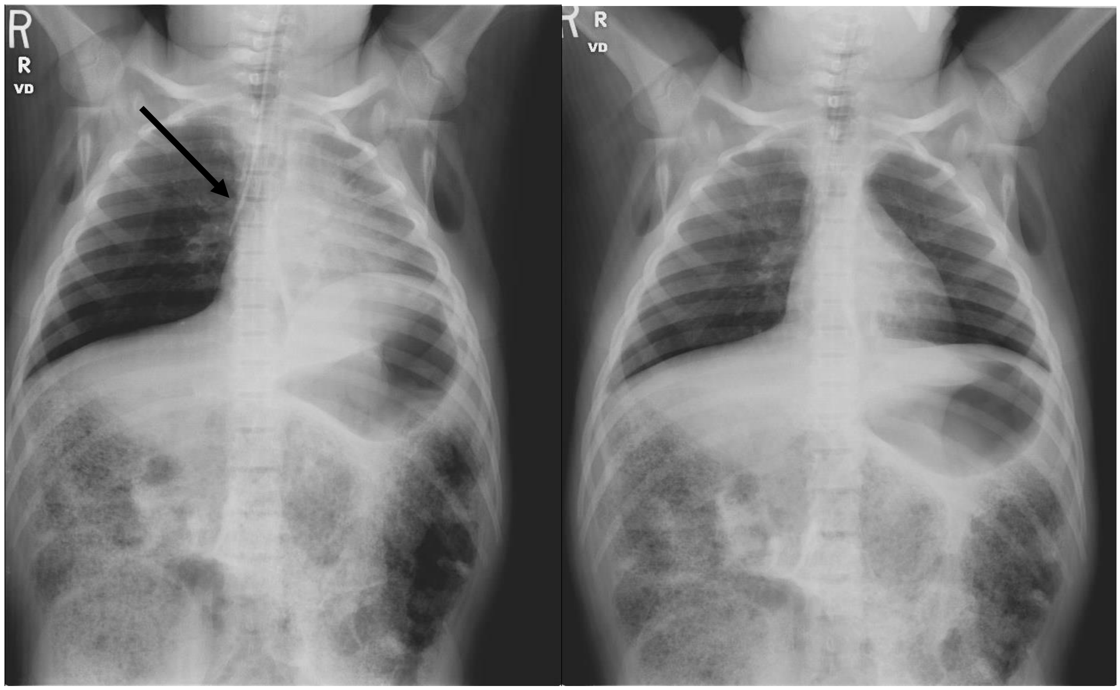


Figure 1 and 2- Radiographs taken to the patient during the annual examination. On the first image (left) moderate opacity of left lung raised suspects of pulmonary collapse or aspiration pneumonia. Note the deviation of the ET tube to the right side, indicating probable intubation of a main right bronchus (pointed by black arrow). After slightly pulling out the ET tube, a second radiograph (right) shows normal insufflation of all lung lobes, excluding the possibility of any pathologic process.

- Echocardiogram: mild pulmonic valve regurgitation
- Reproductive tract ultrasound (US): WNL
- Blood collection for hematology, biochemistry parameters and a vitamin (Vit.) D panel. Abnormal values shown on table 4:

Table 4 - Abnormal hematology and biochemistry values obtained from the blood sampled.

Hematology		
Parameter	**Patient results**	**Normal range (1)**
MCH (pg)	22	24.7- 29.3
MCHC /g/dL)	29	30.5- 33.9
Biochemistry		
Parameter	**Patient results**	**Normal range (1)**
Alkaline Phosphatase (U/L)	1169	81- 793

Glucose (mg/dL)	109	60- 92
Sodium (mmol/L)	142	134- 140
Potassium (mmol/L)	5.3	3.7- 4.7
Bicarbonate (mmol/L)	26.7	-
Calcium (mg/dL)	8.5	8.99- 10.01

MCH- mean corpuscular hemoglobin; MCHC- mean corpuscular hemoglobin concentration; pg- picograms; U/L- units per liter; mg/dL- milligram per deciliter; mmol/dL- milimol per deciliter

- Gastric sampling: a red rubber catheter was passed down the esophagus to evaluate gastric contents of the animal and submit it for culture.
- Tracheal lavage: submitted for culture.
- Vaginal swabs: submitted for cytology.
- Tuberculosis (TB) test: mammalian TB test administered at the right chest (approximately two and a half centimeter below the nipple) and right eyelid. Avian TB test administered at the left chest (approximately two and a half below the nipple) and left eyelid.

Treatments

- Fluid therapy: an IV catheter was placed in the left lateral saphenous vein. Approximately 52 ml of Lactate Ringer Solution (LRS) were administered intravenously (IV).
- 22000 International Units (IU) per kilogram of procaine penicillin G (PPG), administered IM on the right thigh
- 0.2 mg/kg of metoclopramide IM.

Outcome

Echocardiogram results showed no need for treatment of heart disease at this point; monitoring in the future is advised.

Blood-work showed values that were considered WNL by the vet team, with the exception of Calcium, that was considered to be moderately low; this could be due to a low Vit. D deficiency (given that the animal spent considerable amount of time inside the building with no direct sun access) or any other parathyroid hormone (PTH) system disturbance.

Although radiological examination showed no signs that could indicate aspiration of regurgitated material, preventative drug administration was performed with Clavamox® (amoxicillin and clavulanic acid) 12.5 mg/kg, *per os* (PO), twice daily (*bis in die*- BID) during ten days and guaifenesin 6.7 mg/kg PO, BID, during three days. If no productive cough was observed, the last drug would be discontinued.

By the end of the day the animal was displaying normal behavior, eating, drinking and moving around normally, with keepers reporting no signs of coughing or any other abnormality. The animal was released to its enclosure and reunited with its parents.

On the following day, a visual exam post- anesthesia and a TB check showed a BAR gorilla, staying close to its mom, ambulating well with no signs of tachypnea, cough, nasal discharge or exercise intolerance. Keepers reported that she was eating and drinking well and stools were also normal. The TB check yielded no swelling, erythema or redness present on either eye or chest area.

Discussion

1. PREVENTATIVE MEDICINE

Preventative medicine consists in a set of medical measures adopted in order to secure maintenance of an animal's good health status. For each animal, these measures are adapted according to its species, age, housing and medical history, with possible slight variances between different institutions. It might vary from simple vaccinations that do not require immobilization protocols, to complete medical evaluations that require the animal to be anesthetized during long periods of time, as the case described aboved.

Regarding gorilla's preventative medicine, there is a group of management approaches that include aspects on enclosures maintenance, appropriate nutrition and specific quarantine facilities as well as medical care (2). The last include, according to authors referred in (2):

- a parasite monitoring and treatment plan, where the goal will be to maintain parasite levels in a negligible value in all the gorilla population, in a way that parasitism may occur but not in a way of causing disease. Parasitic enteritis, for example, can become a serious concern by inducing uncoordinated or increased peristalsis of the intestines that can provoke a rectal prolapse (3).
- an adequate program of immunoprophylaxis;
- good communication established between keepers, animal managers and vet team, in which each animal can be monitored and personalized measures might be taken, if needed;
- a well-defined protocol for routine physical examinations and health screening programs adapted for each member of the gorilla population;
- all the medical history and other relevant information recorded in a updated medical record system (preferably computerized).

Vaccination is also an important "piece" of many preventative medicine examinations. The manual for gorilla husbandry (by the American Zoological Association-AZA) (2), as well as the American Association of Zoo Veterinarians (AAZV) guidelines for zoos and aquariums veterinary medical programs and veterinary hospitals (4) recommend poliomyelitis and tetanus vaccines for animals between four and six years of age. Rabies vaccination should be started at 15 months and then on an annual basis. Measles vaccinations is also recommended for animals, first at 15 months age and then again, between 10-12 years old (5).

Although tuberculosis is a rare disease found in great apes of North America, it has already occurred in zoos. If positive results are found with tuberculin testing in an asymptomatic animal, further diagnostics should be performed (2) (i.e. gastric lavage with sterile saline, stool sampling and tracheal/broncoalveolar lavage, all for acid fast staining and mycobacterial culture). The Animal Research Advisory Committee (Office of Animal Care and Use), provides a manual (6) with guidelines for prevention and control of tuberculosis in nonhuman primates, where the following grading system for response evaluation can be found (Table 5):

Table 5 - Grading system for assessment of TB test reaction in nonhuman primates (adapted from "Guidelines for the Prevention and Control of Tuberculosis in Nonhuman Primates- Animal Research Advisory Committee).

Observation	Interpretation
0: no reaction	Negative
1: bruising	Negative
2: erythema of the eyelid but no swelling	Negative
3: erythema of the eyelid and slight swelling	Suspect
4: erythematous, swollen and drooped eyelid	Positive
5: swelling and /or necrosis of the eyelid, eye closed	Positive

Prevention and control of this disease is crucial, not only because of its potential for causing morbidity and mortality (in an enormous variety of zoo species), but also because of its zoonotic potential (7)

2. PHYSICAL EXAMINATION

Physical examination is the main topic when the goal is to perform a routine annual health screen (like on the above described case) where any abnormalities may be detected or, in their absence, a healthy status may be proved; its importance relies also on guaranteeing the protection of the remaining group when an infectious disease is detected (2).

The AZA recommends the following steps for a thorough routine physical examination in gorillas (2):

- Accurate body weight, accompanied by a qualitative assessment of the animal's BCS (e.g. cachexy);
- Ophthalmic examination, including fundic exam;
- Oral examination that include gingival buccal tissues, tongue, sublingual tissues, teeth, pharynx, glottis and tonsils assessment;
- Nasal examination with a speculum;
- Visualization and palpation of the axillary, perineal and inguinal region, hand, feet, fingernails, toenails, penis and prepuce or vulvar lips ;
- Otic examination with visualization of the ear canal and tympanum;
- Auscultation of all thoracic quadrants, listening from both anterior (dorsal) and posterior (ventral) aspects;
- Auscultation of the entire abdomen: this should be made in both supine and sitting positions;
- Abdominal palpation: this should be made in both supine and sitting positions;
- Blood collection for: complete blood count (CBC), serum chemistry panel, serum for banking and viral titer panels;
- Sterile rectal swabs for bacterial culture of the most prevalent enteric pathogens (e.g. *Salmonella sp., Shigella sp., Campylobacter sp.*);
- Rectal palpation: males- anus, distal rectum, prostate; females- anus, distal rectum, reproductive tract (including cervix, uterus and ovaries);

- Females: vaginal examination beginning at six to seven years of age. Include speculum examination to visualize the opening of the cervix. Perform a vaginal/cervical cytology if indicated;
- Males: testicular palpation and caliper measurement, including assessment of firmness of tissue and symmetry;
- Noninvasive measurement of blood pressure in the supine, lateral, and sitting positions (cuff technique);
- Radiological examination of the thorax at least every four years that include imaging of the lungs, heart, and great vessels;
- Ultrasound of soft tissues, particularly of female reproductive tracts in animals with poor reproductive histories and the heart of animals with any indication of abnormal cardiovascular function;
- Intradermal tuberculin testing at least bi-annually. *"It is suggested that the eyelid of only one eye be injected with the human tuberculin and other sites (e.g. peri-areolar) be injected with the human tuberculin and avian antigen tuberculin in separate sites. This will assist in potential differentiation of any positive reactions detected in the eyelid."* (2)

Although these actions are recommended for gorillas kept in captivity in general, differences might occur according to each institution's policies or veterinary decisions.

In this patient rectal palpation or rectal swabs were not performed, probably due to frequent catch of feces (by the keepers) from the ground of enclosures that would be consequently analyzed at the zoo's laboratories.

a) Anesthesia-related changes

In order to be able to detect any abnormalities, one should be familiar with "what is normal". Particularities of each species anatomy and physiology must be well known in order to perform a thorough exam. The presented case is a good example that demonstrate how specific anatomy (and physiology) features of the patient might influence interpretation of examinations results; for example, great apes, in general, have fairly short tracheas (8) and therefore erroneous intubation of a primary bronchus might easily happen if the ET tube is inserted too deep (9). The apparent collapsed lung observed at the first thoracic radiograph was actually an insufficient insufflation due to excessive advance of the ET tube through deeper airway structures. This subject will be further developed in the section of anesthesia.

Ability to distinguish what is abnormal from what is normal but changed by anesthesia, is a particularity that has an important role when examining an anesthetized animal. Effects of anesthetics in vital signs can be predicted, enabling the veterinarian to better understanding how to interpret recorded values (10). However, in some cases, interpretation of anesthesia impact on vital signs might be challenging, if no data on conscious values are available. In one study (11), normal HR in two conscious gorillas conditioned by positive reinforcement training was obtained, showing surprising values when compared with those available from anesthetized animals: it was expected that anesthesia would decrease HR but instead, values of awake animals are lower than those recorded in anesthetized animals even under volatile anesthesia. Higher values of HR in anesthetized animals may also be attributed to the use of dissociative anesthetics (e.g. ketamine, tiletamine) (10).

3. DIAGNOSTICS

Nowadays the use of complementary diagnostic tests as guidance for further medical evaluation is an indispensable tool in veterinary medicine and zoological medicine is no exception. During the externship period, the author had the chance to assist with several diagnostics work-ups, including the use of a CAT machine in one of the institutions visited. The text bellow is a summarized explanation of the importance of the main diagnostics procedures witnessed during the externship period:

a) Radiology and Ultrasonography

Radiography provides a rapid, noninvasive mechanism for evaluating certain structures (12) within and surrounding a chosen area of the animal's body. For every annual examination of any animal, at least two radiographic projections (usually VD and RL) of the animal's whole body (including head, limbs and tail), should be taken, in order to compare with previous examinations and detect any changes that, although may not be symptomatic yet, if not treated early enough might progress to a pathologic feature. For certain species, this evaluation should also be adapted to predisposed diseases that might affect those animals (e.g. hip-extended VD view to assess joint congruency (13) for hip dysplasia in canine zoological species).

Ultrasonography in veterinary medicine has had a great impact in diagnostic accuracy and quality of animal care (14). It allows the identification of distinct internal features of soft tissue structures and organs that are not possible to distinguish with radiography (14). For example, a radiographically enlarged liver may indicate the presence of a hepatic mass, diffuse parenchymal enlargement, or hepatic lipidosis (15). Distinction between these soft tissue radiographic lesions can then be possible with ultrasonography. Hepatic myelolipomas affecting goeldi's monkies (patients with which the author had considerable contact) are a great example to this, as initial assessment of animals with whole body radiographs could easily identify hepatomegaly, but only after abdominal ultrasound hepatic masses could be identified and a presumptive diagnosis of hepatic myelolipomas could be done, based in what is described on the bibliography (16, 17) and previous detection in other individuals.

Nevertheless, the complementary role of diagnostic-quality abdominal radiographs on the evaluation of suspected abdominal disease still plays an important role, and x-rays can also supply information about the musculoskeletal system (e.g. detection of fractures) (14).

The main application of ultrasonography is the abdominal examination, followed by echocardiography (14). Thoracic ultrasonography is also useful for assessing pleural disease, mediastinal masses, and peripheral pulmonary lesions (14). *Smith et al.* (18) describe changes detectable with ultrasounds associated with pleuropulmonary diseases in bottlenose dolphins (*Tursiops truncantus*). Thoracic ultrasound was determined to be a valuable diagnostic tool for detecting pleural and pulmonary diseases in this species (18), especially due to this animal's propensity to the develop this type of disease. The author had the chance to assist with this diagnostic method to detect areas of lung consolidation in a bottlenose dolphin calf, for example.

Reproductive assessment of animals can also be easily done with regular ultrasonography of reproductive structures (19), helping to determine fertile periods for inseminations, pregnancy controls and predict time of parturition, for example (Figures 3 and 4).

Figure 3- An associate veterinarian at the Brookfield Zoo, Dr. Jennifer Langan performs an ultrasound on a pregnant bottlenose dolphin, assisted by a marine mammal keeper and a veterinary technician (Picture taken from the official Facebook page of the Institution).

Figure 4- Ultrasound graph of a bottlenose dolphin at the Brookfield Zoo. (Picture taken from the official Facebook page of the Institution)

Finally, ultrasonography in veterinary medicine can be very useful for ultrasonography-guided fine-needle aspirations and biopsies (14). It can safely and accurately guide a needle into a nodule or mass, to perform an abdominocentesis, thoracocentesis, pericardiocentesis, cystocentesis, or biliary centesis, increasing the safety of each procedure when small volumes of fluid are sampled (14).

<u>b) Bronchoscopy and Endoscopy</u>

These diagnostic tools are very useful in both non-invasive diagnostic and therapeutic procedures that can be performed in airways, digestive tract, coelom, in several species not only for examination but also to retrieve foreign bodies or collecting samples for further analysis (20). The author had the chance to participate in procedures such as removal of coins from the digestive system of humboldt's penguins (*Spheniscus humboldti),* collecting several samples from the GI tract of a black-and-white colobus monkey (*Colobus angolensis palliates*), a coelioscopy of a twist-necked turtle (*Platemys platycephala*) (a technique that might also be used to perform surgeries aside of diagnostic imaging (21)), among others. Of note, was of a bronchoscopy performed in a bottlenose dolphin (*Tursiops* truncantus) where examination of the lower airways and collection of samples were performed. Bronchoscopies are extremely valuable tools for assessing of this animal's respiratory status as respiratory disease is common in cetaceans and the use of this diagnostic tool permits early diagnosis of the condition (22, 23).

c) Computed Axial Tomography:

CAT is a sectional image obtained free of superposition by overlaying structures (24). Images can be obtained in transverse, dorsal, sagittal and oblique planes (24). Due to issues related with access, animal/staff safety, and logistics with animal transport, incorporation of CAT in zoological medicine remains fairly limited and is primarily restricted to challenging clinical cases, high-profile specimens or for research purposes (24). When planning to install a CAT unit at a hospital, the associated costs are substantial and there is also the need for staff training and education to become proficient with the unit operation and image interpretation (24). However, immediate unlimited access to a scanner provides an increased level of veterinary care for the patients (24): the use of CAT can provide diagnostic benefits that are not available with other imaging modalities and may accelerate reaching a diagnosis in many cases (24). Routine CAT use for dental evaluation is a valuable tool in species where adequate oral visualization is challenging (e.g. aardvarks, rodents) (Figure 5) and whole body scans can be performed during regular exams to begin establishing a database of normal CT anatomy (24). Scans can also be done to a specific area of the animal's body, as the author had the chance to assist with several zoological species. The author had the chance to assist with a CAT to a bottlenose dolphin (*Tursiops* truncantus) and witness its tremendous impact on diagnosis of respiratory disease, as this condition is known to mainly affect the pulmonary parenchyma instead of large airways (22). CAT can also greatly improve the ability to diagnose respiratory disease in chelonians, for example (25) as the author also had the chance to assist during her externship.

Figure 5- A veterinary technician and a veterinarian preparing an aardvark (*Orycteropus afer*) at the Brookfield Zoo for a CAT scan. (Picture obtained at the website http://www.deseretnews.com/article/700023038/Zoo-finds-high-tech-tools-to-see-aardvarks-teeth.html?pg=all, on 01-23-2015)

For the western lowland gorilla and other great apes, CAT also add benefits to diagnose several diseases. *Pinto A. et al* (26) describe a case of an orangutan with soft paresis of the pelvic limbs where the survey radiographs revealed spondylosis at the thoracolumbar and lumbosacral regions and with the help of a CAT it was possible to diagnose an extradural compression that was accountable for the pelvic limb flaccid paresis. In another study, *Steinmetz H. et al* (27) found that with the use of CAT, early detection of sinusitis is possible, enabling the early initiation of treatment and preventing it to progress to air-sacculitis, a common disease affecting these animals.

Finally, as a last example of the applications of advanced diagnostic modalities like the CAT, *Alonso-Farré et al.* (28) conducted a study where the aim was to provide a detailed anatomical description of the thoracic areas and features in two species of dolphins and to compare anatomical cross-sections with CAT and magnetic resonance (MR) images. As a result, those authors were able to obtain a complete bi-dimensional atlas and a complete reference guide for the interpretation of imaging studies of the thoracic structures of the two species of dolphins.

4. TRAINING AND ANIMAL BEHAVIOR

"*Nurse sharks swimming into a stretcher for weights, a baboon presenting its arm for insulin injections, a killer whale allowing its tooth to be drilled, a tiger submitting to ultra sound exams, and an endangered black rhino allowing blood to be drawn from its ear*" (29)- all realities that can be accomplished nowadays.

a) Positive reinforcement training: what are the benefits?

Training is one of the cornerstones to have a good animal care program for maintenance of wild species in captivity (29); a behavior management component is just as essential as proper veterinary care, good nutrition, and an adequate environment. Training is a method based on proven scientific principles. Burrhus Fredric Skinner, cited by (29) defined operant conditioning as the learning that occurs when an animal's behavior is modified by the consequences that follow it; most training programs follows this "theory" (29), using positive reinforcement techniques, and the goals include the ability to train and accustom their animals to a wide range of husbandry and veterinary procedures (30) having added benefits like reduced stress on the animal, reduced use of anesthesia and reduced need to separate animals from their social group for many procedures that facilitate evaluation of an adequate health status or make animals more habituated to situations that, when no training is provided, can carry great stress for the individual (e.g. injection of anesthetics by hand with voluntary presentation of the limb *versus* injection with a darting system in a stressed animal unfamiliar with the vet team or the confined space where was placed for darting).

b) Animal considerations

Gorillas, as all the other members of the great apes group (i.e. chimpanzees and orangutans) are nonhuman primates with a complex social dynamic that, when disrupted, can bring serious consequences; for example, the removal of a dead infant to its mother can be extremely traumatic, as these animals are known to do mourning (31). Emotional needs of animals must always be taken into account, in order to guarantee that any procedure is performed with professionalism, delicacy and respect, as many times we are talking about feelings very similar to those experienced by the human being (e.g. grieving process) (31). With positive reinforcement animals are desensitized to frightening or painful events and gain the opportunity to voluntarily cooperate in these procedures, rather than being forced to comply (32).

Each time that a training session is used, the goal is that verbal or gestural commands elicit the desired response from the animal; it can be used to train animals for public shows (e.g. teaching dolphins waving with their flippers) or to train animals to present parts of their bodies that allow routine examination or simple medical procedures (e.g. training an otter to open its mouth for evaluation of the oral cavity). No animal should be forced to engage in any training session: sessions are voluntary and animals are positively reinforced with pleasurable rewards for the desired behavioral response (30). It is inhumane to force an animal to perform any action against its will; this is a general quote, valid for any species, knowing that animals do not have the innate ability of knowing human languages or gestures, that forcing an animal (to do anything) against its will provokes high levels of stress and frustration, and that many animals have complex emotional and psychological developments, that need to be considered when working with them, in order to get their compliance instead of their fear and frustration. Punishment, which by definition is used to eliminate a behavior, is only appropriate in a life threatening situation for person or animal (32).

c) Stress

Nowadays stress is a concept studied well enough and is well documented that it can be experienced by a wide range of animals, from the very little zebrafish (33) to reptiles like crocodiles (34) and extremely intelligent mammals like dolphins (35). In zoo animals, measurement of glucocorticoids in feces, urine and saliva is the primary mean of studying stress responses (36). If an animal is not exhibiting the requested behavior, alternative ways of continuing with the training session should be used: asking for a different command, for example, may be enough for the animal to relax and be ready to provide the previous requested (and not given) behavior, instead of ask insistently for a behavior that, for some reason, the animal is not displaying as it should. Regression should be used when behavior deteriorates: it is normal for animals to forget or get confused; taking a few steps back can refresh their memory and get them back on the right track (29), reducing stress experienced by the animal. On the other hand, and regarding errors made by trainers, it is usual when dealing with problem behavior or medical issues that the biggest mistakes are made (29). If a needle is inserted and the animal remains calm, but the operator could not get the sample he/she was looking for, it is not the animal's fault (29); the tendency, will be trying to get the sample again, but asking the animal to perform the behavior again can sometimes cause it to deteriorate, unless the repetition or the extra time was already a part of the training (29).

"Dominance and submission" concepts should not be included in these techniques. If an animal is being trained, we want its compliance, its trust and its will to perform the commands that are being asked for; no fear should be included in these sessions, and this should be looked at as "symbiotic" relationship, instead of a "competition" for hierarchy positions (as it occurs when dominance and submission concepts are used). Training must always be looked like something that will allow humans to better assess and/or manage an animal at the same time that the latter is in a voluntary and as much relaxed as possible position, taking equal advantage of the procedure as humans (e.g. blood collection in change for the animal's favorite meal).

d) Trainers, training skills and the Veterinarian role

Trainers in a zoological setting should be skilled professionals with experience in both animal care and animal behavior. All animal care personnel must recognize the importance of training, know the necessary skills to implement a good behavioral management program and to be aware of the most common difficulties that can cause a training program to fail (29). Planning is the “key” to be prepared for all the circumstances and should include knowing the short and long-term goals, as well as knowing that if a plan doesn’t work it should be changed, keeping in mind that is a dynamic process.

There is no one better to assist with training of an animal than its own keeper. The less number of species one has to take care of, the deepest is the knowledge that that person possesses about those species and, most of all, about certain specific individuals within the group. Keepers have the ability of establishing close relationships with animals to which they provide daily care; they are the ones who prepare and provide their food, who clean their enclosures, who participate on the search for new ways of environment enrichment and the ones that will have the time for gaining animals trust and pursue with daily training (37). Nevertheless, veterinarians can have a tremendous impact on the ability of keepers/trainers to train their animals successfully (29). Animal welfare is the responsibility of the whole team, working together and committed to shared principles (38), and the veterinarian should be aware of the interactions and expectations of everyone involved (37). Regarding training, if the vet has the appropriate communication skills, he/she may greatly influence the trainer on the next course of action, even when ideas might not be shared. As so, the following “rules” should be applied when preparing and performing a procedure:

- Communication: veterinarians must communicate their plans, needs, and expectations to the animal care staff far in advance of a visit or exam (38). Likewise the trainers must communicate their plans needs and expectations to the veterinary staff. (29)
- Understanding: all staff should understand each person’s function and responsibility. (38)

- Respect: each staff member has unique skills and talents that they use in their jobs; it is important to respect those abilities. (38)
- Evaluation: after each procedure there should be an analysis of what worked well and what didn't, so that corrections can be done for future procedures. (38)

e) Environmental enrichment

A complete program of animal welfare is not all about training. Gone are the days when animals were residing in concrete and iron barred exhibits (37). Today, more naturalistic and interactive exhibits, that allow animals to make choices about and within their environments (37), are the standard-of-care regarding enrichment. Animal training and enrichment are now the forefront of zoo animal husbandry and the American Zoo and Aquarium Association is now including enrichment as a requirement for accreditation (37). Appropriate enrichment and care methods should be identified for each species, and meet their physical, social, psychological, and physiologic needs (30). Providing environments that stimulate a greater range of natural behaviors, decrease stress and increase activity (giving opportunities for choice, control, and positive reinforcement) have been linked to improved behavioral and physical health in a variety of studies (39, 40) and should be provided as soon as possible, in order to avoid behavioral disturbances to develop.

f) Behavioral disturbances

Animals that do not display an adequate behavior become a problem from the public's perspective (no public will enjoy to watch an aggressive animal towards its group) (41), as well as from a veterinarian's point-of-view (questions about animal welfare arise when keeping an animal isolated from its group- due to inability of establishing affiliative relations- becomes an option). When behavioral/enrichment programs are instituted after the need arises, there is a delay in correcting the problem (30). A list of behavioral priorities should be developed for each species, and selected species and/or individuals should be identified by the veterinary, animal care, and behavioral husbandry staff and defined as high priority ones for training and enrichment (30). Multiple parameters must be evaluated for a complete assessment of an animal's welfare, and this include its biologic function (e.g. growth, reproduction, ability to maintain homeostasis), its health (e.g. absence/presence of disease or injury), and its behavior and social functions (e.g. adaptation, emotional states, preferences) (42). Care should be taken when interpreting literature about these subjects, as animals in zoo can present behaviors quite different from those they would display in the wild (41). In the gorilla's case, individuals born in captivity tend to display more aggressive behaviors when compared with analogue situations in the wild, and the less space is available for animals to escape or protect themselves, the biggest the chance of conflicts to happen (e.g. the separation of an infant from its mother might lead to an extreme stressful situation that can culminate with the death of the infant) (43). Psychoactive drugs used in great apes to try to curb aggression have not been successful yet (44).

Besides that, because husbandry measures, team education and facilities differ from place to place, the same animal might present very distinct behaviors according to the institution where it is housed (41). It should also be noted that displayed behaviors change according to the season of the year, the hormonal state of animals (31), as well as the age of the individuals (45).

Regarding behavioral disturbances, the ability to list and understand the functional relationship between a dysfunctional behavior and the environment around is extremely important when trying to solve it (39). Auto-aggression or self-directed behavior, for example, are behaviors that have been alleviated or reduced by providing enrichment activities designed to provide more opportunities for natural behaviors such as foraging or food manipulation (40).

g) Stereotypic behavior

There are, however, situations in which simply improving the environment did not always completely stop the problem (46): stereotypic behavior is the greatest example of it. This is one of the more common problems seen in captive wild animals, and the question remains the same: "why do some animals develop stereotypies while others in the very same environment do not?" (46). Stereotypies are defined as invariant, repetitive behavior patterns without obvious goal or function (46). Some specialists suggest that stereotypies are the equivalent of a “mental scar” and that besides the presence of frustration, they also reflect some level of brain dysfunction (46). The hypothesis that environmental constraints for captive animals leave them in a constant state of high motivation, has been considered by many as the more likely cause of stereotypies (46); however, it is now known that a variety of developmental and genetic factors may predispose individuals to develop this problem (46). Studies in horses and voles found that animals with stereotypies had higher levels of endogenous opioids (suggesting neurochemical differences between animals) and that offspring of mothers who exhibited stereotypies had higher incidences of stereotypies themselves when compared with offspring of the non-stereotyping mothers, respectively. Also, it is now known as well that animals raised in confined spaces during the early weeks, months or years of their development have fewer neurons in their brains, decreased dendritic branching and spine density, reduced synaptic connectivity and a higher incidence of stereotypies than animals raised in enriched environments. For the western lowland-gorilla, for example, knowing the natural relationships among animals is crucial for a good management of the species in captivity, but there must be kept in mind that wild-born individuals deserve different psychological considerations from those who were born in captivity (45). Thus, lack of environmental complexity can be damaging, especially on young, developing animals, and a malfunction in the circuitry involving the basal ganglia and the prefrontal cortex has been shown to preserve the behavior, the inappropriate repetition of it and cause an inability to shift goals. Likewise, situations that cause severe stress, such as early or abrupt weaning, can also lead to abnormal neural development (46). Another factor that influence an animal’s adult behavior is the type of rearing that it received: hand-rearing animals tend to present more social behavior disturbances when compared to mother-reared ones (41), and this applies also to the species presented in this case, the western lowland gorilla (45, 47). Early environmental complexity has a prophylactic effect against this disturbance and environmental enrichment effectively decreases the performance of stereotypic behaviors by 50% in most cases (46). However, “decrease" is not “elimination”, and it is notable that most programs fail to completely eliminate the behavior. This can be explained by the fact that repetition strengthens the behavior by sensitizing the neuronal pathways involved and so, treatment plans should be initiated immediately upon discovering an animal engaging in repetitive behaviors, in order to be most effective (46).

In conclusion, and being aware that staff time consumption is the only disadvantage for implementing an animal training and enrichment program, the following statements should be kept in mind:

- Enrichment can mean the difference between an animal exhibiting appropriate or stereotypic behaviors (37);
- Training and enrichment give keepers additional contact and time with the animals, consequently allowing for more opportunities to observe the individuals and detect potential medical problems (37) ;
- With training, animals will have increased trust in the veterinary staff, as they constitute a positive aspect of the animal's lives (37);
- An animal is learning all the time, not just when a training session is taking place (29). Every interaction that humans have with animals at their care creates a "learning" opportunity (39).
- No matter what is the role a veterinarian plays in a certain situation, if we don't help making decisions, we'll have no basis for complaining when they have been made by others (42).
- In cases when, for some reason, animals are not acclimated with training techniques yet or if a certain individual is less cooperative in these sessions, other type of techniques may be used to collect biological material (for example) that will provide useful information about the animal health status (e.g. collecting saliva from discharged food in order to perform hormonal analysis and develop new diagnostic techniques (48)).
- "*Above all, do no harm*" (40).

5. ANESTHESIA

a) Do we really need to anesthetize this patient?

Because of great apes' strong group relationships with an organized hierarchy, every time an animal is removed from its group for a medical evaluation, consequences of these actions must be balanced. Rejection by the group or loss of its hierarchical position are possible consequences every time an animal is separated (even for a brief period of time) from its group to be medically evaluated. Besides that, in the case of gorillas, removal of the dominant individual, even just briefly, might also cause instability in the remaining group that was under its "command" (e.g. removal of the dominant silverback leads to an increase of aggressiveness between females (49)); furthermore, anesthesia itself carries inherent risks and so, the clinician must balance the risks with the benefits of improved diagnostics and treatment options for these large and powerful animals (50).

b) The importance of a good plan

Even for very cooperating animals with training techniques, in order to perform a complete and safe physical examination in a gorilla, general anesthesia is required to insure patient and caregiver safety (50). Although many studies were performed in gorillas anesthetized in the wild, there are significant differences between doing it in the wild or in captivity; fasting is one of them (51). Duration of fasting should be adapted for each species. In the case of gorillas, animals should be fasted of food and water 12-24 hours before anesthesia (10) (realizing that this change of routine may make patients wary of veterinarians and staff) (50).

When preparing an immobilization, as well as for any other procedure, planning is the "key" to success. First of all, security must be guaranteed for both the animal and the human team. Assuring clear exits and paths to work area, having appropriate means to transport the animal following induction, adequate preparation for anesthetic emergencies, planned emergency response procedures in the event of an animal awakening/escape and being prepared in the case of an accidental human drug exposure or injury occur, are all vital to complete planning for anesthetic events in great apes (50) as well as many other dangerous zoological species. The team is expected to follow safety protocols and practice policies that should be included in the orientation of every new team member. The leader of every activity should emphasize that it is mandatory for the entire team to follow safety protocols (52). When in close contact to any primate, facemasks and latex gloves should be obligatory items in order to prevent pathogen transmission to humans by the animal and vice-versa (51).

c) Choosing an anesthetic protocol

The next step of an anesthetic plan, is the choice of drugs. Factors like species involved, immobilization conditions, comparative published data, and the level of anesthesia depth desired should determine which protocol fits better (53). Anesthetic management can be difficult in sick or injured animals (51). In zoos, where previous medical records are available and can provide details about a certain patient's history, it is easier to adapt an anesthetic protocol knowing the animal's current health condition.

The ideal protocol/drug is the one that will promote a quick but smooth induction, has no systemic adverse effects for the animal, induces a safe sedation/tranquilization/anesthetic state for both the animal and the human team, is reversible, allows a calm and also fast recovery to the normal demeanor, and the necessary dosage may be administered in a small volume (54); such as not been found so far. However, in all immobilization settings, the main goal is to provide smooth and fast inductions, adequate depth of anesthesia for the following procedure, and calm, uneventful recoveries; and such, is doable. Shorter recoveries are generally advantageous because this is a time when there is greater potential for human and/or animal (including gorillas) injury (51).

Many injectable drugs have been tested and used for immobilization of gorillas, and usually they are used for inducing an animal to a state that allows safe human approach and supplementation with more anesthetics (injectable or volatiles).

Table 6 provides information with examples of types and range of dosages of injectable anesthetic induction agents used in great apes):

Table 6 – Examples of induction protocols used in great apes (adapted from (10)).

Drug	Chimpanzee	Gorilla	Orangutan
Ketamine	5-2 mg/kg	6-10 mg/kg	6-10 mg/kg
Ketamine/xylazine	10-20/1 mg/kg	-	5-7/1-1.4 mg/kg
Ketamine/medetomidine	2-5/0.02-0.05 mg/kg	2-5/0.02-0.05 mg/kg	-
Ketamine/midazolam	-	9/0.05 mg/kg	1-2/0.03 mg/kg
Telazol	2-6	2-6	2-6.9
Telazol/medetomidine	1.25-0.03-0.04 mg/kg	0.8-2.3/0.02-0.06 mg/kg	-

Induction time is defined as time from injection to recumbency (51). One should only approach an animal when recumbency is achieved and should do it by approaching the animal by the back of it and before becoming an easily reaching target (in the case that the animal arouses), touch it with an instrument (e.g. a pole) that can prove that the animal is not reacting to sensory stimulus. Calmness and silence should remain thorough the procedures, as some animals can easily be aroused by noise under the effect of certain drugs (e.g. alfa-2-agonists).

Considerations such as length of the anesthetic event, involved procedures (e.g. painful procedures, high risk), transport of animals, all may influence the choice when deciding how to maintain anesthesia (50).

Three main groups are available for constituting the basis of an anesthetic protocol (despite the type of other drugs that may be used in combination to improve effects): alfa-2-agonists, opioids and dissociative anesthetics. In apes (and other animals) with suspected cardiac disease that require anesthesia, alfa-2-agonist are currently contra-indicated. *Faber et al.* (55) describe a surgical procedure in which immobilization was accomplished with medetomidine and ketamine and anesthesia was maintained with isoflurane. Although no anesthetic/cardiac complications were reported, neither that was the aim of the study nor the animals were within the indicated age where cardiac disease can be detected (all animals were young and healthy). More details on cardiac disease will be addressed further on this report. Administration of alfa-2 adrenergic agonists typically results in rapid and pronounced vasoconstriction that makes blood pressure increase impressively (10). A physiological response is triggered in an attempt to maintain blood pressure within physiological limits by increasing vagal tone and slowing heart rate that in some cases can decrease by 50% to 75% (10). Occasionally, second-degree atrioventricular blocks are obsrved (10). IM and oral administration (instead of IV) tend to decrease the incidence of profound bradycardia (10). After the initial direct vasoconstriction occurs, vasodilation and reduction in blood pressure may be seen (10). This is more prominent in primate species (10). Medetomidine, for example, decreases cardiac output by increasing cardiac afterload through intense peripheral vasoconstriction in gorillas (50).

Primates are extremely sensitive to opioids; these narcotics have been studied to use as pre-operative sedatives, but respiratory depression, cyanosis and increased risk of aspiration due regurgitation of food material are cons that must be considered (50). Oral formulations have been developed and used in order to investigate its applications for inducing great apes without having the adverse effects expected with parenteral administration. *Kearns et al.* (56) studied the efficacy of transmucosally absorved carfentanil in chimpanzees after oral administration of droperidol, a butyrophenone tranquilizer that potentiates the ventilatory response to hypoxia; its use in combination with an opioid reduces the dose of the narcotic required for induction and, therefore, decreases the potential for respiratory depression. After carfentanil administration, all animals showed a gradual increase in sedation characterized by recumbency and progressive unresponsiveness (56). Variations between individuals that received the same protocol were attributed to part of the dosage being carried to the stomach on the food item, seen that gastric absorption of narcotics is extremely poor when compared with transmucosal absorption (56). All animals had pink mucous membranes throughout the procedure, but because SpO2 and blood gases could not be measured in awaken chimpanzees during the pre-induction period, quantitative data on the probable presence of respiratory depression during this time period was not available (56). As so, the authors recommend supplemental oxygen for anesthetized animals and also the preparation of a naltrexone (opioid antagonist) dart in advance as a precaution; naltrexone is the current preferred antagonist, especially when using ultra-potent opioids, as is the component that presents fewer chances of re-narcotization to occur (57).

When working with ultra-potent opioids (e.g. carfentanil, etorphine), frequently used in zoological and wildlife immobilizations, human safety measures should be carefully planned and understood by all the team members. Carfentanil, for example, is 10 000 times more potent than morphine; besides its potency, this opioids are frequently commercialized on very concentrated vials, so that volumes used can be reduced (10). This increases the risk for a human intoxication, in case of an exposure occurs, even if only with minimal amounts of drug (10). All drug vials should be carefully monitored and stored, and people handling these type of drugs should wear, at least, protective gloves and face-shield (as some of this drugs can be absorbed through mucous membranes) (10). Adequate antagonists should be drawn before the procedure, in order to be easily reached and used in case of human exposure (10). All members of the team should be trained in first aid support and cardiopulmonary resuscitation (CPR) (10).

Symptoms of narcotic overdose in humans include nausea, dizziness and respiratory depression that can easily progress to coma and cardiovascular collapse with severe intoxication (10). Rapid administration of an antagonist (e.g. naloxone, naltrexone) is vital to avoid death in this cases and support respiratory function (e.g. with an Ambu bag and supplemental oxygen) during rescue breathing can provide the respiratory support that is required until the intoxication is treated (10).

Dissociative agents (e.g. ketamine, tiletamine) can cause tachycardia and other CV changes, but they are probably the safest drugs to use as a basis for an anesthetic protocol for apes from both the handlers and the ape perspective, considering their potential for cardiac disease (50). Ketamine hydrochloride is a dissociative anesthetic that can be administered IM to animals, producing longer duration of anesthesia than IV administrations (10). It induces anesthesia and amnesia by functional disruption (dissociation) of the central nervous system (CNS) and causes catalepsy, immobility, amnesia and marked analgesia (10). It increases HR and arterial blood pressure (BP), without altering significantly cardiac output (10). It is a good choice when anesthetizing gorillas, as for this species, an important thing to take into account when choosing anesthetics is to avoid cardiac depression (58).

In the great apes group the dose of ketamine usually ranges between 5 to 15mg/kg; secretions such as saliva may pool in the oropharynx, especially when using dissociative agents (50). An anticholinergic drug (i.e. atropine sulfate, glycopyrrolate) can be used to control hypersalivation (52). Telazol® is a combination of equal parts of tiletamine hydrochloride and zolazepam hydrochloride, a benzodiazepine with tranquilizer properties (10). This preparation is commonly used in combination with ketamine and allows reduction on the amount of the latter drug needed for induction (e.i. Telazol® 2-4mg/kg and ketamine 1-3 mg/kg). The combination produces a reliable smooth induction, stable cardiopulmonary function and good muscle relaxation (50).

Another important factor to take into account when preparing drugs to be administered is to be as much precise as possible regarding the animal's weight. For animals that are trained to go on a scale on a regular basis, keepers can easily obtain an accurate weight of the patient and transmit it to the veterinary staff. However, when facilities are not provided with scales or animals are not trained to use it, weight must be estimated in order to calculate total doses to be administered. If previous records of weights (from previous immobilization procedures) are available, one can estimate the actual weight based on previous values (57). Every immobilization procedure should include weighting of the patient, not only for tracking body weight variations that might indicate health abnormalities, but also because it is crucial to be as accurate as possible when determining total doses of anesthetics, as underdoses and overdoses can both originate serious problems and put both animal and human safety at risk.

For the patient described in this case, a combination of ketamine and Telazol® was the elected protocol for the induction of gorilla. The goal of this mixture was to achieve a deep and safe anesthetic level with tranquilization provided by zolazepam (which smooth induction), as well as counteract to the adverse effects of dissociative anesthetics (muscle rigidity, potential of seizure episodes).

d) Means of drug delivery

Several ways of administering drugs have been used successfully: with behavioral training, gorillas can be trained for voluntary limb's presentation allowing injection of sedatives, tranquilizers or anesthetics, or even present body parts where small veterinary procedures can be performed through operating conditioning (59); gorillas are extremely intelligent animals and can be quite cooperatives in positive training sessions with highly qualified professionals (60), and big accomplishments can be reached with these techniques (61). Because remote methodology, such as darting, can provoke great distress to the animals as well as other physical injuries (described further down), oral premedication can be an option in order to provide sufficient sedation to allow further dosing via pole syringe or hand injection (62). Concomitant use of an anti-emetic (e.g. metoclopramide 0.4 mg/kg) might be indicated to prevent emesis and subsequent aspiration of food material (10). *Pulley et al.* (54) tested different oral protocols for nonhuman primates, using fentanyl, midazolam and ketamine, respectively; midazolam, although devoid of strong anesthetic ability when compared with fentanyl and ketamine, provides anterograde amnesia as well as anxiolysis, which is extremely valuable as great apes have the capability of memorizing human faces and making correlations between similar situations very easily. Drugs were incorporated in pieces of peanut butter and marshmallow sandwich, rice cereal, and vanilla and banana pudding in bowls and offered to animals. Most animals did not consume the medications and therefore did not become sedated as it was intended and those that ingested their entire dose experienced only mild or moderate sedation, indicating the possibility of decreased bioavailability of drugs when mixed with certain foods. Based on results like these, it was determined that for inducing agents, oral administration has unpredictable results and so, the use of this technique by inexperienced users is discouraged (10). On the other hand, *Hunter et al.* (62) developed a protocol for administration of chewable fentanyl to orangutans, chimpanzees and gorillas before a certain procedure, reducing the likelihood that the animals would become alert to a sudden change in feeding (i.e. fasting) at the time of a procedure as well as they would be less reactive to any stimulus. Animals given transmucosal fentanyl showed good signs of sedation and were less reactive and stressed (i.e. decreased movement, vocalization, and aggression toward the veterinarian) while being darted (62). Studies like these support that, although total induction with oral administration might still be risky, obtaining an adequate level of sedation has revealed to be useful in order to lessen some disadvantages of parenteral administration of drugs. In other zoo species (ungulates, for example), good levels of sedation can actually allow simple medical procedures to be done (e.g. blood collection); *Hoyer et al.* (63) report a protocol in which a standing sedation is performed in zebras, allowing the veterinarians to collect blood samples without the need of fully anesthetizing the animals, avoiding the risks related to it. This type of sedation can also be accomplished with other species (e.g. giraffes, elephants (64)) as the author had the chance of assisting during the externships period. It should be noted that regardless of the drug or combinations of drugs used, it is important to allow sufficient time after dosing to assure that peak effect has been reached before supplementing anesthesia (50).

Squeeze cages are restraining devices that have also proved to be useful for some species in the zoological field. It has one moveable wall, allowing the animal in the cage to be compressed against the opposite wall. Animals are trained to enter the device in a routine manner and, when needed, drugs can be administered by hand-injection through the barred wall, at the same time that animals are being squeezed against one side of the cage. It should be quick and uneventful, although for great apes, it might not be the better option due to animal's size, strength and intelligence (animals may be able to strike at the handler through the bars).

For cases in which none of the above options are accepted/available, remote delivery of drugs is warranted. Anesthetic induction in these situations can be quite stressful and risks are added when anesthetizing a highly intelligent nonhuman primate (62) as is the case of the western lowland gorilla. Having keepers who possess strong and positive relationships with the animal and have earned its confidence might have a strong role about keeping animals quiet, relaxed and unstressed (62). A calm and safe (devoid of materials or other group individuals that may cause injury when darting or during induction) setting should be prepared for the immobilization. Minimizing impact in the group should also be prioritized, as immobilization procedures might trigger group social disruption. If a veterinarian is already known by a certain individual (and most likely associated with unpleasant experiences), recognition of the person might be enough to cause substantial agitation and stress that might compromise the immobilization. Special attention should also be given to the fact that these animals have the ability to think with a high level of logic, and a mad gorilla will be able to take the dart of its muscles and throw it back against the veterinarian if the idea or chance comes up (65). Thinking ahead might do the difference, even in very unlikely situations that can expose the human team to great risks.

e) Avoiding problems with remote drug delivery systems

Hyaluronidase, a hidrolytic enzyme which increases tissue permeability (10) by breaking its connections, is commonly used in the wild (51) to decrease induction time, and diminish chances of losing an animal while drugs have not reached its totally effect yet, giving time for the animal to escape and becoming out of sight. Park personnel and gorilla trackers are also very important team members when performing an immobilization in the field, as they play a crucial role if animals escape between darting and recumbency (51). Such is not needed in zoo immobilizations, as animals are restrained in controlled facilities where exits are not available. Trauma, lacerations, fractured bones or pneumothorax are also possible events that can happen when darting an animal (54). Lidocaine hydrochloride 2% can be used to control dart-induced pain (51). A plan for every procedure that involves remote delivering of drugs should include studying how to act in a manner of causing the lowest stress in the animal as possible. Darting without warning may decrease the overriding effects of excitation on anesthesia (51), as the presence of veterinary staff and changes in routine (e.g. fasting) usually leads to suspicion (or recognition in cases when the animal had previous contact with the veterinarian) on the part of the animal (62, 54). Fasting, however, it is not a step that can be excluded or changed, as it is crucial to prevent aspiration (54). Injury potential with high velocity remote drug delivery systems (HVRDDS) can be reduced through various design modifications and appropriate selection of needle and charge or power setting (66).

Human safety concerns include accidental charging of a dart against a member of the team, self-injection, expelling of the drug prior to full needle penetration making the animal's skin a source of exposure, among others (10). Prior practice and familiarization with the equipment avoids mistakes to be made by an inexperienced operator while handling these materials (10).

In the presented case in this report, the animal was not trained to tolerate manual injections and so, a gas charged pistol was used to dart the animal and provide IM delivery of anesthetics.

f) Maintenance of the anesthetic event

Some short procedures do not require the use of volatile anesthesia; however, if longer periods of recumbence are needed, it is wise to supply inhalation anesthesia, in order to avoid and prevent unexpected awakes as duration of effect of the injected drugs is reached. Other alternatives as constant rate infusion (CRI), manually controlled infusion (MCI), or total intravenous anesthesia (TIVA) of anesthetic agents are effective ways when volatile anesthesia is not available (53). In wild gorilla's immobilization, supplemental doses of ketamine are frequently used to prolong anesthesia (51); however, because of gas anesthesia lower adverse effects and reversibility when compared with some injectable drugs, and because nowadays the vast majority of zoos have volatile drugs available, this is the preferable choice for procedures like the described in this document.

g) Intubation and airways control

For most of the induction agents, an adequate plane of anesthesia that allows endotracheal intubation is not achieved (manifested by swallowing, arm movement, or retraction of the tongue (50)) unless supplemental doses and/or other drugs are administered (either injectable or delivered by facemask) (10). *Hendrix et al.* (67) used successfully a low dose of IV thiopental to achieve intubation; other drugs may be used to produce the same results.

Endotracheal intubation of the patient should always be a priority rule before pursuing with any other procedures. Maintenance of airways, especially in animals without endotracheal intubation (and during recovery from anesthesia- lateral recumbency is the preferred position for animals to recover after extubation, as it allows saliva to drain (50)) can be difficult. Hypoventilation may occur due to excessive ventroflexion of the head and subsequent airway occlusion, or secondary to large, gas filled intestines and abdominal pressure on the lungs; positioning the apes on their sides or propping their upper bodies up at a slight angle (when in dorsal recumbency) with their feet in a downhill position (decreasing pressure on the diaphragm and preventing regurgitation) (51) with head and neck extended can help to counteract the hypoventilation risk (50).

Nonhuman primates present a few intubation challenges and so, adequate relaxation must be achieved before attempting laryngeal examination and intubation to minimize the risk of a bite or laryngospasm (67). Intubation can occur once the ape has a slack jaw tone, but this is a phase prone for regurgitation and aspiration to occur, so besides adequate actions to achieve intubation, close monitoring for any signs of gagging, coughing and abnormal respiratory pattern and rate must also be done (50). It should also be noted that gorillas (as well as all the other great apes) are prone to laryngospasm, especially under ketamine anesthesia (10); the case reported in this document is a good example to demonstrate it, as ketamine is a drug that preserves laryngeal reflexes (58) (which offers additional safety against aspiration until intubation is achieved but, at the same time, makes this procedure harder to accomplish, when attempts to intubate cause trauma to the glottis area further predisposing laryngospasm to develop). Applying lidocaine to the glottis area several minutes before intubation can help overcome this issue (10). Laryngospasm can also result from aspiration of gastric contents due to emesis in the induction phase (50).

For intubation process itself, long curved laryngoscopes (50) and thick-walled, armored, or reinforced ET tubes (67) can make it easier. An extremely helpful tool is a small stylette or airway exchange catheter that may be placed between the arytenoids cartilages during difficult intubations (especially when the animal is regurgitating or when it has excessive laryngeal tissue, as is common in great apes) and serve as a guide for endotracheal intubation by threading the end of the stylette through the Murphy eye of the endotracheal tube (50). Long sponge forceps with gauze or, ideally, a suction device should be available to clear the airway if necessary (either from saliva or regurgitated material). Cuffed ET tubes should be used (50) for better protection of airway and gas administration. Even intubated patients are never totally out of risk of having complications related to aspiration of regurgitated materials; a possible alternative to ET tube to help prevent even more efficiently this occurrence can be the use of a laryngeal mask airway instead of the endotracheal tube (8).

The laryngoscope blade is used to gently move the tongue outwardly to allow visualization of the arytenoids and endotracheal tube passage (50). Long endotracheal tubes can easily pass the carina and result in one-lung ventilation, as great apes have short tracheas; because of that, following intubation, the anesthetist should auscultate both hemithoraces to verify that breath sounds are heard on each side and auscultation of all lung fields should be done with concurrent use of PPV; thoracic radiographs can also be used to confirm tube placement (as it was done in this case report). If pulse oximetry readings are low during gas anesthesia in an intubated animal, withdrawal of the ET tube by a few centimeters may be enough to return the blood oxygen saturation to normal values (50). Once an animal is intubated with the right-sized ET tube, a total control of the airways can be obtained, reducing the possibility of regurgitated contents aspiration and giving opportunity for assisted mechanical ventilation if for any anesthetic or biological reason the animal stops breathing by itself or if rate and/or depth of breaths are not adequate in order to provide a good oxygenation to the body.

h) Anesthesia-related complications

Hypoxemia and hypoxia (low blood oxygen content and insufficient tissues oxygenation, respectively) commonly develop during anesthesia of many zoological species. These are life-threatening conditions in which oxygen delivery is inadequate to meet metabolic demands (67) and that are not always treated, or even detected (68). Hypoxia may result from alterations in tissue perfusion, decreased oxygen partial pressure in the blood, or decreased oxygen-carrying capacity; it may also result from restricted oxygen transport from the microvasculature to cells or impaired utilization by the last (68). Recumbency, general anesthesia, and positive intrathoracic pressure (pneumothorax, pleural effusion) predispose to the development of atelectasis, which causes shunting of blood from the right to the left side of the circulation without exposure to oxygen (69). In great apes anesthesia, hypoxemia can easily be generated by inadequate positioning of the patient and/or intubation of a single lung (50); drugs may also play a role in this process: tidal volumes may be decreased and respiratory patterns may be altered (e.g. apneustic) with the use of dissociative anesthetics and inhalant anesthetics may trigger hypoventilation (however if these agents are delivered in 100% oxygen, hypoxemia is unlikely) (50). In one study (51) low hemoglobin oxygen saturation values for three mountain gorillas, anesthetized in the wild with ketamine and breathing ambient air (SpO2 = 86.7%) caused some concern. In addition to the causes already pointed above, low values may have also been exacerbated by the lower oxygen concentration at high altitude (51). In the field, lightweight cylinders with compressed oxygen can be carried, but disadvantages like difficult refilling during remote fieldwork, explosive potential of cylinders under certain circumstances, restrictions for transportation might prevent the use of this equipment to occur as much as desirable. These are also important considerations in the zoo field, as many times anesthesia is performed at animal's enclosures and oxygen cylinders need to be carried as well (68). Portable battery-driven oxygen concentrators and other type of equipment to ensure breathing functions (70, 71) are becoming more and more available to make the use of oxygen easier in every immobilization and prevent hypoventilation to occur. Dr. Jeffery Zuba ("In case of Anesthesia") developed a mega-vertebrate demand ventilator (Figure 5) capable of providing PPV in an easy way, giving the chance of providing respiratory support for large animals that for any reason develop hypoventilation during anesthesia (72). Supplemental oxygen either via ET tube or nasal cannula and means of maintaining airway patency are recommended, even when inhalant anesthetics are not used (50 and 51). Again, planning can help reaching success, and simple measures as the following might make the difference between avoiding or treat hypoxia (73):

Figure 5 – Picture of the mega-vertebrate demand ventilator (In Case of Anesthesia: "Mega---Vertebrate Demand- edited).

- to ensure that the oxygen tanks are full and ready to be used;
- having a backup tank ready to be used, if necessary;

- guaranteeing that there is no leak of gas thorough the system and rebreathing bag;
- checking the level of inhalant anesthetic in the machine;
- checking the CO_2 absorbent for exhaustion.

Lack of tissue oxygenation and inadequate elimination of carbon dioxide (CO_2) can result in cellular acidosis, impaired enzymatic function, cellular oxygen debt and, in the most extreme cases, cell death (74). Vital organs like the heart and the brain are particularly susceptible to hypoxia, as they have very limited ability for anaerobic metabolism and, particularly in the nervous system, neurons have very high metabolic activity. Timely detection and correction of hypoxia in sedated and anesthetized patients becomes then imperative to avoid serious complications, including cardiac dysfunction, blindness, acute renal failure, and death (69).

The use of monitoring equipment allows the veterinary team to monitor blood oxygenation as well as CO_2 expelling and tailor inhalant and intravenous anesthesia to each patient's individual needs and responses (74) and/or assisting lung compliance, to prevent atelectasis, and to improve functional residual capacity (68). Two main basic devices are used to monitor blood oxygenation and CO_2 levels: the pulse oximeter and the capnograph. The first measures the SpO_2, (i.e. hemoglobin saturation level of oxygen) and is recommended that a pulse oximeter is available for all immobilizations (50). The clippers of this equipment can be placed in several body areas as lips, ears (59), vaginal mucosa, prepuce, etc (always adapted to the species). Pulse oximetry readings in healthy patients should be between 98% and 100% (75). Tissue hypoxia can be inferred when SpO_2 is less than 97% (68) and clinically detectable cyanosis corresponds to a reading of 80% (66), which explains why mucous membrane color is a late indicator of hypoxemia (74). However, pulse oximetry readings are not always accurate (69) so any value below 97% should prompt immediate assessment of the patient (69). Blood gas analysis is considered the gold standard for assessment of body oxygenation (68) and an arterial sample is desired, as it will give information about ability to ventilate (partial pressure of arterial carbon dioxide- $PaCO_2$) and ability to oxygenate (partial pressure of oxygen- PO_2) (78). An arterial blood sample suggests tissue hypoxia if:

• PO_2 is < 90 mm Hg (hypoxemia) (69)

• HCO_3^- is < 20 mEq/L (69)

• The base excess (BE) > –4 (69)

• The serum lactate level is > 5 mmol/L (69)

In sedated or anesthetized patients with the above described values, the early sympathetic nervous system reactivity to hypoxemia may be reduced, and bradycardia, severe hypotension, cardiovascular collapse, and apnea may occur before a problem is detected, particularly if adequate monitoring is absent. Tissue hypoxia can be inferred if prolonged hypotension has occurred (mean arterial pressure < 60 mm Hg, systolic arterial pressure < 80 mm Hg) for longer than 10 minutes (69).

The capnograph is a device that measures carbon dioxide levels (in mmHg) at the end of a breath- $ETCO_2$-, which provides direct information about the ventilatory status and indirect information about tissue perfusion and metabolism (79). The amount of CO_2 at the end of an exhalation should be closest to the level of the alveolar-capillary membrane and can be used to estimate the CO_2 level in the blood (75). In a healthy orangutan, a normal $ETCO_2$ level is approximately 40 mm Hg (68); this level will be increased when a patient is hypoventilating. With values below 30 mmHg the patient does not have enough CO_2 in the bloodstream and is hyperventilating (75). Monitoring $ETCO_2$ and/or $PaCO_2$ is important to ensure adequate CO_2 removal. Measurement of $PaCO_2$ is the preferred method for assessment of dissolved carbon dioxide in blood; normal values are between 35 and 45 mmHg for mammals, with $ETCO_2$ values ranging between 1 and 5 mmHg lower than $PaCO_2$ (69). However, as mentioned before, $PaCO_2$ measurement requires arterial catheterization or puncture, and is therefore more invasive and technically challenging than measurement of $ETCO_2$. Arterial blood samples can be taken from either the tibial, radial, or femoral arteries (56).

Hypotension is another occurrence that can easily develop in an anesthetized patient (even the healthy ones), especially if adequate monitoring is not provided. Sedatives, muscle relaxants, induction agents, and gas anesthesia all have potential for depressing cardiac output, causing peripheral vasodilation or vasoconstriction, decreasing tissue perfusion and causing hypoventilation (74). Isoflurane, the volatile anesthetic used in this case, is an agent capable of safely maintain anesthesia in gorillas (as in most of zoological species); however, its vasodilatory properties are well known (10), and preventative measures should be readily adoptable in case of the animal's blood pressure diminish to a life-threatening value. Maintenance of normal blood pressure and perfusion is important to prevent end-organ damage (74). This physiologic parameter, which estimates tissue perfusion through function of the arterial tone and cardiac output (made up of the heart rate and stroke volume) (75) can be measured in both direct (catheterization of an artery- usually the metatarsal for gorillas, easily accessed on the dorsal aspect of the hind limbs (50)) and indirect (e.g. oscillometric) ways but typically the last is more frequently used (75). Bradycardia, tachycardia, hypovolemia, vasodilation, vasoconstriction, poor cardiac contractility are all factors that can influence an animal's blood pressure (75). However, blood pressure accuracy as an indicator of blood flow is not certain (75) and as so, guidelines for basic evaluation of circulation, tissue perfusion, oxygenation, and ventilation for all animals placed under heavy sedation or general anesthesia are available from the American College of Veterinary Anesthesiologists and an adapted table (Table 7) of these standards is provided below:

Table 7 – Guidelines for basic evaluation of an anesthetized patient (adapted from (75)).

Circulation and Perfusion	Oxygenation	Ventilation
Pulse rate/deficits/quality	Pulse oximetry	Chest excursions
Capillary refill time	Arterial blood gas analysis	Lung sounds
Mucous membrane color	-	Movement of air withing ET tube or rebreathing bag
Heartbeat auscultation	-	End-tidal CO2
Electrocardiogram	-	Arterial blood gas analysis
Blood pressure	-	-
Pulse oximetry	-	-

In the western lowland gorilla case described, MBP values recorded were low (32-58 mmHg, normal values ranging 73-121 mmHg), but values were considered inaccurate, according to physical examination findings (good femoral pulse quality, color of mucous membranes and heart rate). Although nowadays there are many different types of equipment to help monitoring anesthesia, one should never rely absolutely and exclusively in equipment values without assessing the patient by physical examination means, otherwise unnecessary emergency measures and erroneous medical approaches may be taken. *Brainard et al.* (50) state that, according to their own experience, great apes have shown to be extremely sensitive to anesthetic agents and they seem particularly prone to hypotension, both with inhalational and intravenous drugs. As a response to this, these authors routinely start an infusion of dopamine (2-10 mcg/kg/min-) due to its inotropic effect, thus increasing cardiac contractility. This can significantly improve blood pressures during anesthetic procedures. These authors also routinely use the non-depolarizing muscle relaxant cisatracurium. This agent competitively inhibits acetylcholine at the motor end-plate in muscle and allows the apes to be maintained at a lower depth of anesthesia without moving (50), which is particularly helpful in apes who are prone to or are already hypovolemic as it reduces the cardiac effects produced by high concentrations of anesthetics. It is also the relaxant of choice for subjects with hepatic or renal dysfunction because it is eliminated by hydrolysis and Hoffman degradation (spontaneous degradation in plasma and tissue at normal body pH and temperature (80)). However, one should keep in mind that cisatracurium does not provide any analgesia, so it should never be used in procedures that infer pain to the patient.

i) Intravenous access and fluid-therapy

Whether for the administration of drugs, collecting samples or administration of fluids, IV access during long procedures should always be obtained. For gorillas, cephalic veins are usually easy to identify and support catheterization (50). Fluid therapy has the main goal of providing patient support. Decisions regarding if fluids should be provided or not during anesthesia and the type and volume used depend on many factors, including the patient's signalment, physical condition, and the length and type of the procedure (76). Advantages of providing perianesthetic fluid therapy for healthy animals include the following:

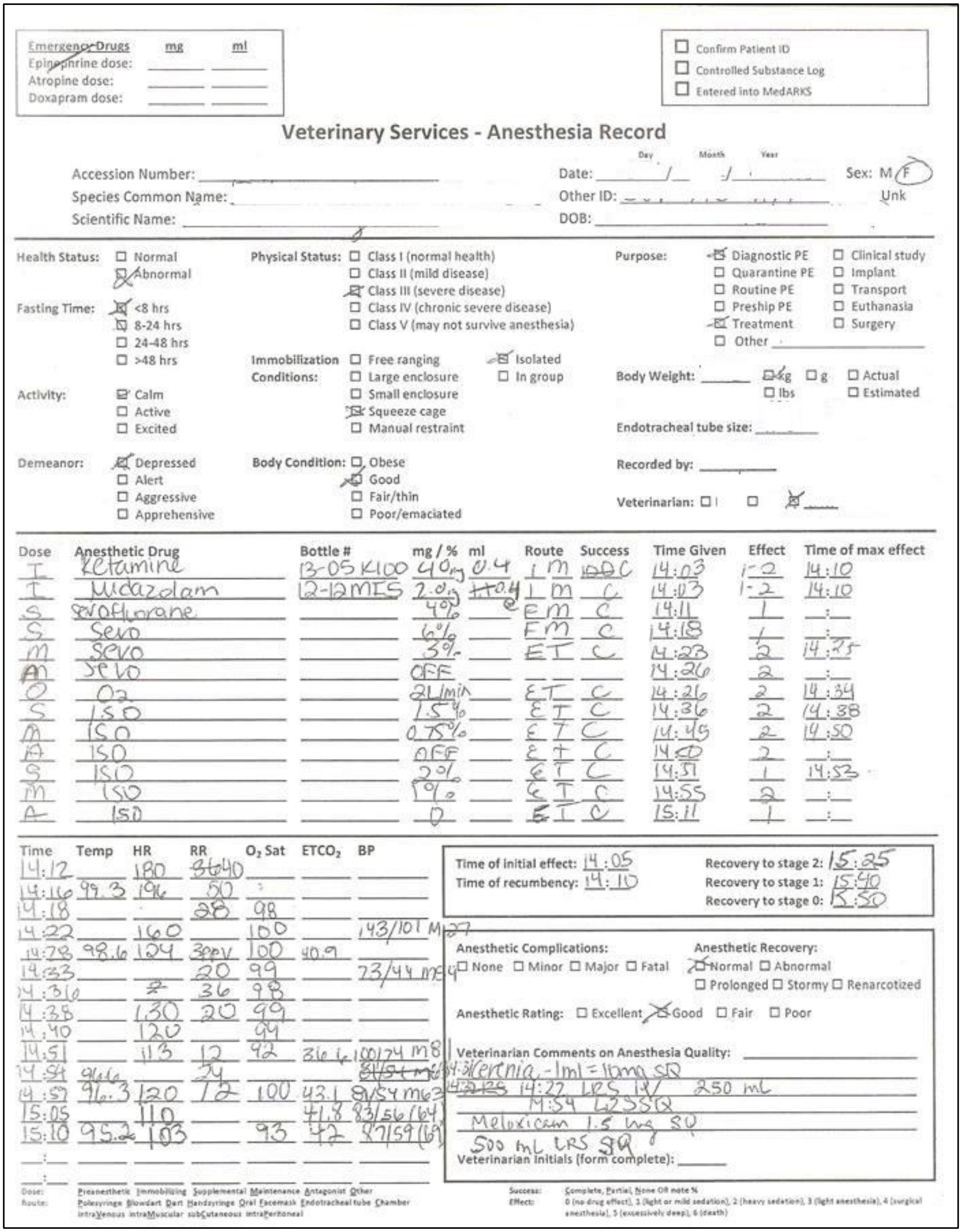
- Correction of normal ongoing fluid losses (76);

- Support of cardiovascular function (76);
- Countering potential vasodilator or hypotensive effects associated with anesthetic agents (76);
- Continuous flow of fluids through an IV catheter prevents clot formation in the catheter and allows the veterinary team to quickly identify problems with the catheter prior to needing it in an emergency (76).

When IV fluids are provided, continual monitoring is essential. The primary risk of providing excessive IV fluids in healthy patients is vascular overload (76). Intravenous fluids should be used sparingly in apes with cardiac disease (or potential to be diagnosed with it) to prevent volume overload (50).

j) Cardiovascular monitoring

Finally, cardiac rhythm should always be monitored during an anesthetic procedure, in order to detect changes in the electrical conduction of the heart. The electrocardiograph is the device used to measure it, but should never be used to prove heart "beat" or organ perfusion; arrhythmias come in many forms- speed, (fast or slow), location (atrial or ventricular), and severity (benign or emergent) – so a perfusion parameter should always be checked (MM/CRT, blood pressure, and pulse quality) if an arrhythmia is present (75). Any detected electrocardiogram (ECG) (or any other parameter) abnormalities should be noted in order to have the maximum information as possible about all immobilizations of that specific animal and its responses to it. The following image (Figure 6) illustrates a very complete and well-organized anesthesia sheet, where valuable data can be recorded during the anesthetic event:



Emergency Drugs mg ml
Epinephrine dose:
Atropine dose:
Doxapram dose:

☐ Confirm Patient ID
☐ Controlled Substance Log
☐ Entered into MedARKS

Veterinary Services - Anesthesia Record

Accession Number:
Species Common Name:
Scientific Name:
Date: Day / Month / Year
Other ID:
DOB:
Sex: M F Unk

Health Status: ☐ Normal ☒ Abnormal
Fasting Time: ☒ <8 hrs ☒ 8-24 hrs ☐ 24-48 hrs ☐ >48 hrs
Activity: ☒ Calm ☐ Active ☐ Excited
Demeanor: ☒ Depressed ☐ Alert ☐ Aggressive ☐ Apprehensive

Physical Status: ☐ Class I (normal health) ☐ Class II (mild disease) ☒ Class III (severe disease) ☐ Class IV (chronic severe disease) ☐ Class V (may not survive anesthesia)
Immobilization Conditions: ☐ Free ranging ☐ Large enclosure ☐ Small enclosure ☒ Squeeze cage ☐ Manual restraint ☒ Isolated ☐ In group
Body Condition: ☐ Obese ☒ Good ☐ Fair/thin ☐ Poor/emaciated

Purpose: ☒ Diagnostic PE ☐ Quarantine PE ☐ Routine PE ☐ Preship PE ☒ Treatment ☐ Other ☐ Clinical study ☐ Implant ☐ Transport ☐ Euthanasia ☐ Surgery
Body Weight: ☒ kg ☐ g ☐ lbs ☐ Actual ☐ Estimated
Endotracheal tube size:
Recorded by:
Veterinarian:

Dose	Anesthetic Drug	Bottle #	mg / %	ml	Route	Success	Time Given	Effect	Time of max effect
I	Ketamine	13-05 K100	40mg	0.4	IM		14:03	1-2	14:10
I	Midazolam	12-12 MES	2.0mg	0.4	IM	C	14:03	1-2	14:10
S	Sevoflurane		4%		FM	C	14:11	1	
S	Sevo		6%		FM	C	14:18	1	
M	Sevo		3%		ET	C	14:23	2	14:25
A	Sevo		OFF				14:26	2	
O	O2		2L/min		ET	C	14:26	2	14:34
S	ISO		1.5%		ET	C	14:36	2	14:38
M	ISO		0.75%		ET	C	14:45	2	14:50
A	ISO		OFF		ET	C	14:50	2	
S	ISO		2%		ET	C	14:51	1	14:53
M	ISO		1%		ET	C	14:55	2	
A	ISO		0		ET	C	15:11	1	

Time	Temp	HR	RR	O2 Sat	ETCO2	BP
14:12		180	36-40			
14:16	99.3	196	50			
14:18			28	98		
14:22		160		100		143/101 M127
14:28	98.6	124	3ppV	100	40.9	
14:33			20	99		73/44 M54
14:36			36	98		
14:38		130	20	99		
14:40		120		99		
14:51		113	12	92	36	100/74 M8
14:54	96.6		24			84/54 M64
14:57	96.3	120	12	100	43.1	81/54 M63
15:05		110			41.8	83/56 (64)
15:10	95.2	103		93	42	87/59 (69)

Time of initial effect: 14:05
Time of recumbency: 14:10
Recovery to stage 2: 15:25
Recovery to stage 1: 15:40
Recovery to stage 0: 15:50

Anesthetic Complications: ☐ None ☐ Minor ☐ Major ☐ Fatal
Anesthetic Recovery: ☒ Normal ☐ Abnormal ☐ Prolonged ☐ Stormy ☐ Renarcotized
Anesthetic Rating: ☐ Excellent ☒ Good ☐ Fair ☐ Poor
Veterinarian Comments on Anesthesia Quality:
Cerenia - 1ml = 10mg SQ
14:27 LRS IV 250 mL
LRS SQ
Meloxicam 1.5 mg SQ
500 mL LRS SQ
Veterinarian Initials (form complete):

Dose: Preanesthetic Immobilizing Supplemental Maintenance Antagonist Other
Route: Polesyringe Blowdart Dart Handsyringe Oral Facemask Endotracheal tube Chamber intraVenous intraMuscular subCutaneous intraPeritoneal
Success: Complete, Partial, None OR note %
Effect: 0 (no drug effect), 1 (light or mild sedation), 2 (heavy sedation), 3 (light anesthesia), 4 (surgical anesthesia), 5 (excessively deep), 6 (death)

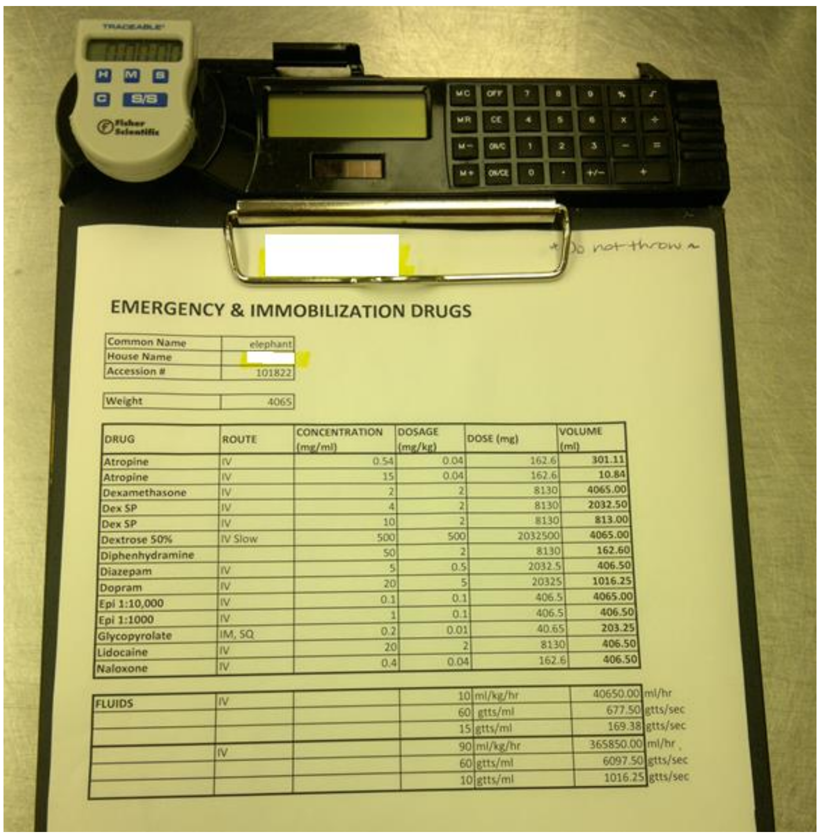
Figure 6 - An example of an anesthesia sheet from one of the visited institutions. (Edited for privacy purposes)

6. EMERGENCY

In the presented case, major anesthetic complications due to the initial impossibility of intubating the patient, were almost responsible for a cardiorespiratory arrest. Difficulties to accomplish intubation were thought to be related with insufficient depth of anesthesia, which allowed for a laryngospasm to develop after attempts for introduction of the ET tube. An emergency situation aroused when possible regurgitated materials got trapped in the glottis area, making the animal to start coughing and hampering it to take further breaths. In addition, signs of cardiorespiratory arrest presented with a rapidly decreasing heart rate.

a) Prepared for an emergency? Checked!

Being prepared for complications that may be life-threatening is crucial when anesthetizing any animal. Emergency situations are stressful for everyone involved (81). The team needs to remain calm and establish an immediate line of communication. Training sessions should be planned during team meetings attended by all members and specific responsibilities to each team member should be assigned. All personnel must know how to set up and use all resuscitative equipment, possess the skills to perform resuscitative procedures and be able to identify potentially life-threatening situations (82). Having one (or several) portable carrying case with necessary supplies and drugs for an emergency situation is mandatory for every animal immobilization (either wild or domestic) (81) and electrical outlets should be easily accessible (82). Daily review of all equipment, medical supplies and drugs avoids that in an urgent setting necessary material is not available. Drugs should be inspected on a frequent basis as well as after each resuscitation effort to ensure readiness for the next emergency situation (82). Every box should have different compartments that should be properly labeled and, at the hospital, a “crash” cart should be adequately furnished, with all drawers labeled on the outside and compartmentalized to expedite identification of the desired object (82). Each compartment should also be labeled. Emergency drugs should be alphabetized to facilitate location and ET tubes should be placed in ascending or descending order of size with the laryngoscope placed in the same drawer (82). Syringes and needles should be kept with the drugs. Tables of easy consultation, where doses and quantities of emergency drugs are easily expressed and adapted for the anesthetized animal (regarding species and body weight) should be kept together with anesthesia monitoring sheets, so that both the drug and the amount to be drawn can be easily accessed and given to the patient in a major complication setting. If available, the emergency sheet should also include voltage doses for external and internal defibrillation (82). The following image (Figure 7) shows a good example of an organized emergency sheet properly adapted to the patient, inserted in a board making easier to perform any other calculation if needed:


Do not throw

EMERGENCY & IMMOBILIZATION DRUGS

Common Name	elephant
House Name	
Accession #	101822

Weight	4065

DRUG	ROUTE	CONCENTRATION (mg/ml)	DOSAGE (mg/kg)	DOSE (mg)	VOLUME (ml)
Atropine	IV	0.54	0.04	162.6	301.11
Atropine	IV	15	0.04	162.6	10.84
Dexamethasone	IV	2	2	8130	4065.00
Dex SP	IV	4	2	8130	2032.50
Dex SP	IV	10	2	8130	813.00
Dextrose 50%	IV Slow	500	500	2032500	4065.00
Diphenhydramine		50	2	8130	162.60
Diazepam	IV	5	0.5	2032.5	406.50
Dopram	IV	20	5	20325	1016.25
Epi 1:10,000	IV	0.1	0.1	406.5	4065.00
Epi 1:1000	IV	1	0.1	406.5	406.50
Glycopyrolate	IM, SQ	0.2	0.01	40.65	203.25
Lidocaine	IV	20	2	8130	406.50
Naloxone	IV	0.4	0.04	162.6	406.50

FLUIDS	IV		10	ml/kg/hr	40650.00	ml/hr
			60	gtts/ml	677.50	gtts/sec
			15	gtts/ml	169.38	gtts/sec
	IV		90	ml/kg/hr	365850.00	ml/hr
			60	gtts/ml	6097.50	gtts/sec
			10	gtts/ml	1016.25	gtts/sec

Figure 7- Example of an emergency sheet, from one of the visited institutions, adapted to a specific animal, where drugs, routes, doses and volumes to be administered are explicit and readily retrievable (for privacy purposes the name of the animal was erased from this picture).

Due to the elevated number of animals housed in zoos nowadays, having an adapted emergency sheet for each animal is not feasible. In this cases, an emergency sheet for the group (e.g. reptiles, birds) (Table 8) where the animal belongs is a good and practical alternative:

Table 8 - Example of a reptile emergency drugs sheet (adapted from emergency sheets of one of the visited institutions).

Reptile Emergency Drugs

Drug	Dose / Concentration	Weight / Route	50g	100g	150g	200g	300g	500g	750g	1 kg	1.5 kg	2 kg	5 kg	10 kg	25 kg	50 kg
			Doses (ml)													
Atropine	**0.04 mg/kg**	IP,IM,IV	0.004	0.008	0.012	0.016	0.024	0.04	0.06	0.08	0.12	0.16	0.4	0.8	2	4
	0.5 mg/ml															
Epinephrine	**0.2 mg/kg**	IM,IP,IC	0.01	0.02	0.03	0.04	0.06	0.1	0.15	0.2	0.3	0.4	1	2	5	10
	1 mg/ml															
Doxapram	**5 mg/kg**	IP,IV	0.01	0.025	0.037	0.05	0.075	0.12	0.19	0.25	0.38	0.5	1.3	2.5	6.3	12.5
	20 mg/ml															
Dex SP*	**0.25 mg/kg**	IM,IP,IV	0.003	0.006	0.009	0.012	0.018	0.03	0.046	0.06	0.09	0.12	0.3	0.6	1.5	3.1
	4 mg/ml															
Prednisone Sodium Succinate	**10 mg/kg**	IM,IP,IV PO														
	100mg vial 10mg/ml		0.05	0.1	0.15	0.2	0.3	0.5	0.75	1	1.5	2	5	10 (1vial)	25 (2.5 vial)	-
	500mg vial 50mg/ml		-	-	-	-	-	-	-	-	-	-	-	-	5	10
Sodium bicarb. **	**1 mEq/kg**	IV	0.05	0.1	0.15	0.2	0.3	0.5	0.75	1	1.5	2	5	10	25	50
	1 mEq/ml															

*Dex SP- Dexamethasone Sodium Phosphate; ** Sodium Bicarb.- Sodium Bicarbonate

The following table (Table 9) provides a list of equipment that should be available, ideally, in every anesthesia or procedure that can progress to an emergency (82):

Table 9 - List of equipment that should be available in all anesthetic events.

Ventilation support	**Fluids (**at least 1 liter of each fluid type should be included)	**Catheters, Tubing and Syringes**	**Other Equipment and Supplies**	**Monitoring Equipment**
Ambu-bag OR anesthetic machine with ventilator	Balanced electrolyte solution (i.e. Lactated Ringer's Solution) ,0.9% saline,or 5% dextrose in water	Intravenous catheters (multiple sizes of 14- to 22-gauge)	Mouth gags	Capnograph
Oxygen source with humidifier	Hypertonic saline (7%)	Over-the-needle or through-the-needle catheters*	Ophthalmoscope	Defibrillator
Facemask	Synthetic colloid	Syringes (multiple sizes) with and without attached needles; multiple needle sizes	Orogastric tubes	Digital thermometer or rectal probe
Laryngoscope and ETTs with multiple blade and tubes sizes, respectively. Also ETT stylet	-	Three-way stop cocks and extension sets	Otoscope	Electrocardiogram
Tape or rolled gauze to secure ETT	-	3.5- to 12-French polypropylene catheters**	Penligh	Indirect blood pressure measurement via Doppler or oscillometry
Suction apparatus and suction tip catheters	-	If possible, pre-manufactured chest tubes and Foley catheters for urethral catheterization	-	Pulse oximeter
Emergency tracheotomy equipment***	-	-	-	iStat

*- for pericardiocentesis; **- for instilling emergency drugs via the ETT or rectal, urethral catheterization, nasal oxygenation, creating vascular loops, and chest tube placement; ***- (minor surgical pack, umbilical tape, temporary tracheostomy tubes). The tracheostomy tube should be approximately two thirds the tracheal diameter

b) Identifying an emergency

Every time an emergency situation comes up or is imminent, primary assessment of the patient should be performed. This assessment is based on the acronym "ABCD" (83) and should be quick, lasting less than a minute:

- A- Airway;
- B- Breathing;
- C- Circulation;
- D- Demeanor

This determines the urgency of the situation and gives an idea of the gravity of the situation based on (83):

- Airway- Is the airway patent/obstructed/swollen? Are there any abnormal respiratory sounds?
- Breathing- Is the patient breathing? Is the rate normal/abnormal? Is there respiratory effort present? Is there abdominal effort? What is the respiratory pattern like?
- Circulation- Are mucous membrane color and capillary refill time normal? Is there any active bleeding? Is the femoral pulse present, and if yes, what is the character of the pulse? Does it match with the heart rate?
- Demeanor- this is an assessment that might not always be possible in the zoo field as most of the times animals are unconscious for procedures. However, sometimes it can be done before anesthetizing the patient (i.e. is the patient dull/depressed? Has it responded to stimuli?) or during anesthesia (i.e. is the patient comatose? Is it seizuring?)

c) Cardiopulmonary arrest

In this case major anesthetic complications (failure to intubate the patient, possible regurgitation and aspiration and sudden decrease in heart rate) could have given opportunity for a cardiopulmonary arrest situation to develop. Luckily, administration of glycopyrrolate successfully raised HR and further procedures in order to get the animal intubated could be pursed.

Glycopyrrolate, like atropine, is a parasympatholytic agent; cardiovascularly, they have little effect on blood pressure but they do dramatically increase heart rate (84).

Cardiopulmonary arrest (CPA) is the abrupt cessation of the cardiac pump and is detected by the absence of a heartbeat and lack of peripheral pulses and spontaneous respirations (85). It should not be confused with respiratory arrest, which is the lack of spontaneous respirations, but there is an audible heartbeat and the presence of peripheral pulses (85). The ECG allows the clinician to identify arrhythmias that would benefit from defibrillation before a total cessation of the electrical impulses occur, making this equipment to be considered mandatory in resuscitation (82). Prompt identification of signs that might indicate a CPA is imminent can be life-saving (Table 109) and one can be better prepared if risk factors and signs are known in advanced (85):

Table 10- Risk factors for development of CPA and assessment signs related to an imminent CPA.

Risk Factors for CPA	Signs of imminent CPA
Preexisting disease/ Electrolyte or acid-base abnormalities/ Vagal stimulation/ Cardiac, pulmonary, or neurologic disease/ Critical illness/sepsis/ Anesthesia/ Hypoxemia/ Hypercapnia/ Hypotension/ Hypothermia/ Cardiac arrhythmias/ Severe anemia	Hypotension/ Bradycardia/ Arrhythmias/ Hypothermia/ Cyanosis/ Pupillary dilation/ Changes in respirations (rate, depth, or pattern, including agonal breath)

CPA requires cardiopulmonary cerebral resuscitation (CPCR). CPCR is a technique used to provide ventilatory and cardiac support following respiratory and/or cardiac arrest, in which the goal is to maintain tissue oxygenation and restore effective circulatory and neurologic function (85). For basic life support one should follow the “ABCs” (i.e. airway, breathing, circulation): after verifying patency of the airway and if the patient is not breathing, immediate intubation using a cuffed endotracheal tube should be performed (85). If intubation is not possible, an emergency tracheostomy must be performed (85). In the case presented in this report, because intubation without success was attempted during a considerable amount of time, the team started to set up for an emergency tracheostomy. However, although the practical procedure is the same, husbandry is not, when comparing a tracheostomy in a domestic *versus* wild animal. Many zoo animals, especially primates, are well known for their tendency to self-mutilate surgical incisions (65) and so, there would be high chances of this animal to suffer consequent trauma either from herself or from her group.

Luckily, such procedure was not necessary to be done, as after several supplemental doses of ketamine, administration of isoflurane by facemask and spraying of dexamethasone (an anti-inflammatory steroid) the animal was finally intubated and total control of vital parameters was accomplished with no other complications occurred afterward.

Administration of medication can be done by IV, intraosseous (IO), and intratracheal (IT) routes. To optimize myocardial drug delivery, a central IV catheter is preferred but a peripheral catheter is also adequate (preferably on a forelimb) (85). Tracheal administration of steroids has good potential for diminishing inflammation and swelling (86), allowing better visualization of the glottis area and enabling a successful intubation.

After intubation, positive pressure ventilations of isoflurane in 100% oxygen aided the animal to be maintained at an adequate depth of anesthesia as well as counteracting eventual hypoxia that was probably already present. When providing ventilatory support, one should aim for normal chest wall movement and should not exceed peak airway pressures of 20 cm H2O (85).

Although cessation of heart beat was not registered in the described case, in any cases where the absence of a heartbeat and palpable peripheral pulses are noted, cardiac compressions should be performed immediately, using either external chest compressions (closed chest CPCR) or internal cardiac massage via open chest CPCR (83). Every time such procedure is performed, the following parameters should, ideally, be monitored in order to evaluate if there is a good progress with resuscitation techniques (85):

- Heart rate;
- Respiratory rate;
- Temperature;
- Capillary refill time;
- Mucous membrane color;
- Pupillary light response;
- Level of consciousness (mostly impracticable in zoo/wild species);
- Electrolytes;
- pH and blood gases;
- Packet cell volume (PCV)/ Total Protein (TP)/ Glucose/ Blood Urea Nitrogen (BUN) and/or Creatinine
- Urine output

Kenny et al. (68) describe a critical case of an orangutan that developed negative pressure pulmonary edema (NPPE) during an anesthetic procedure. Just like gorillas, orangutans have a propensity for laryngospasm, a thick and robust tongue, a long flaccid soft palate and excessive caudal pharyngeal tissue, which can cause an upper airway obstruction (68). Because of this, they should be considered susceptible to this (NPPE) syndrome during anesthesia. In that case, the authors suspect that the orangutan developed NPPE because of an obstruction at the glottis during induction (68). Attempts to breathe against a closed upper airway causes an abnormal increase of the negative intrathoracic pressure (68). Increased negative intrapleural pressure leads to a rise in the transmural pressure across pulmonary capillaries, producing transudate that moves from capillaries into the interstitial space and finally into the alveoli (68). A rise in negative pressure may also cause an increase in venous pulmonary return (68), which in combination with hypoxia, induces vasoconstriction, leading to fluid accumulation in the pulmonary interstitium (68). Despite intensive care provided to this patient, survival was not possible.

Another example of a critical situation that can occur during anesthesia of wild animals is the so-called “pink foam syndrome” in anesthetized elephants. This syndrome is linked to the use of ultra-potent opioids (e.g. etorphine) during elephant immobilizations; a high increase in blood pressure caused by this drugs (87), causes capillary bleeding which in turn leads to pulmonary edema due to accumulation of blood in alveoli. Consequently, a pink foam (formed by the combination of air and blood in the alveoli) can be seen coming out of the trunk of the elephants and it may actually lead to death (88). The use of azaperone may counteract this hypertensive effects (88) and, once again, knowledge about each species response and susceptibility to certain drugs can predict dangerous situations and avoid them.

Whatever is the species, anesthetic protocol and the planned procedure, life-threatening situations are always possible to occur and the veterinarian (as well as the rest of the team) should be well prepared to deal with them, not only because there is a life in risk, but also because in the zoo field there is a whole set of factors that must be taken into account when dealing with a situation like this: the loss of a (many times) genetically valuable individual, the loss of an important member for the animal’s group, the loss of a loved animal by the keepers, and the loss of a (sometimes) iconic animal for the public.

Anticipated action and preparation can make the difference. Every second counts.

7. CARDIAC DISEASE

A veterinary cardiologist was requested to be present and perform an echocardiogram at the described clinical case. Cardiovascular disease is currently the leading cause of morbidities and mortalities in captive western lowland gorillas, being responsible for 41% of all deaths in adult gorillas (89). Historically, infectious diseases used to play an important role on mortality in captive gorillas; with the improvement of husbandry practices and medical care, nowadays, gorillas live longer and in better zoo facilities (90). Cardiac disease has been linked to this in a way that gorillas are living to an older age that gives opportunity for this type of disease to develop (90). The condition affects mainly adult gorillas, with one study showing abnormal echocardiogram findings in all males selected with ages comprised between 31 and 40 years of age (91).

a) Prevention and early detection

Although the patient described in this case was a five years old female, there is an urgent need to improve methods for early identification of cardiac disease or parameters (e.g. cardiac biomarkers) that might indicate it; trans-esophageal echocardiography appears to be a promisor way of improving early heart disease diagnosis (92). It permits close inspection in particular of the descending and ascending aorta, the left ventricular wall thickness, and the aortic valve (93). It may also be used as a means of screening adult gorillas for markers of risk for aortic dissection (93). Hypertension, atherosclerosis, elevated cholesterol and pregnancy have been previously identified as important factors in the pathogenesis of aortic dissection in gorillas (93) and trans-esophageal echocardiography can be used to identify the presence or absence of some of these risks. Left ventricular hypertrophy (as a marker for poorly controlled systemic hypertension), aortic atherosclerotic plaque, aortic dilatation, aortic valve insufficiency, and intramural hematoma are all abnormalities that can be identified by this method (93) and, in conjunction with other cardiac diagnostic tests it may provide a more complete and detailed examination (92).

However, effective ways of preventing this disease are still unknown. The Great Ape Heart Project is currently asking all institutions (belonging to AZA) to submit an echocardiogram form every time that an awake (94) or anesthetized echocardiogram is performed on a gorilla (and this explains why such procedure was performed on an animal that is not currently included in the risk group susceptible for this disease); blood samples are also suggested to be sent for biomarkers (insulin, glucose, leptin, low-density lipoprotein-producing oxidized phospholipid (oxLDL), and cholesterol) and B-type Natriuretic Peptide (BNP) levels (94) as abnormal results might be correlated with cardiac disease even in asymptomatic patients (96, 97, 98, 99). After analyzing and studying all echocardiogram forms that will be submitted, the goal is to establish a uniform and accurate way of cardiac diagnosis, treatment and preventive measures to be adopted (100).

Hypercholesterolemia has been considered a likely etiology in the development of heart disease in gorillas (101). In humans, treatment is recommended for cholesterol levels greater than 200 mg/dl (101), however the average cholesterol level in gorillas is over 280 mg/dl. *Baitchman et al.* (101) describe lipid profile results and propose a possible correlation between specific lipid levels and risk of atherosclerosis in gorillas. The results suggested that evaluation of complete lipid profiles as part of a comprehensive cardiac evaluation in gorillas may be valuable and that it might be misleading to evaluate total cholesterol alone as an indicator of coronary health, as there was no significant difference in total cholesterol between the affected (with cardiac disease) and unaffected groups.

Lipid profiles are used in conjunction with other potential risk factors to predict risk for development of coronary heart disease (CHD)- atherosclerotic disease of the coronary arteries (102). The major risk factor associated with this disease is dyslipidemia (102). In one study (102) it was found that high-density lipoprotein (HDL) (known by their protective effect against atherosclerosis) decrease more rapidly with age than total cholesterol. In humans, decreased HDL is a strong positive predictor for cardiovascular disease but, although the physiologic basis for CHD and dyslipidemia may be similar between humans and gorillas, the scaling of human reference ranges may not be applicable (102).

In the same year of publication of the previous study, and three years later than results showed by *Baitchman et al.* (101), *Schmidt et al.* (103) published a study where they banked serum samples from free-ranging mountain gorillas (*Gorilla beringei*), western lowland gorillas (*Gorilla gorilla gorilla*), and Bornean orangutans (*Pongo pygmaeus*) and analyzed it for total cholesterol, triglyceride, high-density lipoprotein cholesterol, and low-density lipoprotein (LDL) cholesterol concentrations. Captive gorilla total cholesterol and LDL concentrations were significantly higher than in free-ranging groups and triglyceride concentrations for captive gorillas were significantly higher than the male mountain and western lowland gorillas. They concluded that the higher total cholesterol and LDL concentrations in captive apes may predispose them to cardiovascular disease and could be attributed to diets, limited energy expenditure, and genetics.

Regarding the role of BNP as a predictor for cardiac disease, *Hope et al.* (104) described the progression of two cases of gorilla cardiac failure – one acute and one chronic

– and compared by examining serial cardiac ultrasound examinations over 10 years in conjunction with the BNP blood test. In humans, BNP is a sensitive and noninvasive method of diagnosing congestive heart failure, monitoring response to treatment, and determining prognosis (104). The peptide is secreted by the ventricles as a response to myocardial stretching, and levels are significantly increased in patients with cardiac disease (104). The retrospective analysis of BNP levels in these two cases suggested that BNP may be an effective method of diagnosing and monitoring cardiac disease in gorillas.

b) Alternative ways for cardiac control without anesthetic influence

When performing an echocardiography (105) or taking indirect blood pressures in an animal under anesthesia, anesthetic features must be considered, as drugs used, positioning of the patient and the timing of measurements might affect results and give inaccurate results (106, 107)

In this patient, low values of BP were attributed to equipment error. Because both of these diagnostic examinations (BP and echocardiography) are important indicators of cardiac function, awake BP and ultrasounds (using behavioral restraint) should be done (106) to monitor the progress of cardiac health without the use of immobilizing drugs that may influence cardiac function (108).

Suedmeyer et al. (109) describe the use of radio telemetry technology to evaluate blood pressure in woolly monkeys (*Lagothrix lagotricha*). Catheters were placed into a branch of the femoral artery and positioned so the catheter tip was in the femoral artery near the dorsal aorta and the body of the implant in the first monkey was placed subcutaneously over the caudo-lateral abdomen and in the second monkey it was sutured to the body wall inside the abdominal cavity. Although the authors of the study concluded that this could be a feasible way of monitoring blood pressure in awaken animals in a zoo setting, due to the likelihood for self-mutilation, the fact that the implant on the first monkey failed due to trauma when the monkey was netted for evaluation of lameness in the catheterized leg (109) and the fact that the implant on the second monkey became occluded with fibrin about 30-40 days after placement (109) makes the author of this document to question about the usefulness of such method on a long-term use as well as considering that the risks do not worth “the try”. Moreover, if there is the chance of training animals for voluntary blood pressure measures, invasive methods like this are not needed at all.

c) Treatment options

Early treatment (as well as early detection) of cardiovascular disease in western lowland gorillas has the potential to slow and even reverse some changes associated with disease (110). Cardiac medication may be warranted in patients exhibiting clinical signs or with such echocardiographic abnormal findings that justify the implementation of medication (89), and for patients with high stages of cardiac disease, *Harris et al.* (111) described a successful implantation of a cardiac resynchronization therapy device (also known as “pace-maker”), for treatment of non-ischemic dilated cardiomyopathy and hypokinetic cardiac disease in gorillas, that resulted in improvement of life quality and prolonged life expectancy for the patient.

In the clinical case described in this document, cardiac disease findings were not relevant, which correlates with what is described in the literature (cardiac disease affecting male adult gorillas).

8. METABOLIC AND NUTRITIONAL DISEASES IN ZOO SPECIES- HYPOVITAMINOSIS D AS AN EXAMPLE

a) Metabolism and role of Vitamin D

“*Vitamin D deficiency is a well-known cause of disease in primates*” (112). Human and nonhuman primates have two mechanisms of obtaining their daily values of vitamin D: dietary intake or cutaneous biosynthesis (43) through skin exposure to ultraviolet (UV) light (112). After absorption it is hydroxylated in the liver to 25-hydroxy vitamin D (25OHD) and this component is subsequently hydroxylated into the active metabolite 1,25-dihydroxy vitamin D (1,25(OH)2D) in the kidney (112). This active metabolite regulates the gastrointestinal absorption of calcium and phosphorus (112).

Vitamin D deficiency produces changes in the metabolism of calcium and phosphorus including hypophosphatemia and, in more severe deficiencies, frank hypocalcemia and the presence of rickets (112) due to the compensatory increase in PTH that promotes calcium resorption from the skeleton (113).

Diagnose can be made through blood analysis and radiological examination (114, 43, 112). Serum calcium is decreased and serum phosphorus and PTH are increased (secondary to hypocalcemia (112). Alkaline phosphatase (ALP) appears to be increased in hypocalcemia cases (values greater than 2,000 IU/L), (115) which might be related to activation of osteoblasts by excessive compensatory PTH production (43). 25OHD levels will be low, while circulating 1,25(OH)2D levels may be normal or elevated due to increased renal hydroxylation until all 25OHD is depleted (112). On radiographs, generalized hypomineralization, widened growth plates, flared and cupped metaphyseal ends, decreased cortical ends, bowing of the long bones, pathologic fractures, decreased callus formation in fracture sites, are all signs of hypocalcemia (43). Clinical signs may vary from lethargy to lameness and gait abnormalities. Besides these signs and findings, Vit. D deficiency appears to be also associated with pneumonia, although the mechanism is unknown (112).

b) Husbandry interference

Captive primates housed indoors with little or no access to ultraviolet light have historically been susceptible to metabolic bone disease (114) and require a dietary source of this component (112). In zoological institutions where weather temperatures are mild thorough the year, animals can be housed in enclosures that provide them direct sunlight year-round; however, there is a trend in zoological parks toward building large, indoor exhibits (114) (Figure 8), especially if facilities are located in areas that can get temperatures below the lower limit of recommended values for the species (for great apes minimum temperature values required are -1 to 3 ºC if sunny or 7ºC if overcast or rainy (2)), where animals have to be partially, or even completely, housed indoors, which exacerbates the problem (114). Most skylight materials are not transparent to the wavelengths of UV light necessary for endogenous production of Vit. D, and this is a problem that affects several species at the zoo fields: for most, but not all animals, there is the possibility of supplying Vit. D needs through the diet (114). However, in some basking reptiles (e.g. green iguanas, giant day geckos) dietary vitamin D may not protect them against the development of this deficiency (114). With the increase in large, indoor, multispecies exhibits in zoos this issue becomes increasingly concerning (114). The use of artificial UV-B light sources could be effective under certain circumstances, but the potential eye and skin hazards of high intensity UV lights for both animals and keepers must be considered, as well as the rapid weakening in UV intensity that occurs while the distance from the source increases (114).

Figure 8 - A large, multi-species exhibit at the Omaha Henry's Doorly Zoo with skylights through the building. (Picture taken from the website http://www.zoochat.com/569/lied-jungle-blue-monkey-pygmy-hippo-285570/, accessed on 27th January 2015).

c) Predisposed nonhuman primates

There are two categories of captive primates in which it appears to be difficult to maintain adequate Vit. D levels by dietary means only: mother-reared and nursing infants, and multiparous callitrichids (specifically common marmosets (*Callithrix jacchus*)) (114). Clinical rickets has been diagnosed in several colobus monkeys (Genus *Colobus)* and a francois langur (*Trachypithecus francois*) (114), silvered leaf monkeys (*Trachypithecus* cristatus), sakis monkeys (Genus *Pithecia*) (114), and gorillas (117); in all those cases animals were infants or young juveniles that had been mother-reared in indoor enclosures (114). This can be explained by the fact that milk is a poor source of Vit. D (115, 112), which can be understood when viewed from an evolutionary and natural perspective: under normal conditions, Vit. D is not a nutritional requirement for primates, young or old (114). Neonates depend on stored Vit. D obtained before birth across the placenta, and later, on endogenous production due to UV exposure and so, there is no evidence for an evolutionary "need" for Vit. D in maternal milk (114). Using human studies as comparison, until three months of age, Vit. D levels are probably adequate in the infant's body, as it crosses the placenta during pregnancy (43). Concern arises with indoors mother-reared infants of species with long lactation periods, where infants get the vast majority of their nutrients from milk for a considerable length of time (114, 43, 113). *Ryan et al* (47) reported a case where weaning of a baby western lowland gorilla occurred at three months of age, but this is a very unique case, as most of the times gorillas are weaned around three or four years old (116). There is no evidence that supplementing mothers after birth is likely to have any beneficial effect on the infant (114), however, it is possible that maternal Vit. D status during pregnancy could affect the amount of stored Vit. D in the neonate, and thus have some effect on the latency of deficiency of this nutrient.

<u>d) Preventing hypovitaminosis D</u>

For animals that are housed indoors without access to sunlight for a considerable amount of time, a special diet was developed for great apes in these conditions (43); supplementing the diet of captive primates has largely proved effective at reducing the incidence of bone disease in primates (114). However, dietary intake of Vit. D becomes a problem when looking at great apes infants that are not consuming chow supplemented with Vit. D yet. *Junge et al.* (43) make a good description of three cases of rickets in three chimpanzees, caused by inadequate amount of dietary intake as well as absence of direct UV light. They suggest that preventative measures (supplements of Vit. D) should be adopted by every institution in which great apes are housed indoors (or with insufficient amount of time exposed to direct sunlight), starting at four months of age, as this appears to be the time that initial signs of rickets start developing (43). Clinical intervention with the administration of either oral or injected Vit. D can be disruptive and labor intensive, but it may also be the only practical approach for nursing infants of some primate species when is not possible to ensure adequate exposure of the infant to UV light (114). Actually, this supplementation might also be needed in institutions where animals have access to the outside: *Killick et al.* (119) measured UV light levels in a zoo located at the United Kingdom. They found that, in addition to UV light values being substantially lower during winter when compared to summer, the majority of New World primates sampled, had low vitamin D levels (compared to previously published values) and that these did not vary significantly between summer and winter (119). In contrast, lemur's Vit. D levels were found to be high (compared to previously published values) and greatest values were obtained during summer (119). This difference might be related to lemurs' sunning behavior allowing them to make better use of the UV levels available, or an innate higher levels of UV required for New World primates in order to produce vitamin D (119). Thus, this study illustrates well the importance of all factors that might influence the production of Vit. D by certain species, according to the zoo's location, type of housing, species behavior and distinct physiological needs for the same component.

In the presented case, the patient had a subjective low body size for its age, but it was not presenting any clinical evidence of disease. No abnormal radiological findings were present and the Vit. D panel requested was also normal. No apparent cause for diminished growth rate was found, as physical examination and diagnostics yielded no abnormalities and so, the patient was considered to be normal and healthy.

Nevertheless, because some conditions might be asymptomatic until later stages of severe disease, radiological examination and adequate blood analysis (ionized calcium, PTH levels, phosphorus, ALP and 25[OH]D (principal circulating form of Vit. D (43)) should be promptly performed in order to rule out metabolic disease, as it was done in the present case.

e) Nutrition role in zoological health

The previous section illustrates well the role that an adequate nutrition might play between disease and health. Nowadays, many zoological institutions have nutritionists and other professionals who make and manage animal nutrition programs, allowing better control over the items (and thus the nutrients), delivered to an individual animal (120). Factors as the groups' hierarchy, animal feeding habits and all other issues that might play a role on an animal eating habits, are studied and taken into account to make sure that every animal gets its daily diet. Besides that, feeding might also be used as environment enrichment, as food can be provided by means that stimulate animals psychologically and encourages exercise (e.g. hanging food items on trees, providing it inside toys, serving aliments inside ice cubs) (120). A nutritionist can provide the expertise to minimize the incidence of health problems and improve the animal's quality of life (120).

f) Providing the right nutrition for the right individual

A successful program includes assessing body condition regularly, which facilitates making changes on the diet or management of the animals in a timely manner to achieve the desired weight goal in the desired time (121). Frequent weighing of animals is the ideal method for following progress, but it can be difficult, especially for large animals (e.g. elephants, giraffes, hippos) if a scale is not incorporated at the facilities (121). Body measurements have been shown to be helpful to assess body condition of Asian elephants (122) and it may be an alternative way to apply to other species as well. There is a trend in zoos towards creating big multi-species exhibits (Figure 9) instead of small, one-specie enclosures; from a nutritional point of view, this can be challenging in many ways (123). Besides ensuring that each species (as well as each individual) has access to its diet without excessive competition from other species, one also needs to ensure that animals with different nutrient requirements are able to consume the appropriate diet (123). Finally, it should also be assured that animals do not consume a diet which may be balanced for one species but dangerous/toxic to another (123). Practical solutions for this include separated and stratified feeding stations (123), but there have been suspected cases of nutrient toxicity in terrestrial animals that consumed food refused and dropped by the arboreal species in the same exhibit (123).

Figure 9 - A multiple species exhibit where aadvarks (Orycteropus afer) and bushbabies (Otogale pallida) are housed together (Picture taken from the official Facebook page of the Institution, accessed on 27th January 2015).

g) Examples of nutritional disorders

For some species, improper diet can actually become the first cause of disease if specific requirements are not met. This is the case of captive reptiles, where metabolic bone disease and hypovitaminosis A are at the top differential diagnosis when an animal presents with malaise (124). Browsers nutrition (especially giraffes) is another big issue in the zoological field, being the subject of several publications, as nutritional imbalances in diet have been linked to rumen acidosis, chronic wasting, peracute mortality syndrome, hoof disease, mortality caused by cold stress, urolithiasis, serous fat atrophy, among others (125, 126).

Regardless the fact that some animals being more predisposed to nutritional imbalances than others, if the diet meets more closely the nutrient requirements of each animal, it will allow more successful reproductive efforts and/or increased longevity of our patients (120).

9. CRITICAL CARE IN ZOO PATIENTS

Although the gorilla case described in this report does not fit into the considered "critical patients", critical care is still a valuable tool for saving animals that arrive at the hospital in very poor health condition.

Most of the times zoo animals will only show signs of disease (i.e. depressed, not moving or interacting as much) when the condition is already well advanced, as this is the natural way they would act on their habitat, hiding weakness from possible predators. Occasionally, patients arrive at the hospital with a health status that is determined to be too ill for a safe return to their enclosures/exhibits without continuous medical support. In those cases, keeping the animal in an ICU at the hospital is the best option.

Every critically ill or injured animal is under significant physiological stress (77), which in the case of zoo animals is even more exacerbated by the fact that these animals do not react well to frequent handling and contact with humans as a cat or a dog would. The cornerstone to monitoring critical patients is serial physical examinations (77), but again, due to the stress involved in it, even with visual observation only, this is not always possible (observations should be done in a way that avoids the animal to understand that it is being observed and, whenever possible, cages should be covered in order to diminish stress due to visual stimulation). Still, main parameters to be monitored in animals on ICU include (77):

- Hydration status- assessed by skin turgor, mucous membrane moistness and/or acute change in body weight;
- Pain (it may go unnoticed as zoo animals might hide their pain as a defense mechanism, as mentioned before)- often referred to as the fourth vital sign and it should be anticipated and treated preemptively or presumptively whenever possible;

- Oxygenation/Ventilation- respiratory rate and effort can give some indication about the ventilatory and oxygenation status of the patient. Changes in respiratory rate, pattern, or effort may warrant further exploration with pulse oximetry, end-tidal CO2, thoracic radiographs, or arterial blood gas analysis;
- Nutrition- critically ill patients need good nutrition to adequately meet the body's needs. Patients who have lost more than 5% of their body weight, who have not eaten, or are expected not to eat for 3 or more days are candidates for nutritional support, which will help avoid protein/calorie malnutrition, delayed recovery, or other adverse effects of starvation/catabolic state. The author had the chance to assist with several tube-feedings performed on anorectic patients kept at the hospital on ICU during her externship in one of the visited institutions. One of the zoological medicine specialists taught her a simple way of calculating the amount of food to administer to critical birds, as an example:

    1) The capacity of the stomach of birds ranges from 30 to 50 ml/kg;
    2) Through references consult, one should find the daily caloric needs of that species in particular;
    3) Then, one should find the amount of calories present in each milliliter of the chosen meal (e.g. Emeraid®);
    4) Calculate the number of milliliters necessary to provide the daily amount of calories needed, knowing that:
        a. Chicks: need twice the amount of calories when compared with an adult;
        b. Sick birds: need more than twice the amount of calories;
        c. Underweighted birds: need twice the amount of calories in order to increase the animal's weight.
    5) Dividing the total number of daily milliliters for the capacity of stomach one will get the number of feeds that should give daily to the bird

a) Critical babies

In some instances, however, critical care can (and must) be provided to animals in their own facilities at the zoo. The author had the chance to assist on a daily basis (during half of the externship period) with a case of a hand-reared dolphin calf (Figure 10). This was a very unique and special experience, not only because it was one of the species with greatest interest for the author, but also because hand-rearing dolphins is a very complex and time-consuming husbandry practice that, although much improved when compared with the 90's (127) still presents challenges to every team faced with such situation. "(…) hand-rearing is as much an art as a science." (127)

Unlike other species, dolphins are generally not confined to seasonal breeding and births can occur at any time of year (19). Sometimes, due to factors as mother's inexperience or group aggression (128), a calf may not be accepted by its mother and staff must act quickly in order to separate both animals and start a hand-rearing process. For bottlenose dolphins, mortalities of neonate calves up to day 30^{th} post-parturition accounts for the largest rate of loss to the population as compared to any other demographic age category (124). Failure to thrive and infections are the two main parameters contributing to these mortalities (128) and so, monitoring is essential for success (127). Twice weekly blood collection is recommended until the calf is medically stable and initial blood tests should include compete blood cell counts, serum chemistries, and electrolytes (127). Target weight gain for a bottlenose dolphin should be 0.25 kg/day and, ideally, the calf should be weighted on a daily basis in order to confirm adequate growth (127). Although frequent handling is unavoidably necessary for monitoring the baby's growth (including body measures- Figure 11) and health status, stress should be avoided as much as possible and at no time should a neonate be chased in an attempt to capture it for restraint (128).

Even with such a rigorous monitoring and care plan as the one that was used for this baby (including a person inside the pool with the animal 24 hours a day, monitoring respiratory rate and behavioral activities), because it is still a critical patient, emergency measures and plans of action (including list of supplies with the material to be taken to the animal’s enclosure) should be well known by the entire team (including keepers, curators, etc) in order to avoid complications with such an emblematic and valuable animal.

Figure 10- The vet team and the keepers work in conjunction during a tube-feeding of the calf (Picture taken from the official Facebook page of the Institution).

Figure 11- Mark Gonka, lead trainer for the Chicago Zoological Society assists Rita Stacey, marine mammal curator, as she measures the girth (Picture taken from the official Facebook page of the Institution)

10. EUTHANASIA

Quality of life is a right to which every animal should have access. Veterinarians, as the primary responsible entity for providing care and assure welfare to animals, are also responsible for evaluating suffering and determine whether and when it should have an end or not. In the same way a weighted conversation should take place between the veterinarian and a domestic animal owner about the pet's quality of life, the same occurs in zoos. Veterinarians, keepers, curators, animal managers, all of them have a word regarding the animal's quality of life and, together, they make decisions whether to put an animal "to sleep" or to continue with palliative care.

The word "euthanasia" comes from the Greek "eu," meaning goodly or well, and "thanatos," meaning death; it literally means "good death" (129). There are certain signs one can look to detect when animals are suffering (129) and decide what is the best approach to it.

a) Evaluating quality of life

Most animals do better during the day and worse at night (128). Asking multiple keepers (as shifts might influence observance) about the animal's behavior and abnormal changes in its demeanor may help to determine if there is a decrease on the quality of life or not.

Doctor Dani McVety, a veterinarian who works in a veterinary hospice which also provides in-home euthanasia service, listed the four main groups that should be analyzed in order to evaluate an animal's quality of life (130):

- Social functions: does the animal interact normally with staff and other members of its group? (i.e. increased aggression)
- Natural Functions: has the animal's appetite/drinking/urination/bowl movements/ability of ambulate stayed the same?
- Mental Health: is it enjoying normal play activities (either by itself or with other members of the group)? Does it still dislikes the same things? Is it showing signs of

stress or anxiety? Does it seem confused or apathetic? Is the nighttime activity normal, with no changes seen?

- Physical Health: does the animal show changes in breathing or panting patterns? Does the animal show signs of pain? Did his/her body condition changed recently?

According to the answers to these questions, decisions can be made whether to euthanize an animal or not.

b) Methods for euthanasia

Nowadays, several ways of euthanasia are available and acceptable. In this document, the author will summarize information about euthanasia methods assisted during the externships.

i. Injectable

"*Injectable euthanasia is one of the most rapid and reliable methods*" (131). Acceptable injectable euthanasia agents result in smooth loss of consciousness followed by cessation of cardiac and/or respiratory function, minimizing pain and distress to the animal (131). IV injection allows fast distribution of the agent to the brain or neural centers, resulting in rapid loss of consciousness, but aggressive or fearful animals should be sedated prior to restraint (131).

Barbiturates depress the CNS in descending order, beginning with the cerebral cortex, with loss of consciousness progressing to anesthesia (131). With an overdose, deep anesthesia progresses to apnea due to depression of the respiratory center which in turn is followed by cardiac arrest (131). There is a rapid onset of action, and loss of consciousness results in minimal or transient pain associated with venipuncture (131). All barbituric acid derivatives used for anesthesia are acceptable for euthanasia, but the most desirable ones are those that are potent, nonirritating, long acting, stable in solution, and inexpensive (131). Sodium pentobarbital is the one that best fits these criteria and is therefore the most widely used (131). Disadvantages of barbiturates include the possibility of an aesthetically objectionable terminal gasp to occur, some animals may go through an excitatory phase that may be distressing to observers, and tissue artifacts (e.g. splenomegaly) (131). Nevertheless, these type of drugs are still the preferred method of euthanasia. Intracardiac (in mammals and birds) administration must only be used if the animal is unconscious or anesthetized (131).

Potassium Chloride is also a possible agent that might be used to provide an ethical way of animal death; however, it must always be administered to animals that are already unconscious as it does not provide depression of the CNS, and death is caused only by the cardiotoxic properties of the potassium ion which will cause cardiac arrest when injected rapidly by IV route or intracardiacally (131). Administration of potassium chloride IV requires animals to be in a surgical plane of anesthesia (i.e. loss of consciousness, loss of reflex muscle response, and loss of response to noxious stimuli) (131). Apart from the need of having the animal already unconscious during injection, the other main disadvantage of using the agent is the fact that saturated solutions are required to obtain suitable concentrations for rapid injection into large animals (131).

ii. Decapitation

It has been demonstrated that electrical activity in the brain persists for 13 to 14 seconds following decapitation but more recent studies and reports indicate this activity does not imply that pain is being perceived (131). Amphibian and reptilian hearts can beat even after brain death (131) and so, after animals have been anesthetized (or even after IV administration of barbiturics), decapitation using heavy shears or a guillotine is effective for these (129) species. It has been assumed that stopping blood supply to the brain by decapitation causes rapid loss of consciousness; however, because the CNS of reptiles and amphibians is tolerant to hypoxic and hypotensive conditions (131) decapitation must be followed by pithing or another method of destroying brain tissue (131).

c) Confirmation of death

Lack of pulse, breathing, corneal reflex and response to firm toe pinch, inability to hear respiratory sounds and heartbeat by use of a stethoscope, graying of the mucous membranes, and *rigor mortis* should be used all together to confirm death (except *rigor mortis* which can be used as single parameter to confirm death) (131).

d) Euthanasia of surplus animals

Recently (in 2014), a public wave of animal defenders raised against European zoos who killed young animals of their own collections stating that there was not enough space in the zoo for keeping all the animals. The situation became even more controversial when other zoo facilities volunteered to keep the animals and the requests were denied (132, 133).

In 2012, veterinarians from the Basel Zoo (Switzerland) and the Wuppertal Zoo (Germany) gave a presentation at the AAZV conference entitled "Breed and Cull: Let's Talk About a Taboo" (134). Arguments as contraception excluding the animals from all aspects of reproductive behavior (i.e. courtship, pair-bonding, mating, pregnancy, rearing offspring, mother-infant bonding, playing, etc) were referred, and cultural and legal aspects as well as the way of dealing with staff, public awareness and the media were also quoted, with the final conclusion that the actual decision of culling an animal can only be made by a person who possesses the specific expertise and is familiar with the situation- the zoo veterinarian.

Whether "lack of space" is considered a valid argument for euthanizing animals whose birth could have been prevented, depends on each person's principles and ethics.

Regardless of the animal, method for euthanasia elected and reasons why such decision was taken, people form attachments with animals in a variety of situations and acknowledging loss and grief in the zoo is one aspect of this work field and institutions should develop strategies for handling grief-related situation in the zoo (135).

11. FINAL CONSIDERATIONS

a) Zoo Medicine: What's the goal?

Zoo and wild species medicine is a very attractive and fascinating field for many students that get into the veterinary schools every year. The idea of working with emblematic species, especially the large African mammals (e.g. lions, elephants, giraffes) is something that several students would like to do, but few will. Although most veterinary students enroll into small animal practice, the number of small animal clinics and hospitals cannot be compared to the number of zoological parks and wildlife rescue centers; as a consequence, competition is inherent and ruthless, and having skills that can highlight enough an individual in order to be chosen among all the others to enroll in a program of zoo and wildlife medicine can make the difference in a whole life career.

Even if one can get into a training program (e.g. residency, master) for zoo and wildlife medicine, there is not the guarantee of getting a job after it, which makes even more uncertain the future in this area. To succeed, zoo and wildlife veterinarians need to be knowledgeable about more than the animals' physiology; they need to have a basic understanding of the natural history, niche, behavior, nutrition, and diseases of all (and "all" can be "a lot!") of the species under their care (136). In addition, these veterinarians must have non-technical skills, a general awareness of how the world works, common-sense, and recognition that how we choose to live our lives impacts the environments in which we live (136). Still, many vet students and graduated veterinarians are convinced to work hard to achieve this career goal, and the author knows well why:

Current and predicted future extinction rates are very high, and most of them appear to be caused either directly or indirectly by human activity (137). Every species loss can be looked at as a tragedy (137).

Zoos and aquariums are the principal institutions holding *ex situ* populations of animal species for captive breeding purposes (137). Although most originated as menageries for public entertainment, nowadays they are increasingly turning their attention to animal conservation and public education (137). Animal captive populations of animals can function as a genetic pool from which "new blood" can be obtained for wild populations (137). During the last years some of the species most at risk of extinction have been saved thanks to direct manipulative intervention and *ex situ* preservation, although it is not the only option for wildlife managers, it often represents the only hope for species near extinction in the wild (137). Figures 12, 13 and 14 show three examples of endangered species with which the author had the chance to contact with and be a witness of their expansion in zoos.

Figure 12- three-month-old snow leopard cub with his mom at the Brookfield Zoo (Picture taken from the official Facebook page of the Institution, accessed on 29 January 2015)

A prerequisite for successful reintroductions of captive specimens is to have viable, well-managed and self-sustaining captive populations with broad genetic representation (138) and that's why animal reproduction in zoological institutions is such an important aspect for endangered species conservation.

Unfortunately, many times reintroduction program fails, due to a variety of factors. Apparently, "loss" of wild instincts and inaccessible learning of vital wild behaviors seem to be the main causes for failure of programs. *Jule et al (2008)* (139) made a comparison between success of reintroduced captive-born versus wild-born carnivores. They tried to find if captivity could affect the survival of reintroduced carnivores (reviewing previous publications) and they found that wild-caught animals have significantly more chances to succeed than captive-born animals (139). According to their review, humans were the direct cause of death in over 50% of the cases of reintroduced animals (139), which might be related with the familiarity that these animals had with humankind since they were born. Starvation, unsuccessful predation and disease are also more likely to affect captive-born carnivores than the wild-caught ones (139).

Long-term maintenance of captive populations followed by release of these animals into the wild is one of many approaches to conservation of endangered species (140). McPhee (140) "tested" captivity's effects on behavior, by presenting a simulated predator to groups of wild and captive oldfield mice (*Peromyscus polionotus subgriseus*) and they measured its response behaviors. Various numbers of generations (i.e. 35, 14, two and zero (wild-caught)) were tested in order to evaluate differences between them (140). Results showed that the more number of generations a population has been in captivity, the less likely an individual is to escape and refuge after seeing a predator (140).

Studies like this show how difficult it might be to accomplish tasks regarding animal reintroduction and conservation. Nevertheless, several projects have taken some of the last wild individuals of severely threatened species into captivity and built up numbers until conditions were suitable for the re-establishment of free-living populations (138), proving that with great effort done, great results can follow: *Spalton et al.* (141) and *Haque et al* (142) demonstrated that even for cases thought to be "lost", like the Arabian oryx (*Oryx leucoryx*) and the Arabian san gazelle (*Gazella subgutturosa*), if human interference (in these cases, mainly the illegal poaching) is controlled, species can thrive again in their natural environment. (141, 142). In another study, Raesly (140), based on direct and circumstantial evidence, stated that reintroductions of the river otter (*Lontra canadensis*) were successful in restoring extirpated populations at determined locations of the United States of America (143). These are just a few examples of hundreds of other animal reintroductions that have occurred during the last decades.

Sanz V. et al. (144) also describe a successful reintroduction program of the yellow-shouldered amazon parrot (*Amazona* barbadensis), but they remark that substantial portion of the success rests on the five years period of previous work on environmental education, public awareness and studies on the parrot's biology (144) and all of these parameters are also responsibility of a zoo veterinarian other than reproduction. Conservation will only work if people understand what it is, its importance and whose interest it serves (145). Veterinarians must take the education of people as an integral part of their job, and it can be done in many ways (145):

- School groups: having specific days available for visits and lectures to primary, middle and high schools. Close relationships with local universities can be also pursued to encourage programs of workshops, lectures and sponsored research by students in other disciplines.
- Publications: journals, newspapers, brochures, newsletters and professional journals.
- Personal approach: ensuring that all contacts throughout the daily routine understand what the veterinarian is doing and why, so that he/she can receive greater cooperation and action.

People can see the beauty of animals in zoological parks; however it is up to conservation and veterinary staff to help people acquire an understanding why it is beautiful. "***Any individual who hears your words can become an ally and carry your message further*"** (145).

Unfortunately and despite all efforts to make the role of zoos in conservation known, there are still many people considering inhuman keeping wild animals in captivity, no matter the endings for. The two main considerations to be surveyed in such sensitive subject are the question of the moral reason for maintaining captive populations and the question of the moral requirements for their care in captivity (146). "(…) *Humankind has all too often abused or destroyed other life capriciously and wantonly*" (146). Although the motive of animal protection associations is ethic and valid (keeping animals where they belong), they argue that zoo animals are under continuous distress and suffering (which, in some cases, is true), only for entertainment of people. They claim that there is no need to display animals for education and sensitization of public for environment problems to occur and that zoos have no value for reproduction and reintroduction programs. Facts tell the contrary…

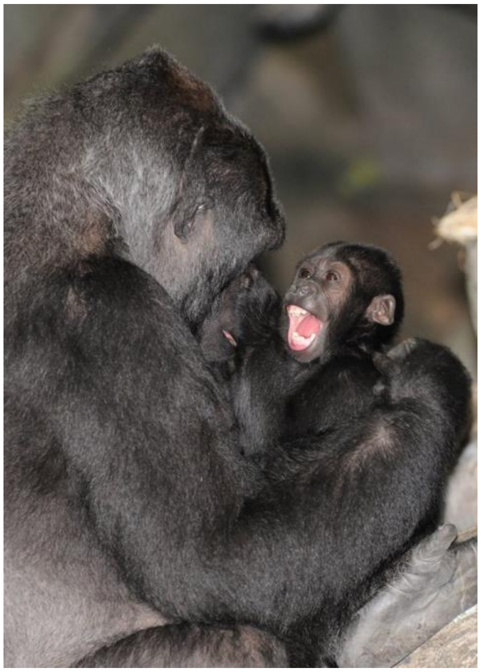


Figure 13 – One-year-old western lowland gorilla with her mother at the Brookfield Zoo (Picture taken from the official Facebook page of the Institution, accessed on 29 January 2015)

In all the visited institutions, the author had the chance to assist with obstetric, pediatric and reproductive procedures of many species. One great example of conservation is the Amphibian Conservation Area at the Omaha's Henry Doorly Zoo, where threatened amphibians are bred for subsequent release in their natural habitat. Once again, although captive breeding and

Figure 14 - a baby giant panda playing at the Smithsonian's National Zoological Park (Picture taken from the official Facebook page of the Institution, accessed on 29 January 2015)

reintroduction may be a controversial management action, amphibians possess a number of attributes that make them potentially good models for such programs (147).

Regarding the western lowland gorilla and other great apes reintroductions, several projects have been successfully concluded in the last few years (148). As an excellent example, *Monaghan C. et al* (149) describe a case of a 14-yr-old captive born Sumatran orangutan that was released into a protected park as part of a reintroduction program. One year later, the released animal (born and raised in captivity by its mother at Perth Zoo) was still doing well, adapting to the wild environment rapidly and successfully, with supplementary feeding being provided in the forest once per week and trackers following its progress (149).

b) <u>Zoo Medicine: What are the risks?</u>

In 1998, *Hill D. et al* (150) conducted a study undertaken to identify the prevalence of occupational injuries and illnesses associated with the zoo veterinarian medical practice. 61.8% of the injuries were major animal-related injury (defined as one for which medical treatment was required either by a physician or self-administered, excluding those requiring only topical antibiotics), 40.2% were adverse formalin exposure, and 30.2% zoonotic infection (150). They identified that zoo veterinarians with more years of experience were more likely to receive a major animal-related injury and associated hospitalization, adverse anesthetic gas exposure, and a positive skin test for tuberculosis (150). Results were compared to hazards reported by veterinarians working in other fields and they concluded that these happen in a much higher frequency in zoo veterinarians (150). X-rays and anesthetic gas are two main sources of adverse effects in the veterinary field, but effects are only revealed in the long-term, often giving chance for people to undervalue protection measures against these hazards.

The diagnostic use of x-ray irradiation has the potential to cause significant deleterious biologic effects, with major effects being development of fatal cancers, genetic effects passed on to their children, and developmental defects in the fetus when irradiated in utero (151). Time, distance, and shielding are the main ways of protecting from radiation:

keeping the time of exposure as short as possible, increasing the distance from the source of radiation and placing shielding material between the operator and the source of radiation (151). In the United States, annual radiation dose limits for occupational workers are set by state health codes and the Nuclear Regulatory Commission in order to protect personnel working with this material and the use of radiation dosimeters is strongly recommended for any person who participates in making radiographic exposures (151). Having several assistants trained to make radiographs serves to divide the radiation exposure among individuals, planning radiographic procedures so that the desired image can be accomplished the first time and using mechanical restraining devices and/or chemical restraint are three main methods of reducing exposure risks (151).

Regarding waste anesthetic gas, it has been associated with numerous health problems in individuals that chronically inhale polluted air: hepatic disease, renal disease, immunosuppression, bone marrow depression, abortion, infertility, birth defects, cancer, pruritus, and a wide range of CNS disturbances (152). In zoos, most patients that arrive at the hospital need to be anesthetized (in order to be safely restrained), even if only for simple physical examinations. As such, frequency of exposure to anesthetic gases is much higher, especially because most of the animals are induced by facemask or induction chambers. Having good quality equipment, able to collect and retain considerable amounts of wasted gas, to install a scavenging system, and educate employees on the safe administration of anesthetic gases (152) are good measures that help to prevent unnecessary exposures.

As previously described, the use of potent capture drugs carries the inherent risk of human injury (153). Though prevention is the mainstay in avoiding drug related accidents, it is important (and required by the Association of Zoos and Aquariums for all accredited zoos) to establish protocols to deal with potentially lethal exposure, as accidental capture drug injection is always considered an emergency that will require calm, prompt and organized action (153). Although IV administration of naloxone is considered the standard measure for accidental human exposure to ultra-potent opioids, two studies have shown that concentrated 1mg/ml naloxone given intranasally to people is as effective as giving the same dose intramuscularly or intravenously (154) and another study showed that 83% of individuals suspected of opioid overdose responded to intranasal administration of naloxone without the need for intravenous supplementation (154). Intranasal administration of naloxone can then be considered an alternative method to provide emergency relief in the zoo or field settings to individuals not trained on intravenous administration of medications to humans (154).

Regarding methods of self-defense, oleoresin capsicum products (i.e. pepper sprays) are useful because they cause temporary but severe pain and inflammation when they contact ocular and respiratory mucous membranes (155). The subsequent compromise of vision and respiratory function debilitate an attacker and gives enough time for a defender to escape (155). This type of products should only be used when human lives are in danger, and staff in zoological institutions should receive training on this type of tools (155).

c) The "Externship Adventure": What was brought home?

After having the privilege of working with 194 different species in a variety of medical cases, the author feels now much more comfortable about several aspects of zoological medicine than before and the specific goals established were definitely accomplished. A fragment of the evaluation letter from the Brookfield Zoo, written by Doctor Jennifer Langan was extracted, so that a better description of what the author improved (from a medical point of view) can be done:

"*Marisa assisted with daily veterinary duties such as patient care, anesthesia, radiology and preventative medicine. (…) She became increasingly more* comfortable *during her rotation working with new species. (…) She learned to take a thorough history, performed thorough physical examinations, was able to detect and prioritize problems and formulate appropriate diagnostic plans. She was able to interpret diagnostic test results, formulate therapeutic plans and provide patients appropriate care. Her ability to safely restrain and handle animals improved significantly with a wide variety of different species. She collected samples and practiced using common instruments learning proper technique.*"

Notwithstanding the great acquirement of technical and scientific knowledge, the author learned about other important aspects that people often fail to integrate in their daily practice as a veterinarian…

Having the ability to clearly communicate with keepers and other animal managers about medical issue; one should always remember that a routine subject for a veterinarian, it's probably not seen the same way for keepers and curators (156) and so, speech and manners of explaining subjects should be simple and clear so that the whole team understands the process.

We (veterinarians) are always interested in improving our level of care, but research in human medicine has shown that "gaps" in non-clinical skills are just as important as lack of medical knowledge (38). "Soft skills", as they are called, include communication, listening, relationship building and conflict resolution. When used in conjunction with the already known technical skills, they are associated with a higher degree of success and elevated patient care (38). Hence, a good relationship between the veterinarian and the rest of the zoo workers is fundamental, in order to guarantee that everyone is aware of what are the problems and, together, they can manage it and find the best solution for it.

Probably the biggest accomplishment for the author, both professional and personally, was finally to understand the importance of working with and as a team member. Many times, people feel frustrated with their work environment due to failure of receiving and giving support to other team members in a coordinated and organized manner. Several issues as poor training, lack of communication, opposite ideas and discouragement due to a number of factors might be enough for a "team-work" to become unviable. However, organization, planning and discussions about how to get the best results should be encouraged and have all team-members participation, so that everyone is aware of every step and all the opinions can be considered. Good teams share accountability for outcomes and take responsibility for a collective product; they are flexible, synergistic, and ensure quality throughout their work system (157). It was fascinating to the author to realize that, with a good team, results can be accomplished so much faster, in such a better way and with outstanding results. Daily meetings must occur and be thorough about all the cases. Everyone is aware and willing on getting the desired results.

But no good team can exist without the guidance of a great leader. Leadership must be transparent in order to build trust and keep team members moving toward the goals and standards they have helped define (158). For a leader to exist, team members must appreciate his/her vision, understand the reasons behind directions, and follow eagerly and enthusiastically (159). An effective leader points out clear specific expectations and makes certain that the whole team understand the reasons behind the goals. Such a leader takes time to consistently evaluate performance and commitment, stepping in when necessary (159). He/she asks questions or concerns, listens respectfully, and appreciates others' perspectives to modify or clarify directions, demonstrating that "two heads think better than one" and everyone can learn from everyone (159). The author had the chance to be included in teams with ways of working and hierarchies like these, saw her confidence boosted and felt appreciated when suggestions regarding approach to patients were heard and taken by other members of the team, even if it came "just from a student". It was also notable, with specific teams, to notice how much reinforcement and support is given among everyone involved. If there are words and lessons that Portuguese veterinarians should learn with the American fellows are the capacity of recognizing other peoples' value and skills (even if they're better than ours) and to say the simple, but so grateful words "Good job!"

d) <u>The "Low" aspects</u>

Despite all the offers available for doing externships (no matter what field of veterinary medicine), choosing a place that actually is going to provide good tutoring and learning opportunities is, in its basic aspect, a matter of "luck".

The author considers that in every places there will be learning opportunities; either by the good or the bad aspects of that facility. If one is able to identify mistakes, then one should be able to keep in mind not to do so. Every time a bad conduct, medical errors or any other bad aspects are witnessed, that is a learning opportunity for the student to identify what other ways could have been done to avoid the bad situation to follow. Just like it was stated before for animals "learning is a continuous experience"...unfortunately, humans often fail to learn when it applies to recognizing mistakes.

Lack of mentorship has been cited as the primary reason for discontentment among students and new graduates, either with externship places or places of employment, respectively (160). Mentorship goals to expand the mentee's knowledge, confidence, productivity, and clinical skills through the mentor's investment into teaching and coaching (160). It can also expand beyond the traditional roles of senior and junior veterinarians and apply to other team members (160), as the author had the chance of experiencing (by teaching veterinary technicians how to draw blood from species with which the author had already had worked before). Unfortunately, many times people that are assigned to be the mentors are not actually interested in doing it so. Teaching can occur in many instances, during meetings, medical procedures and any time that a mentor and a mentee are together. But again, lack of "soft skills" and even lack in interest for teaching are not always present. People who don't take opportunities for teaching new generations are forgetting our common goal: to provide the best care to our patients. And if that is the goal, then everyone should be a part in making sure that new generations of veterinarians will be as good as or even better than the current ones. But with no teaching, these new generations will only learn by themselves, and that means they will make many mistakes until they can identify them and how to correct them. If they had the chance of having someone advising them before they make those mistakes, teaching them better ways of approach and telling them which references they should consult to get more information, then maybe whenever they would be by themselves for the first time, they would be better performers. Specific individuals who are interested in teaching should be the ones selected to run an externship program as well as being responsible for providing the mentorship that students are expecting for. They should be aware that every person that has the chance of receiving good mentorship will get more clinically relevant skills, a greater sense of personal accomplishment, and feels happy about its experience, at the same time that the mentor may gain a team member who is more productive, causes less stress, and provides better patient care (160) even if is "just a student". The author had the chance of experiencing both "gold-standard" mentoring as well as no-mentoring at all. As a result, people who gave her the chance of showing her skills, challenged her with quizzes and cases and taught her about how to improve herself as a future veterinarian, had the chance of knowing much more about the person they had under their tutoring as well as being a priceless contribute to her improvements when compared to "mentors" that showed no interest for interacting with the mentee at all.

e) Suggestions for future students:

Many students feel inhibited about posing questions to professionals they might be following during an externship. It is true that there will be people that react/answer in a protective manner when their methods are questioned (161) but this doesn't necessarily occurs with that much frequency. Again, mentorship is one of the cornerstones for a successful externship, and a mentee should not hesitate to bring up struggles and problems or ask questions to the mentor, as long as is cognizant of the mentor's time (160). Every question that is not answered now, is a medical mistake that might be done in the future.

For students who are defenders of providing equal medical care among every species, moral distress can occur in some institutions. Moral distress is defined as when one knows the ethically appropriate action to take but is unable to act upon it, and instead acts in a manner contrary to his/her personal and professional values (160). The author had the chance of working in facilities where due to financial support, equal medical approaches (e.g. diagnostics, treatments) could be provided to any species; however, some institutions will adapt their medical approach according to the "value" of that species, and students who want to pursue this field should be aware of it.

Students who really want to pursue this field of veterinary medicine should be sure of what do they really want to do as a zoo veterinarian, how long will it take to get them there and what obstacles do they need to overcome (163). But most of all, they should be realistic about the future, and be aware of the skills needed to achieve their goals (163). There are several programs that give education about wild species medicine, and is up to the student to be aware of what their goals are and if they can be accomplished with one specific program. They should never forget that, due to the high competition in this field, having a plan B is very important, as the "dream job" may not arrive as soon as we would like it to.

Finally, the author would like to state that incredible experiences as the one she had the chance to live during this externship period are also important to remember us about the value of things we are used to contact daily, and we definitely miss a lot when we are far away from home. Leaving your country, your family, your friends, and embrace something like this to have the chance of getting knowledge that, unfortunately, is not available at our nation yet, also emphasizes that, although career success is important, general happiness and optimism are fuel to our performances and achievements (164). We must couple both professional and personal goals so that more than getting the perfect job, we will be happy.

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Attachments

Table 1A- Fish cases at the Brookfield Zoo

Procedure/Problem	1*	2*
Euthanasia	1 (group)	
Buoyancy		1

1* Sea horse (*Hippocampus sp.*)

2* Moray eel (*Gymnothorax mordax*)

Table 2A- Amphibian cases at the Brookfield Zoo

Procedure/Problem	1*
Ophthalmology	1

1* Climbing toad (*Pedostibes hosii)*

Table 3A- Reptile cases at the Brookfield Zoo

Procedure/Problem	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*	12*	13*	14*	15*	16*	17*	18*	19*	20*	21*	Total
Reproductive	1																	1				2
Oncology		1	1													1	1					4
Dermatology				1		1	1				7	1	1		1				1	1	1	16
Respiratory					1									1								2
Quarantine Exam	2																					2
Gastroenterology								1	1									1			1	4
Generalized Malaise										5												5
Total	3	1	1	1	1	1	1	1	1	5	7	1	1	1	1	1	1	2	1	1	2	**35**

1* Twist-necked Turtle (*Platemys platycephala*)

2* Common agama (*Agama agama*)

3* Thai Bamboo Rat Snake (*Elaphe porphyracea coxi*)

4* Boa Constrictor (*Boa constrictor*)

5* African spurred tortoise (*Geochelone sulcata*)

6* Northern Map Turtle (*Graptemys geographica*)

7* Southern copperhead (*Agkistrodon contortix*)

8* Egyptian Tortoise (*Testudo kleinmanni*)

9* Shingle back Skink (*Tiliqua rugosa*)

10* Garter Snake (genus *Thamnophis*)

11* Dumeril's Ground Boa (*Acrantophils dumerili*)

12* Musk Turtle (*Sternotherus odotarus*)

13* Eastern Cottonmouth (*Agkistrodon piscivorus piscivorus*)

14* Reticulated Python (*Broghammerus reticulatus*)

15* American red-bellied turtle (*Pseudemys rubriventris*)

16* Rough Greensnake (*Opheodrys aestivus*)

17* Brown House Snake (*Lamprophis fuliginosus*)

18* Panther chameleon (*Chamaeleo pardalis*)

19* Cat-eyed Snake (*Leptodeira annulata*)

20* Texas Indigo Snake (*Drymarchon coralis erebennus*)

21* Jamaican's Boa (*Epicrates subflavus*)

Table 4A- Bird cases at the Brookfield Zoo

Procedure/Problem	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*	12*	13*	14*	15*	16*	17*	18*	19*	20*	21*	22*	23*	Total
Pre-ship. Exam	1																							1
Preventative Med.		3		1				2												2	1			9
Podology								1						10										11
Infectious			1		1														2					4
Neurology						1																		1
Dermatology							1					1												2
Cardiology								1																1
Quarantine Exam									1	1												2		4
Ophthalmology													1											1
Traumatology			1								1					1	1						1	5
Orthopedics																		1						1
Total	1	3	2	1	1	1	1	4	1	1	1	1	1	10	0	1	1	1	2	2	1	2	1	**40**

1* Budgerigar (*Melopsittacus undulatus*)

2* Inca tern (*Larostena inca*)

3* Superb Starling (*Lamprotornis superbus*)

4* Red bird of paradise (*Paradisaea rubra*)

5* Micronesian Kingfisher (*Todiramphus cinnamominus cinnamomi*)

6* Red-billed hornebill (*Tockus erythrorhynchus*)

7* Japanese Bantam (*Gallus gallus*)

8* Humboldt Penguin (*Spheniscus humboldti*)

9* Golden-breasted Starling (*Cosmopsarus regius*)

10* White Ibis (*Eudocimus albus*)

11* Greater Road Runner (*Geococcyx californianus*)

12* Bali Mynah (*Leucopsar rothschildi*)

13* Emu (*Dromaius novaehollandiae*)

14* Helmeted guineafowl (*Numida meleagris*)

15* Ringed Teal (*Callonetta leucophrys*)

16* White-headed Buffalo Weaver (*Dinemellia dinemelli*)

17* Common Peacock (*Pavu cristatus*)

18* Princess Parrot (*Polytelis alexandrea*)

19* Golden Conure (*Aratinga guarouba*)

20* Great Combattant du Nord Chiken (*Gallus gallus domestic Wyandotte*)

21* Cockatiel (*Nymphicus hollandicus*)

22* Blue-winged Teal (*Anas discors*)

23* Green Aracari (*Pteroglossus viridis*)

Table 5A- Mammal cases at the Brookfield Zoo

Procedure/Problem	1*	2*	3*	4*	5**	6*	7*	8*	9*	10*	11*	12*	13*	14*	15*	16*	17*	18*	19*	20*	21*	22*	23*	24*	25*	26*	27*	28*	29*	Total
Pre-ship. Exam	1			1				2											2											6
Respiratory		1																1			1									3
Preventative Med.								2	1																				1	4
Cardiology																			2											2
Reproductive		5		1	1																									7
Oncology					3																		1	1						5
Gastroenterology			1		1			1				1									1		1							6
Ophthalmology						4	2																							6
Pediatrics		2				1																							1	4
Dermatology	2	1							2									1	1			1								8
Dentistry	1								2														1			1			1	6
Infectious										1																				1
Traumatology		1									3		1		3					1					1			1		11
Quarantine Exam			10											2																12
Urology					1											1							1							3
Obstetrics		2				1																								3
Orthopedics																	1							1			1			3
Neurology																				1										1
Podology																												1	1	2
Behavior		1																												
Total	4	13	11	2	6	6	2	5	5	1	3	1	1	2	3	1	1	2	5	2	2	1	4	2	1	1	1	2	4	**94**

1* Black-and-Rufous Elephant Shrew (*Rhynchocyon petersi*)

2* Bottlenose dolphin (*Tursiops truncantus*)

3* Common Squirrel Monkey (*Saimiri sciureus sciureus*)

4* Mexican Grey Wolf (*Canis lupus baileyi*)

5* Goeldi's Monkey (*Callimico goeldii*)

6* Grey seals (*Halichoerus grypus*)

7* California sealion (*Zalophus californianus*)

8* Polish rabbit (*Oryctolagus cuniculus polish*)

9* Aardvark (*Orycteropus afer*)

10* Habor Seal (*Phoca vitulina*)

11* Western Grey Kangoroo (*Macropus fuliginosus melanops*)

12* Black-and-White Colobus (*Colobus angolensis palliates*)

13* Small-spotted Genet (*Genetta genetta*)

14* Binturong (*Arctictis binturong*)

15* Golden Lion Tamarin (*Leontopithecus rosalia*)

16* Ferret (*Mustela putorius furo*)

17* Polar Bear (*Ursus maritimus*)

18* Ring-tailed Lemur (*Lemur catta*)

19* African Hunting Dog (*Lycaon pictus*)

20* Rodrigues Fruit Bat (*Pteropus rodricensis*)

21* Black-footed Cat (*Felis nigripes*)

22* Red-river Hog (*Potamochoerus porcus*)

23* Asian Small-clawded Otter (*Aonyx cinerea*)

24* Cotton-top Tamarin (*Saguinus oedipusi*)

25* Brown Capuchin (*Cebus apella*)

26* African Crested Porcupine (*Hystrix Africaeaustralis*)

27* Amur leopard (*Panthera pardus orientalis*)

28* Reticulated Giraffe (*Giraffa camelopardalis reticulata*)

29* Okapi (*Okapia johnstoni*)

Table 6A- Fish cases at the Henry Doorly Zoo

Procedure/Problem	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*	Total
Euthanasia		1										1
Buoyancy	1											1
Pathology			1			1						2
Dermatology				1	1						1	3
Behavior							2	1	1 (group)	1 (group)		5
Total	1	1	1	1	1	1	2	1	1	1		**11**

1* Stonefish (*Synanceia horrida*)

2* Tetra fish (family *Characidae*)

3* Rainbowfish (family *Melanotaeniidae*)

4* Seahorse (genus *Hippocampus*)

5* Ocellate River Stingary (*Potamotrygon motoro)*

6* Undulated moray eel (*Gymnothorax undulates*)

7* Yellow Moray Eel (*Gymnothorax prasinus*)

9* Whitespotted Moray Eel (*Gymnothorax punctatus*)

9* Stingrays (suborder *Myliobatoidei*)

10* Bonnethead Shark (*Sphyrna tiburo*)

11* Lined Seahorse (*Hippocampus erectus*)

Table 7A- Amphibian cases at the Henry Doorly Zoo

Procedure/Problem	1*	2*	3*	4*	5*	6*	Total
Ophthalmology	1						1
Podology		1					1
Reproductive			1			1	2
Ceolomic distension				1			1
Dermatology					7		7
Pathology						1	1
Total	1	1	1	1	7	2	**13**

1* Climbing toad (*Pedostibes hosii*)
2* African Bullfrog (*Pyxicephalus adspersus*)
3* Boreal Toad (*Bufo boreas boreas*)
4* Puerto Rican Crested Toad (*Bufo lemur*)
5* Panamanian Golden Frog (*Atelopus zeteki*)
6* Mississippi Gopher Frog (*Lithobates sevosus*)

Table 8A- Reptile cases at the Henry Doorly Zoo

Procedure/Problem	1*	2*	3*	4*	5*	6*	7*	Total
Pathology		1			1			2
Oncology						1		1
Dermatology			1					1
Orthopedics	1							1
Ophthalmology				1				1
Behavior							1	1
Total	1	1	1	1	1	1	1	**7**

1* Rosy boa (*Lichanura trivirgata*)
2* Cape dwarf Chameleon (*Bradypodion pumilum*)
3* Western Hognose Snake (*Heterodon nasicus*)
4* Gecko (Infraorder *Gekkota*)
5* Python snake (genus *Python*)
6* Yellow Rat Snake (*Coelognathus flavolineatus*)
7* Rock Monitor (*Varanus albigularis*)

Table 9A- Bird cases at the Henry Doorly Zoo

Procedure/Problem	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*	12*	13*	14*	15*	16*	17*	18*	19*	20*	21*	22*	23*	24*	25*	26*	27*	28*	29*	30*	Total
Reproduction	12										4																				16
Preventative Med.						24	1	5			5	1	14	1	19	3	1	1	2	9	1			1	1						89
Orthopedics					2				1													1									4
Neurology																				1											1
Ophthalmology										1																	1			1	3
Traumatology				1																								1	1		3
Podology	1	1	1																	2						1					6
Toxicology											1																				1
Pathology																				1		1									2
Endocrinology																							1								1
Total	13	1	1	1	2	24	1	5	1	1	10	1	14	1	19	3	1	1	2	13	1	2	1	1	1	1	1	1	1	1	**126**

1* Cattle Egret (*Bubulcus ibis*)
2* African Spoonbill (*Platalea alba*)
3* Southern rockhopper penguin (*Eudyptes chrysocome*)
4* Abyssinian Hornbill (*Bucorvus abyssinicus*)
5* Grey crowned crane (*Balearica regulorum*)
6* Sandhill crane (*Grus canadensis*)
7* Owl (Order *Strigiform*)
8* Hawk (family *Falconidae)*
9* Blue-winged Teal (*Anas discors*)
10* Humboldt Penguin (*Spheniscus humboldti*)
11* Bald Eagle (*Haliaeetus leucocephalus*)
12* Crested Screamer Bird (*Chauna torquata*)
13* Screech Owl (genus *Megascops*)
14* Wattled Crane (*Bugeranus carunculatus*)
15* American While Pelican (*Pelecanus erythrorhynchos*)
16* Kestrel (genus *Falco*)
17* Barn Owl (*Tyto alba*)
18* Great Horned Owl (*Bubo virginianus*)
19* Ostrich (*Struthio camellus*)
20* Chicken (*Gallus gallus domesticus*)
21* American Wigeon Duck (*Anas americana*)
22* Quail (order *Galliformes*)
23* King Penguin (*Aptenodytes patagonicus*)
24* Yellow-collared macaw (*Primolius auricollis*)
25* Scarlet Macaw (*Ara macao*)
26* Black-footed Penguin (*Spheniscus demersus*)
27* Tawny Frogmouth (*Podargus strigoides*)
28* Red-tailed Hawk (*Buteo jamaicensis*)
29* Sulphur-crested Cockatoo (*Cacatua galerita*)
30* Gentoo Penguin (*Pygoscelis papua*)

Table 10A- Mammal cases at the Henry Doorly Zoo

Procedure/Problem	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*	12*	13*	14*	15*	16*	17*	18*	19*	20*	21*	22*	23*	24*	25*	26*	27*	28*	29*	30*	31*	32*	33*	34*	35*	Total
Pathology	2			1										1			1		1						1		1									8
Respiratory								1								1																				2
Preventative Med.		2		2		1	1					9									3	1		1		3					1					24
Reproductive											1		1																			1				3
Oncology														1			1										1									3
Pediatrics					1																															1
Dermatology		3										1																								4
Dentistry																															1					1
Traumatology					1										1			1												1						4
Urology				1						2																										3
Orthopedics				1									1										1	1												4
Neurology																												1								1
Podology						1	1		1																											3
Behavior			1**	1**	1**						1				1		1																1	1	2	7
Pre-shipment Exam																	4			2									2							8
Wild control																			1																	1
Endocrinology																						1														1
Euthanasia																	1																			1
Total	2	5	0	5	2	2	2	1	1	2	2	10	2	2	2	1	8	1	2	2	3	2	1	2	1	3	2	1	2	1	2	1	1	1	2	**79**

**- group

1* Common Vampire Bat (*Desmodus rotundus*)

11* Aye-aye (*Daubentonia madagascariensis*)

21* Pygmy Hippopotamus (*Choeropsis liberiensis*)

2*	Indian Rhino (*Rhinoceros unicornis*)	**12***	Prairie dog (genus *Cynomys*)	**22***	Grevy's Zebra (*Equus grevyi*)
3*	Ring-tailed Lemur (*Lemur catta*)	**13***	Addax (*Addax nasomaculatus*)	**23***	Squirrel Monkey (*Saimiri sciureus*)
4*	Common Brown Lemur (*Eulemur fulvus*)	**14***	Howler Monkey (*Alouatta caraya*)	**24***	Cacomistle (*Bassariscus sumichrasti*)
5*	Domestic Goat (*Capra hircus*)	**15***	Slow loris (genus *Nycticebus*)	**25***	Screaming hairy Armadillo (*Chaetophractus vellerosus*)
6*	Malayan Tapir (*Tapiris indicus*)	**16***	Norwegian Rat (*Rattus norvegicus*)	**26***	White rhinoceros (*Ceratotherium simum*)
7*	Reticulated Giraffe (*Giraffa camelopardalis reticulata*)	**17***	Lion (*Panthera leo*)	**27***	Naked Mole Rat (*Heterocephalus glaber*)
8*	North-American Beaver (*Castor canadensis*)	**18***	Short-tailed Fruit Bat (genus *Carollia*)	**28***	Harvest Mouse (*Micromys minutus*)
9*	Sable Antelope (*Hippotragus niger*)	**19***	Opossum (family *Didelphidae*)	**29***	Dama gazelle (*Nanger dama*)
10*	Black-footed Cat (*Felis nigripes*)	**20***	Common Agouti (genus *Dasyprocta*)	**30***	Greater Bulldog Bat (*Noctilio leporinus*)

Table 11A- Fish cases ate the Smithsonian's National Zoological Park

Procedure/Problem	1*
Dermatology/Buoyancy	1

1* Vermiculate River Stingray (*Potamotrygon castexi*)

Table 12A- Amphibian cases at the Smithsonian's National Zoological Park

Procedure/Problem	1*
Coelomic Distension	1

1* Aquatic Caecilian (*Typhlonectes natans*)

Table 13A- Reptile cases at the Smithsonian's National Zoological Park

Procedure/Problem	1	2	3	4	5	6	7	Total
Reproductive	1						1	2
Quarantine Exam		2	1	2	1	2		8
Total	1	2	1	2	1	2	1	**10**

1* Green Crested Basilisk (*Basiliscus plumifrons*)
2* Common Spider Tortoise (*Pyxis arachnoides*)
3* Fiji Banded Iguana (*Brachylophus fasciatus*)
4* Mexican lance-headed Rattlesnake (*Crotalus polystictus*)
5* Grey-banded Kingsnake (*Lampropeltis alterna*)
6* Lined Flat-tail Gecko (*Uroplatus lineatus*)
7* Malagasy leaf-tailed gecko (*Uroplatus fimbriatus*)

Table 14A- Bird cases at the Smithsonian's National Zoological Park

Procedure/Problem	1	2	3	4	5	6	7	8	Total
Pre-ship. Exam							1	2	3
Preventative Med.			1						1
Pediatrics	5								5
Parasitic		1							1
Dermatology							1		1
Cardiology					1		1		2
Ophthalmology						1			1
Traumatology				1		1			2
Total	5	1	1	1	1	2	3	2	**16**

1* Elegant Crested Tinamou (*Eudromia elegans*)
2* Raven (*Corvus corax*)
3* Micronesian Kingfisher (*Todiramphus cinnamominus cinnamomi*)
4* Scarlet Ibis (*Eudocimus ruber*)
5* Eclectus Parrot (*Eclectus roratus*)
6* Fairy Bluebird (*Irena puella*)
7* Red-billed Hornbill (*Tockus erythrorhynchus*)
8* Black Crake (*Amaurornis flavirostra*)

Table 15A- Mammal cases at the Smithsonian's National Zoological Park

Procedure/Problem	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*	12*	13*	14*	15*	16*	17*	18*	19*	20*	21*	22*	23*	24*	25*	26*	27*	28*	29*	30*	31*	Total
Pre-ship. Exam																															1	1
Respiratory	1				2																											3
Preventative Med.			2	2	1			1	1		8																1			1		17
Cardiology													1													1	1					3
Reproductive																1					1									1		3
Oncology													1		1							1										3
Gastroenterology				2	1								1												1							5
Ophthalmology					3												3	2														8
Pediatrics					1									1																		2
Dermatology												1													3				1			5
Dentistry																										1						1
Traumatology						1	1		1	1																1						5
Quarantine Exam									3																							3
Urology																								1	1							2
Orthopedics																											1					1
Podology		1							1																							2
Endocrinology													1																			1
Behavior																			1	2									1	1		5
Euthanasia																							1									1
Toxicology																								1								1
Pathology																												1				1
Total	1	1	2	4	8	1	1	1	6	1	8	1	4	1	1	1	3	2	1	2	1	1	1	2	5	3	3	1	2	3	1	**73**

1* Alpaca (*Lama pacos*)

2* Sitatunga (*Tragelaphus spekii*)

12* Siamang (*Symphalangus syndactylus*)

13* Banded Mongoose (*Mungos mungo*)

23* Rock Cavy (Kerodon rupestris)

24* Prehensile-tailed Porcupine (Coendou prehensilis)

3*	Grevy's Zebra (*Equus grevyi*)	**14***	Fishing Cat (*Prionailurus viverrinus*)	**25***	Greater Madagascar Hedgehog Tenrec (Setifer setosus)
4*	Cheetah (*Acinonyx jubatus jubatus*)	**15***	Spectacled Bear (Tremarctos ornatus)	**26***	Slender-tailed Meerkat (Suricata suricatta)
5*	Grey Seal (*Halichoerus grypus*)	**16***	Giant Panda (Ailuropoda melanoleuca)	**27***	Grey Wolf (*Canis lupus*)
6*	Red Ruffed Lemur (*Varecia rubra*)	**17***	California Sealion (Zalophus californianus)	**28***	Red Panda (*Ailurus fulgens*)
7*	North American River Otter (*Lontra canadensis*)	**18***	Harbor Seal (Phoca vitulina)	**29***	Prevost's Squirrel (*Callosciurus prevostii*)
8*	Western Lowland Gorilla (*Gorilla gorilla gorilla*)	**19***	Orangutan (Pongo pygmaeus)	**30***	Golden Lion Tamarin (*Leontopithecus rosalia*)
9*	Sri Lankan Elephant (*Elephas maximus maximus*)	**20***	Sloth Bear (Melursus ursinus)	**31***	Dama gazelle (*Nanger dama*)
10*	Short-eared Elephant Shrew (*Macroscelides proboscideus*)	**21***	Scimitar-horned oryx (Oryx Dammah)		
11*	Lion (*Panthero leo*)	**22***	Ring-tailed Lemur (Lemur catta)		

Table 16A- Total reptile cases (by Superorder)

Procedure/Problem	1*	2*	3*	4*	5*	6*	7*	Total
Reproductive	1	1				1	1	4
Oncology		1	4					5
Dermatology			14	3				17
Respiratory			1	1				2
Quarantine Exam	2	1	3	2			2	10
Orthopedics			1					1
Gastroenterology			1	1	1	1		4
Generalized Malaise			5					5
Pathology		1	1					2
Ophthalmology							1	1
Behavior							1	1
Total	3	4	30	7	1	2	5	**52**

1* Suborder *Pleurodira* **5*** Suborder *Sauria*

2* Suborder *Iguania* **6*** Suborder *Lacertilia*

3* Suborder *Serpentes* **7*** Suborder *Scleroglossa*

4* Suborder *Cryptodira*

Table 17A- Total bird cases (by Order)

Procedure/Problem	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*	12*	13*	14*	15*	16*	17*	18*	19*	20*	Total
Pre-ship. Exam	1				1									2							4
Preventative Med.	3	3	1	1		11	2	19			2			25	17	8	5	2			99
Podology						11	3						2								16
Infectious	2		2	1																	5
Neurology					1	1															2
Dermatology			1		1	1															3
Cardiology	1				1		1														3
Quarantine Exam			1					1			2										4
Ophthalmology			1				2			1									1		5
Traumatology	1		3	1		1			1			1	1			1					10
Orthopedics	1					1					2			1							5
Reproduction													12				4				16
Toxicology																	1				1
Pathology						2															2
Endocrinology							1														1
Pediatrics																				5	5
Total	9	3	9	3	4	28	9	20	1	1	6	1	15	28	17	9	10	2	1	5	**181**

1* Order *Psittaciformes*
2* Order *Charadriiformes*
3* Order *Passeriformes*
4* Order *Coraciiformes*
5* Order *Bucerotiformes*
8* Order *Pelecaniformes*
9* Order *Cuculiformes*
10* Order *Casuariiformes*
11* Order *Anseriformes*
12* Order *Piciformes*
14* Order *Gruiformes*
15* Order *Strigiformes*
16* Order *Falconiformes*
17* Order *Accipitriformes*
18* Order *Struthioniformes*

6*	Order *Galliformes*	**13***	Order *Ciconiiformes*	**19***	Order *Caprimulgiformes*
7*	Order *Sphenisciformes*			**20***	Order *Tinamiformes*

Table 18A- Mammals: Order *Carnivora*

Procedure/Problem	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	Total
Pre-ship. Exam	3						4				7
Respiratory		2					1				3
Preventative Med.	1	1					10			1	13
Cardiology	3							2			5
Reproductive	1					1					2
Oncology					1	1	1	1			4
Gastroenterology		1			1		3	1			6
Ophthalmology		9	5								14
Pediatrics		2					1				3
Dermatology	1										1
Dentistry					1			1			2
Infectious		1									1
Traumatology				1	1			1			3
Quarantine Exam				2							2
Urology					2		2				4
Obstetrics		1									1
Orthopedics	1					1	1			1	4
Endocrinology								1			1
Behavior	1	1	1			2	3				8
Pathology							1		1		2
Euthanasia							1				1
Total	11	18	6	3	6	5	28	7	1	2	**87**

1*	Family *Canidae*	**6***	Family *Ursidae*
2*	Family *Phocidae*	**7***	Family *Felidae*
3*	Family *Otariidae*	**8***	Family *Herpestidae*
4*	Family *Viverridae*	**9***	Family *Ailuridae*
5*	Family *Mustelidae*	**10***	Family *Procyonidae*

Table 19A- Mammal: Order *Primata*

Procedure/Problem	1*	2*	3*	4*	5*	6*	7*	8*	9*	Total
Respiratory				1						1
Preventative Med.		1		2	1					4
Reproductive		2	1				1			4
Oncology		4		1				1		6
Gastroenterology	1	1	1							3
Dermatology				1		1				2
Traumatology	1	3		1					1	6
Quarantine Exam	10									10
Urology		1		1						2
Orthopedics	1	1		1						3
Behavior		1		2	1		1		1	6
Pathology				1				1		2
Total	13	14	2	4	2	1	2	2	2	**42**

1* Family *Cebidae*
2* Family *Callitrichidae*
3* Family *Cercopithecidae*
4* Family *Lemuridae*
5* Family *Hominidae*
6* Family *Hylobatidae*
7* Family *Daubentoniidae*
8* Family *Atelidae*
9* Family *Lourisidae*

Table 20A- Mammals: Order *Artiodactyla*

Procedure/Problem	1*	2*	3*	4*	5*	Total
Pre-ship. Exam				3		3
Respiratory			1			1
Preventative Med.		2			3	5
Reproductive				2		2
Pediatrics		1		1		2
Dermatology	1					1
Dentistry		1				1
Traumatology		1		1		2
Orthopedics				1		1
Podology		3		2		5
Behavior				1		1
Total	1	8	1	11	3	**24**

1* Family *Suidae*
2* Family *Giraffidae*
3* Family *Camelidae*
4* Family *Bovidae*
5* Family *Hippopotamidae*

Table 21A- Marine mammal cases

Procedure/Problem	1*	2*	3*	4*	5*	Total
Respiratory	1	2				3
Preventative Med.		1				1
Reproductive	5					5
Gastroenterology		1				1
Ophthalmology		7	5	2		14
Pediatrics	2	2				4
Dermatology	1					1
Infectious				1		1
Obstetrics	2	1				3
Orthopedics					1	1
Behavior	1	1	1	1		4
Traumatology	1					
Total	13	14	5	3	1	**36**

1* Bottlenose dolphin (*Tursiops truncantus*)
2* Grey seals (*Halichoerus grypus*)
3* California sealion (*Zalophus californianus*)
4* Harbor Seal (*Phoca vitulina*)
5* Polar Bear (*Ursus maritimus*)

Preanesthetic Checklist

- ☐ Ensure the oxygen tanks are full, a backup tank is ready, and the regulator is working
- ☐ Turn on the flow meter to ensure that the anesthetic machine delivers oxygen when connected to the oxygen source
- ☐ Perform a leak test:
  - —Attach a rebreathing circuit and rebreathing bag to the machine
  - —Close the pop-off valve
  - —Place thumb over the end of the rebreathing circuit to block flow
  - —Turn on the flow meter to fill rebreathing bag
  - —Watch the manometer; turn off the oxygen when the needle approaches 20 cmh20
  - —Watch the needle for 30 seconds to ensure the machine holds the pressure
  - —When satisfied there is no leak, remove thumb from the rebreathing circuit to relieve pressure and open the pop-off valve
- ☐ Check the level of inhalant anesthetic in the machine
- ☐ Check the carbon dioxide absorbent for exhaustion (even if rebreathing circuit procedures will not be performed)
- ☐ Make sure the pop-off valve is open.

Figure 1A- Preanesthetic Checklist. Tech Talk/Team's Brief

Crash Course in ECG Monitoring

Pulse Oximeter: This measures the saturation level of oxygen in hemoglobin. A patient with fairly normal lungs should be ideally 98% to 100%. A pulse oximetry measurement <98% under 100% oxygen means there is not enough oxygen in the blood and saturation in the hemoglobin.

End-/tidal CO_2: This device measures carbon dioxide levels (in mmHg) at the end of a breath (end-tidal). The amount of CO_2 in the breath at the end of an exhalation should be closest to the level of the alveolar-capillary membrane and can be used to estimate the CO_2 level in the blood. This level will be >40 mmHg when the patient has high levels of CO_2 and is hypoventilating. When the patient does not have enough CO_2 and is hyperventilating, levels <30 mmHg will be present. Hypoventilation is a common cause of hypoxia or hypoxemia under anesthesia, as ventilation drives oxygenation.

ECG: This device measures the electrical conduction of the heart. Electrical signals from the sinoatrial and atrioventricular nodes are responsible for normal cardiac conduction and contraction; however, electrical signals can be present even without cardiac contraction, which is an anesthetic emergency. Do not use the ECG to prove heart "beat" or organ perfusion. Arrhythmias come in many forms—speed (fast or slow), location (atrial or ventricular), and severity (benign or emergent)—so always check a perfusion parameter (MM/CRT, blood pressure, and pulse quality) if an arrhythmia is present.

Blood Pressure: This physiologic parameter can be measured in different ways, but typically an oscillometric monitor is used. Blood pressure is a function of the arterial tone (normal, vasoconstricted, or vasodilated) and the cardiac output, which is made up of the heart rate and stroke volume. Patients can be bradycardic or tachycardic, hypovolemic, or vasodilated or vasoconstricted, or have poor cardiac contractility, and their blood pressure may suffer. Hypotension under anesthesia, especially in routine procedures, is often related to anesthetic drugs and inhalants, which are potent cardiac depressants and vasodilators.

Figure 2A- Crash course in ECG monitoring. Tech Talk/Team's Brief

CAREER ROAD MAP

Rebecca Rose, CVT

Vision of the Future

1. What do I really want to be doing in my career?
2. How long will it take me to get there?
3. Obstacles I need to overcome:
4. Those supporting me in my professional development/mentors:
5. Benefits to the pet:
6. Benefits to the pet owner:
7. Benefits to the veterinary practice:
8. Benefits to me, once I achieve my professional goal:

SMART Goal*

S	**SPECIFIC** (give it a title):
M	**MEASURABLE** (what does the outcome look like):
A	**ATTAINABLE** (brainstorm all aspects to completion, equipment needed, financial cost):
R	**REALISTIC** (skills needed to achieve goal, classes required):
T	**TIMELY** (beginning, middle, and end timeline):

Figure 3A- Rose R. (unknown year) Career Road Map. Veterinary Team Brief